‘An investigation of Organisational Carbon Accounting (OCA) practices in the Defence Sector to determine how these can best support Low Carbon Technology Innovation’

By

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Glossary of Terms and Definitions

Article 75 of the Grenelle II Package	French legislation requiring organisations to publish details of their greenhouse gas emissions associated with their legal entities based in France.
Article 225 of the Grenelle II Package	French legislation requiring organisations to publish details information on their social and environmental impacts in their public management reports.
Attributional Carbon Accounting	'Attributional methods [of Carbon Accounting] provide static inventories of emissions allocated or attributed to a defined scope of responsibility' (Brander & Ascui, 2015, p.100). Often referenced in contrast to 'Consequential Carbon Accounting' (defined below)
Blooms Taxonomy	Blooms Taxonomy (Andersen, LW et al., 2001) identifies several distinct levels of cognition that are addressed in an educational course, and is used in this thesis to define and classify the 'Aims and Objectives of the Thesis' (see section **1.4**)
Brookings Institution	US based think tank (defined below) focused on all parts of public policy, including defence and foreign affairs.
C4ISTAR	This term refers to a group of technologies used in the defence industry that are related to: Command, Control, Communications, Computers, Information/Intelligence, Surveillance, Targeting Acquisition and Reconnaissance. Technologies categorised in this way are often thought of as 'Joint Enabling Technologies' (defined below).
Carbon Accounting	A term used in this thesis to describe the broad range of activities related to measuring and reporting greenhouse gas emissions. The breadth of the term is explained in Figure 1 (Source: Ascui & Lovell, 2011: p.980)
Carbon Reduction Commitment (CRC)	A mandatory carbon reduction scheme in the UK that applies to large organisations in the public and private sector. Now called the CRC Energy Efficiency Scheme.
CDP	CDP (formerly the Carbon Disclosure Project) are a non-governmental organisation that works with investors, companies and cities to disclose their environmental impacts.
Center for a New American Security (CNAS)	US based think tank (defined below) that is engaged in defence and security research.
Center for Strategic & International Studies (CSiS)	US based think tank (defined below) that is engaged in defence and security research.
Chain Linked Model of Innovation	Term used to describe the interactions of the 'Technology Push' and 'Demand Pull' models of innovation (defined elsewhere in this glossary), and presenting these interactions as the factors most likely to determine the relative success of a particular product.
Clean Development Mechanism (CDM)	One of several flexible mechanisms allowed by the Kyoto Protocol (defined below) that provides for emissions reduction projects to produce allowances that countries or organisations can trade in order to meet their emissions reduction obligations. Its main significance for this research is in developing a range of methodologies for accounting for greenhouse gas emissions from individual projects.
Climate Change	Term used to describe activities that aim to deal with the

Adaptation	physical effects of climate change. It is used in this thesis to distinguish from activities related to Climate Change Mitigation, which are focused on preventing further climate change.
Climate Change Agreements (CCAs)	A voluntary UK government policy allowing energy-intensive organisations to obtain discounts on the UK Climate Change Levy (CCL – defined below) in order for them to remain competitive. It is significant for this research for its application at the sector-level.
Climate Change Governance	Term used to describe the wide range of activities at all levels to understand and react to climate change.
Climate Change Levy (CCL)	A tax on energy delivered to non-domestic users in the United Kingdom, designed to encourage energy efficiency and reduction in their GHG emissions.
Climate Change Mitigation	Term used to describe activities that are focused on preventing further climate change. It is used in this thesis to distinguish from activities related to Climate Change Adaptation, which aim to deal with the physical effects of climate change.
Climate Disclosure Standards Board (CDSB)	A non-governmental organisation that aims to advance and align corporate reporting models in relation to their environmental impacts.
Combat Platform	Any military structure or vehicle bearing weapons. It is a broad term used in this thesis to describe many types of defence product.
Commercial Off-The-Shelf (COTS)	A term used in the defence industry to describe parts and products that are bought and used from the commercial sector, as opposed to those that have been specifically designed and developed within the defence sector.
Consequential Carbon Accounting	'Consequential methods [of Carbon Accounting] attempt to measure the system-wide change in emissions that occurs as a result of a decision or action' (Brander & Ascui, 2015, p.100). Often referenced in contrast to 'Attributional Carbon Accounting' (defined above)
Defence Academy	Where referenced in this thesis, the Defence Academy is a part of the UK MoD that delivers courses and thought leadership related to defence strategy, science & technology, and business skills.
Defence Capability	Term describing the ability of a nation state to project or use military power. It is often used to discuss how defence inputs (people, knowledge, systems, tools, processes) aggregate to a level of 'capability' at the system level. Synonymous with 'Military Capability' (defined below).
Defence Dependence	Hartley (2011) defines 'defence dependent companies' as those where arms sales represent more than 70% of total sales, but this is not a clearly established threshold on which all authors and commentators agree.
Defence Enterprise	Term used to describe the complex network of organisations related to defence, at whichever level the term is applied (e.g. UK Defence Enterprise; EU Defence Enterprise; NATO Defence Enterprise). This includes but is not limited to defence departments, multinational defence companies, small and medium sized entities, non-governmental organisations, and relevant academic institutions.
Defence Equipment & Support (DE&S)	Used in this thesis to describe the trading entity in the UK MoD that manages complex projects to buy and support all

	the equipment and services for the Royal Navy, British Army and Royal Air Force.
Defence Industrial Base	A term used to refer to a government's industrial assets that are of direct or indirect importance for the production of equipment for a country's armed forces. Can be used to describe e.g. the UK Defence Industrial Base; the US Defence Industrial Base.
Defence Industrial Policy	Term used to describe a set of literature that is concerned with the interactions between defence departments and their 'defence industrial base' (see definition above). It is made up of both academic and grey literature (see definition below), with sources often emerging from defence departments or related defence organisations.
Defence Science and Technology Laboratory (DSTL)	An executive agency of the UK MoD, whose purpose is to maximise the impact of science and technology for the defence and security of the UK.
Defense Advanced Research Projects Agency (DARPA)	An agency of the US DoD responsible for the development of emerging technologies for use by the military.
Defense Energy Support Center (DESC)	The DESC is the part of the US Defence Logistics Agency (defined above) that is specifically focused on energy logistics.
Defense Logistics Agency (DLA)	The Defense Logistics Agency (DLA) is the Department of Defense's logistics combat support agency, providing worldwide logistics support to the military services as well as several civilian agencies and foreign countries
Defense Science Board (DSB)	Part of the US DoD. Particularly relevant in this research for their Task Force on Energy Security that have made a series of recommendations for how the US DoD should optimally manage its energy use (e.g. Department of Defense, 2008b)
Delivered Energy	This is a term used to describe the 'delivered energy' used by various organisations in the research (electricity, heat, steam, cooling), which will have involved some form of combustion by other organisations before being 'delivered' to site.
Demand Pull Model of Innovation	Term describing innovation models from the Innovation Studies field (see definition below), where the actions of consumers are the dominant factor in determining the success of a particular product.
Department for Environment, Food and Rural Affairs (Defra)	The UK government department responsible for environmental protection, food production and standards, agriculture, fisheries and rural communities.
Direct Emissions	This term commonly refers to Scope 1 greenhouse gas emissions (defined above), where the greenhouse gases can be directly assigned to the organisation's activities. In the context of the literature on Scope 3 emissions specifically, the term can sometimes also be used to describe Scope 3 emissions categories that relate directly to the Value Chain (defined below).
Discourse Analysis	A general term for a number of approaches for analysing language. Its relevance to this research relates to how debates about defence and climate change are framed.
Discourse Coalition	'Discourse coalitions' can be created when relevant 'Storylines' (defined below) recruit a range of actors around a particular point of view (Scrase & Ockwell, 2009).
Discursive Hegemony	Scrase & Ockwell (2009) describe most public policy debates as 'a struggle for 'discursive hegemony' in which actors seek

	to…secure support for their definition of reality' (p.41). Its relevance to this research relates to how debates about defence and climate change are framed.
Dow Jones Sustainability Index (DJSI)	A market index produced by S&P Dow Jones, that tracks the sustainability performance of a range of companies, based on their response to a questionnaire dedicated to the topic.
Emissions Trading System (ETS)	The first large Emissions Trading System (ETS) launched globally for greenhouse gas emissions was the EU ETS, which required large installations buy and trade 'allowances' for their emissions. Similar schemes under different names have also now emerged in California and China.
Energy Savings Opportunity Scheme (ESOS)	A UK scheme mandating large organisations to undertake energy efficiency surveys for their operations. It implements Article 8 of the EU Energy Efficiency Directive (defined below)
Energy Security	Energy security is a term widely used to describe the relationship between national security and the availability of natural resources for energy consumption, which are fundamental to the functioning of modern economies.
Environment Agency (EA)	A non-departmental public body in the UK, that is sponsored by Defra (defined above), with responsibilities relating to the protection and enhancement of the environment in England and Wales.
Environmental Protection Agency (EPA)	An agency of the federal government of the USA created to protect human health and the environment.
EU Energy Efficiency Directive	A European Union Directive (2012/27/EU) that mandates energy efficiency improvements within the European Union. Implemented differently across the EU member states, and by ESOS in the UK (defined above)
Facility Energy Use	Defence departments commonly report their energy use in two categories. Facility Energy includes energy needed to power fixed installations and non-tactical vehicles. It is distinguished from Operational Energy (defined below), which refers to energy required for training, moving, and sustaining military forces.
Foreign Military Sales (FMS)	Military sales between countries that are controlled by governments. Defence companies will refer to FMS when they are not making the sales directly themselves.
Forward Operating Base (FOB)	A Forward Operating Base (FOB) is a secured forward military position, commonly a military base, that is used to support military operations.
Fully Burdened Cost of Energy (FBCE)	A metric that helps describe the full cost (including logistics and other items) associated with military energy use. This term is predominantly used in the UK, whereas the term Fully Burdened Cost of Fuel (FBCF) is predominantly used in the US. However, both terms describe the same thing.
Fully Burdened Cost of Fuel (FBCF)	See definition of Fully Burdened Cost of Energy above. This is the US version of the same metric.
General Public Document	This term is used in the thesis to describe the most important public documents produced by an organisation (e.g. the organisation's Annual Report and Accounts, or public vision or strategy). These documents have been identified for the organisations included in this research as part of the archival research strategy described in the Methodology chapter. They are distinguished form the 'Specialist Public

	Documents' identified, which have a specific focus on environment, energy, or climate change.
GHG Intensity of the Organisation	Also referred to as 'emissions intensity', the GHG intensity of an organisation can refer to any metric that attempts to normalise the amount of greenhouse gases produced by an organisation, by reference to some other indicator. The most common metric used in this thesis to describe the GHG Intensity of an Organisation divides their total GHG emissions by their total revenue (or budget in the case of the defence departments). This allows the emissions totals of different organisations to be compared despite the fact that some are larger than others.
GHG Protocol	The Greenhouse Gas Protocol refers to a number of related standards, guidance, and tools for business and government to quantify and manage GHG emissions. The most well-known of these standards is the GHG Protocol Corporate Standard (WRI, 2004), but the same organisation also produces, for example, the WRI's Corporate Value Chain (Scope 3) Accounting and Reporting Standard for Scope 3 emissions (WRI, 2011).
Global Reporting Initiative (GRI)	An international independent standards organization that helps organisations understand and communicate their impacts on environmental and social issues.
Greenhouse Gas (GHG)	Greenhouse Gas / Greenhouse gases. Atmospheric gases that contribute towards the 'greenhouse effect' which is one of the main causes of climate change. Where used in the thesis the term refers to the six most abundant greenhouse gases (or groups of gases) that are referenced in the Kyoto Protocol (see below for definition): Carbon Dioxide; Methane; Nitrous Oxide; Sulphur Hexafluoride; Hydrofluorocarbons; Perfluorocarbons.
Greening Government Commitments (GCC)	These set out the actions UK government departments and their agencies will take to reduce their impacts on the environment. They have succeeded the Sustainable Operations on the Government Estate (SOGE) targets, which were the original targets for UK government departments to monitor and reduce their energy usage.
Grey Literature	Documents that have not been produced through traditional academic publishing channels (i.e. peer-reviewed books and journals). The term is mainly used in this thesis to describe 'defence-energy' and 'defence-carbon' literature produced by a variety of organisations linked to the defence enterprise (see definition above).
Indirect Emissions	This term commonly refers to Scope 2 and Scope 3 greenhouse gas emissions, where the greenhouse gases cannot be directly assigned to the organisation's activities, but are indirectly linked to its activities. In the context of the literature on Scope 3 emissions specifically, the term can sometimes also be used to describe Scope 3 emissions categories that do not directly to the Value Chain (defined below), but instead represent supporting activities.
Industrial Team	Two or more defence companies can present themselves as an 'Industrial Team' in order to bid for work from a defence department.
Innovation Networks	Term describing popular contemporary perspectives from the Innovation Studies field (see definition above), where

	innovation is conceptualised as 'an interactive process involving many actors and extending over time…They typically engage in information exchange, problem solving, and mutual learning as part of the process of innovation.' (Lundvall, 2013, p.33). In this thesis the term can be seen as synonymous with 'Innovation Systems', and 'Socio-Economic Models of Innovation' (also defined in this glossary).
Innovation Studies	Term used to describe an interdisciplinary academic field focused on how innovation occurs. Many 'models of innovation' are defined in this glossary and discussed in the thesis. The debates around these various innovation models constitute a large part of the Innovation Studies field.
Innovation Systems	Term describing popular contemporary perspectives from the Innovation Studies field (see definition above), where innovation is conceptualised as 'an interactive process involving many actors and extending over time…They typically engage in information exchange, problem solving, and mutual learning as part of the process of innovation.' (Lundvall, 2013, p.33). In this thesis the term can be seen as synonymous with 'Innovation Networks', and 'Socio-Economic Models of Innovation' (also defined in this glossary).
Intergovernmental Panel on Climate Change (IPCC)	An intergovernmental body that aims to provide an objective, scientific view of climate change and its political and economic impacts. Its work informs and supports the United Nations Framework Convention on Climate Change (UNFCCC – see definition below)
International Aerospace Environment Group (IAEG)	A non-profit organization of global aerospace companies created to collaborate on innovative environmental solutions for the industry.
International Collaborative Programme	Many defence combat platforms (see definition above) are now designed and constructed as International Collaborative programmes between defence departments of different countries and their supporting defence industrial base (see definition above).
International Petroleum Industry Environmental Conservation Association (IPIECA)	The global oil and gas industry association for environmental and social issues.
International Relations Theory	The study of international relations (IR) from a theoretical perspective.
ISO 14001; ISO 14064	These are part of the ISO 14000 set of standards related to environmental management that are used globally to help organizations minimize their impact on the environment. ISO 14001 specifically relates to management systems, and ISO 14064 provides guidance on quantifying and reporting greenhouse gas emissions.
Joint Enabling Technologies	A term used in the defence industry to describe technologies that enhance defence capability (defined above) by connecting up different defence inputs (whether people, knowledge, tools, equipment etc.)
Key Performance Parameter (KPP)	A term referring to specific indicators that have been established by the US DoD and are part of its military doctrine (defined below).
Kyoto Protocol	An international treaty adopted in 1997 which extended the

	1992 United Nations Framework Convention on Climate Change (UNFCCC – see definition below), and committed certain countries to reduce their greenhouse gas emissions
LEED	Leadership in Energy and Environmental Design. LEED is a popular green building certification programs used worldwide.
Lifecycle Assessment (LCA)	A technique used to assess environmental impacts associated with all the stages of a product's life from raw material extraction through processing, manufacture, distribution, use, repair, and disposal. There is an established academic field associated with the topic of LCA
Linear Model of Innovation	Term describing innovation models linked to the early development of the Innovation Studies field (see definition above), where the technological characteristics of a particular product were the dominant factor in determining its success. In this thesis this model can be seen as synonymous with the 'Technology Push Model of Innovation' and 'Techno-Economic Model of Innovation' (also defined in this glossary).
Lock In	A phenomenon used to describe Socio-technical Regimes (defined below) that are very resistant to change.
Military Capability	Term describing the ability of a nation state to project or use military power. It is often used to discuss how defence inputs (people, knowledge, systems, tools, processes) aggregate to a level of 'capability' at the system level. Synonymous with 'Defence Capability' (defined above).
Military Doctrine	Military Doctrine is used in this thesis to summarise the various policies, processes, and mandates by which defence departments operate.
Military-Industrial Complex	A term used to describe the mutually beneficial relationship between a nation's defence department and defence industrial base (see definition above), where together they are able to influence public policy.
Military Lexicon	Military Lexicon is used in this thesis to summarise terms and acronyms that are widely acknowledged in the defence sector.
Monitoring, Reporting & Verification (MRV)	Term used to refer to three distinct sets of activities related to corporate disclosure of greenhouse gas emissions. For the purposes of this thesis it is included within the breadth of the term Carbon Accounting (defined above).
Normalising Data	Term used to describe data that doesn't directly relate to greenhouse gas emissions, but is used to help understand the 'GHG Intensity of an Organisation' (defined above). Examples include but are not limited to: revenue; budget; employee numbers.
Normalising Metric	Term used to describe the particular way that an organisation's emissions have been normalised, and often used to describe the 'GHG Intensity of an Organisation' (defined above). Examples include but are not limited to: 'tCO_2e per $m Revenue'; '$tCO_2e$ per employee'.
North Atlantic Treaty Organisation (NATO)	An intergovernmental military alliance between several North American and European states, who agree to mutual defence in response to an attack by an external party.
Office of the Secretary of Defense (OSD)	Office of the Secretary of Defense. The OSD is the headquarters-level staff of the US DoD, and assists the Defense Secretary in managing the Department of Defense.
Operational Energy Use	Defence departments commonly report their energy use in two categories. Operational Energy (or sometimes

	'Equipment Energy') refers to energy required for training, moving, and sustaining military forces and weapons platforms for military operations. It is distinguished from Facility Energy (defined above), which includes energy needed to power fixed installations and non-tactical vehicles.
Organisational Carbon Accounting (OCA)	Organisational Carbon Accounting / Organisational Carbon Account / Organisational Carbon Accounts. A term used in this thesis to describe the public emissions accounts produced by organisations, as distinguished from those produced by countries, cities, specific installations or projects.
Pew	US based think tank (defined below) focused on all parts of public policy, including defence and foreign affairs.
Product Lifecycle	Term used to describe all the stages of a product's life from raw material extraction through processing, manufacture, distribution, use, repair, and disposal.
Product Sales	Most defence companies included in this research report their revenues in relation to 'Product Sales' (e.g. sales of a ship or aircraft), and 'Services Sales' (e.g. sales related to maintenance and upgrade of equipment, or training)
Project Level Carbon Accounts	Term used to describe the Greenhouse Gas emissions associated with a specific project or product.
Research and Development (R&D)	The term is used to refer to innovative activities undertaken by organisations to develop new services or products, or improving existing services or products.
Research Onion	Saunders, Lewis & Thornhill (2015) use the concept of the 'Research Onion' to inform and describe the design of a research methodology. The concept has been used in this research and is described in the Methodology chapter.
Revenue-Adjusted Emissions	This term is unique to this research and refers to some analysis in the Results chapter, where the emissions of certain defence companies have been adjusted with reference to their revenues associated with a related organisation. For example, if a certain percentage of BAE Systems revenues related to the UK MoD, its 'Revenue-Adjusted Emissions' related to the UK MoD refer to its total emissions multiplied by that percentage sales figure.
Rocky Mountain Institute (RMI)	A US-based non-profit organisation that encourages organisations to shift from fossil fuels to efficiency and renewables. Relevant here for their publications focused on the energy strategy of the US DoD.
Royal United Services Institute (RUSI)	UK-based think tank (defined below) that is engaged in defence and security research.
Scope 1; Scope 2; Scope 3 Greenhouse Gas Emissions	Three established categories of emissions produced by an organisation, that have been popularised by the GHG Protocol (defined above). Each of these categories are defined in more detail below.
Scope 1 Greenhouse Gas Emissions	Scope 1 Greenhouse Gas emissions are described as follows in the GHG Protocol (WRI, 2004): 'Scope 1 emissions occur from sources owned or controlled by the organisation' (p.25)
Scope 2 Greenhouse Gas Emissions	Scope 2 Greenhouse Gas emissions are described as follows in the GHG Protocol (WRI, 2004): 'Scope 2 accounts for GHG emissions from the generation of purchased electricity consumed by the organisation, but physically occur at the facility where electricity is generated' (p.25)

Scope 3 Greenhouse Gas Emissions	Scope 3 Greenhouse Gas emissions are described as follows in the GHG Protocol (WRI, 2004): 'Scope 3 allows for the treatment of all indirect emissions. They are a consequence of the activities of the organisation, but occur from sources it does not own or control' (p.25). The different categories of Scope 3 emissions referred to in this thesis are also defined below.
Scope 3 Greenhouse Gases related to Business Travel	This category of Scope 3 emissions is defined by the WRI's Corporate Value Chain (Scope 3) Accounting and Reporting Standard for Scope 3 emissions (WRI, 2011) as follows: 'Transportation of employees for business-related activities…in vehicles not owned or operated by the reporting company' (p.8)
Scope 3 Greenhouse Gases related to Downstream Transportation and Distribution	This category of Scope 3 emissions is defined by the WRI's Corporate Value Chain (Scope 3) Accounting and Reporting Standard for Scope 3 emissions (WRI, 2011) as follows: 'Transportation and distribution of products sold by the reporting company…between the reporting company's operations and the end consumer' (p.9)
Scope 3 Greenhouse Gases related to Employee Commuting	This category of Scope 3 emissions is defined by the WRI's Corporate Value Chain (Scope 3) Accounting and Reporting Standard for Scope 3 emissions (WRI, 2011) as follows: 'Transportation of employees between their homes and their worksites…in vehicles not owned or operated by the reporting company' (p.8)
Scope 3 Greenhouse Gases related to Fuel and Energy Related Activities Not Included in Scopes 1 & 2	This category of Scope 3 emissions is defined by the WRI's Corporate Value Chain (Scope 3) Accounting and Reporting Standard for Scope 3 emissions (WRI, 2011) as follows: 'Extraction, production, and transportation of fuels and energy purchased or acquired by the reporting company…not already accounted for in scope 1 or scope 2' (p.7)
Scope 3 Greenhouse Gases related to Purchased Goods and Services	This category of Scope 3 emissions is defined by the WRI's Corporate Value Chain (Scope 3) Accounting and Reporting Standard for Scope 3 emissions (WRI, 2011) as follows: 'Extraction, production, and transportation of goods and services purchased or acquired by the reporting company' (p.7)
Scope 3 Greenhouse Gases related to Upstream Leased Assets	This category of Scope 3 emissions is defined by the WRI's Corporate Value Chain (Scope 3) Accounting and Reporting Standard for Scope 3 emissions (WRI, 2011) as follows: 'Operation of assets leased by the reporting company (lessee)…and not included in scope 1 and scope 2' (p.8)
Scope 3 Greenhouse Gases related to Upstream Transportation and Distribution	This category of Scope 3 emissions is defined by the WRI's Corporate Value Chain (Scope 3) Accounting and Reporting Standard for Scope 3 emissions (WRI, 2011) as follows: 'Transportation and distribution of products purchased by the reporting company…between a company's tier 1 suppliers and its own operations…[and] transportation and distribution services purchased by the reporting company' (p.8)
Scope 3 Greenhouse Gases related to Use of Sold Products	This category of Scope 3 emissions is defined by the WRI's Corporate Value Chain (Scope 3) Accounting and Reporting Standard for Scope 3 emissions (WRI, 2011) as follows: 'End use of goods and services sold by the reporting company' (p.9)

Scope 3 Greenhouse Gases related to Waste Generated in Operations	This category of Scope 3 emissions is defined by the WRI's Corporate Value Chain (Scope 3) Accounting and Reporting Standard for Scope 3 emissions (WRI, 2011) as follows: 'Disposal and treatment of waste generated in the reporting company's operations' (p.8)
Scope 4 Greenhouse Gas Emissions	Matthews, Hendrickson & Weber (2008) complain that the Scope 3 criteria at present are far too vaguely defined, and offer a potential step forward in this area by introducing a 'Scope 4' in order to tighten definitions in this area. Scope 3 would then be reserved for indirect emissions for production, and the new Scope 4 used for indirect emissions that directly relate to the product lifecycle or Value Chain (as defined below).
Security Studies	An interdisciplinary academic field that overlaps significantly with Strategic Studies (see definition below), and can be seen as a sub-field of International Relations Theory (see definition above)
Selection Environment	This term is related to the Innovation Systems perspective (defined above) and describes the specific environment (or system) into which a product or technology is introduced. The 'Selection Environment' for the product or technology is heavily influenced by the wider socio-technical regime in question (defined below), and is likely to determine whether it is adopted or neglected.
Services Sales	Most defence companies included in this research report their revenues in relation to 'Product Sales' (e.g. sales of a ship or aircraft), and 'Services Sales' (e.g. sales related to maintenance and upgrade of equipment, or training)
Single Services / The Services	Term often used in the literature related to defence to describe the non-civilian parts of the defence departments (e.g. Air Force, Army, Navy, and in some cases special forces divisions)
Small and Medium-sized Enterprises (SMEs)	Small and medium-sized enterprises (SMEs) are businesses whose revenues or employee numbers fall below certain thresholds, which can be defined differently in different jurisdictions.
Socio-economic Model of Innovation	Term describing popular contemporary perspectives from the Innovation Studies field (see definition above), where innovation is conceptualised as 'an interactive process involving many actors and extending over time…They typically engage in information exchange, problem solving, and mutual learning as part of the process of innovation.' (Lundvall, 2013, p.33). In this thesis the term can be seen as synonymous with 'Innovation Networks', and 'Innovation Systems' (also defined in this glossary).
Socio-technical Regimes	Socio technical regimes 'consist of a set of technologies embedded in a social, political and institutional context, with its associated regime-specific set of rules, procedures, habits and practices.' (Lehtonen and Kern, 2009, p.104).
Socio-technical Transitions	This term is used to describe or propose changes to established 'Socio-technical Regimes' (defined above).
Specialist Public Document	This term is used in the thesis to describe the most relevant 'specialist' public documents produced by an organisation in relation to environment, energy, or climate change (e.g. the organisation's Sustainability Report, or Energy Strategy). These documents have been identified for the organisations

	included in this research as part of the archival research strategy described in the Methodology chapter. They are distinguished form the 'General Public Documents' identified, which represent mainstream public documents such as an Annual Report and Accounts, or a public vision or strategy.
Stockholm International Peace Research Institute (SIPRI)	A non-profit organization publishing various reports and statistics about global defence spending.
Storylines	The concept of 'Storylines' in discourse analysis can help define policy problems. 'Storylines' are referred to in this research for their potential to help create 'discourse coalitions' (defined above) in relation to the defence sector's development of low carbon technologies.
Strategic Studies	An interdisciplinary academic field centred on the study of conflict and peace strategies, often devoting special attention to the relationship between international politics, diplomacy, economics, and military power.
Strategic Vector	Lovins (2010) describes 'Strategic Vectors' as 'succinct descriptions of capabilities that make a big difference in military operations' (p. 3-4). The current vectors used by the US DoD are speed, stealth, persistence and networking, and the DSB Task Force on Energy Security recommend two further vectors to appropriately consider energy within this process: endurance and resilience. (Department of Defense, 2008b: p.35)
Sustainability Reporting	Term used to describe an academic field and professional practice concerned with how organisations publically report their environmental and social impacts.
Sustainable Procurement	Sustainable Procurement is a widely used term that describes procurement processes that consider the economic, social, and environmental impacts of a procurement decision.
Techno-Economic Model of Innovation	Term describing innovation models linked to the early development of the Innovation Studies field (see definition above), where the technological characteristics of a particular product were the dominant factor in determining its success. In this thesis this model can be seen as synonymous with the 'Technology Push Model of Innovation' and 'Linear Model of Innovation' (also defined in this glossary).
Technology Push Model of Innovation	Term describing innovation models linked to the early development of the Innovation Studies field (see definition above), where the technological characteristics of a particular product were the dominant factor in determining its success. In this thesis this model can be seen as synonymous with the 'Linear Model of Innovation' (defined above).
Tether of Fuel	Term used in the defence sector to describe the way that logistics associated with supplying fuel to operational forces can restrict their defence capability (defined above).
Think tank	A think tank is an organisation that performs research and advocacy concerning topics relevant to government policy. Can also be known as a 'policy institute' or 'research institute'.
Tooth-to-Tail Ratios	'Tooth-to-Tail' ratios are a concept used to compare the proportion of military activity associated with applying force (tooth), with that associated with supporting logistics (tail).
UCLan	University of Central Lancashire.

UK Mandatory Carbon Reporting	This refers to a 2013 amendment to the Companies Act in the UK, mandating that UK listed companies publish their GHG emissions in a particular format in their Annual Report and Accounts.
UK Ministry of Defence (UK MoD)	The defence department of the United Kingdom.
UK National Security Strategy (UK NSS)	The UK NSS and UK SDSR (defined below) provide the overarching policy framework for defence in the UK. They are usually updated alongside the electoral cycle.
UK Strategic Defence and Security Review (UK SDSR)	The UK NSS (defined above) and UK SDSR provide the overarching policy framework for defence in the UK. They are usually updated alongside the electoral cycle.
UN Framework Convention on Climate Change (UNFCC)	The first international treaty adopted by UN member states aimed at stabilizing greenhouse gas concentrations in the atmosphere in order to prevent dangerous levels of climate change. It was adopted in 1992 and is the foundation for most of the subsequent activity on climate change mitigation at the nation state level.
US Department of Defense (US DoD)	The defence department of the USA.
US Executive Order 13514 on Federal Sustainability	This is an Executive Order titled 'Federal Leadership in Environmental, Energy, and Economic Performance' which was issued in 2009 and mandates energy efficiency requirements for US federal agencies, including the US Department of Defense.
US National Military Strategy (US NMS)	The US QDR (defined below) and US NMS provide the overarching policy framework for defence in the US. They are usually updated alongside the electoral cycle.
US Quadrennial Defense Review (US QDR)	The US QDR and US NMS (defined above) provide the overarching policy framework for defence in the US. They are usually updated alongside the electoral cycle.
Value chain	A value chain is a set of activities that a firm operating in a specific industry performs in order to deliver a product or service for the market. It is used in this thesis to distinguish between emissions-producing activities that directly relate to a defence product/service, and are therefore a fundamental part of its value proposition (e.g. sourcing parts, building a product, testing a product, using the product), and those that can be considered as supporting activities (e.g. business travel; employee commuting).
World Resources Institute (WRI)	A global research non-profit organization that was established in 1982 to promote environmental sustainability, economic opportunity, and human health and well-being. Its main significance to this research is its role in developing the GHG Protocol (defined above) that defines how many organisations account for their greenhouse gas emissions.

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For Isla and Freya, who I hope grow up into a more safe and sustainable world.

Abstract

'Climate change' and 'defence' are becoming closely associated topics, particularly in relation to the potential that the defence sector has to support the development of low carbon technologies. This exploratory research applies an inductive approach and a strongly archival strategy in order to investigate how Organisational Carbon Accounting (OCA) practices in the defence sector can best support low carbon technology innovation. It takes an interdisciplinary approach to the literature, drawing on the fields of Carbon Accounting, Defence Industrial Policy, and Innovation Studies.

It finds that there some difficulties allocating emissions to organisations in existing OCAs, which are particularly marked in the defence sector due to close working relationships between organisations. These allocations can result in abstract OCAs that do not always reflect the underlying activities causing emissions to be produced. In contrast, 'Project Level' Carbon Accounts focused on large-scale collaborative programmes can better account for the emissions of the defence sector in an understandable way that engages new and relevant actors to defence-energy debates. These accounts are therefore more likely than existing OCA practices to support low carbon technology development across innovation networks. A positive selection environment for low carbon technologies can be promoted if these 'Project-Level' Carbon Accounts are presented within an appropriate strategic framework, and this research describes the relevance of the defence sector concepts of 'resilience' and 'endurance' and the related metric of the Fully Burdened Cost of Energy (FBCE).

The findings emphasise the value of sector-level analyses of OCA practices, which are not represented in the literature at present. The sector-level perspective can help identify relevant methods from the wider Carbon Accounting field that can improve existing organisational approaches. More importantly, it can help researchers engage with the fundamental question of what Carbon Accounting is for, by analysing how the OCA practices within a specific sector support or inhibit its most effective contribution to climate change mitigation.

1) Introduction

This introductory chapter is divided into five parts.

The first provides some essential background to the research, introducing the concept of climate change and describing how the defence sector is being characterised as a ‘technology innovator’ in climate change debates.

This research is concerned with Organisational Carbon Accounting (OCA) practices, and specifically how these can best support low carbon technology innovation in the defence sector. The second part of the introduction briefly describes the academic context to these debates, defining OCA, and describing some other relevant academic literatures that have been necessary to investigate the title question (Defence Industrial Policy and Innovation Studies). It also discusses the novelty of this research, particularly with reference to the relative scarcity of sector-level analyses of OCA.

The third part of this chapter introduces the research approach taken. It explains how the research has been conducted over seven years with a strong-industrial link. Given these factors, and its context within an academic field of Carbon Accounting where both professional practice and academic analysis are still relatively immature and evolving, it explains the rationale for taking an inductive and exploratory approach to the research. Despite the evolving nature of the field, it comments on the scale of Carbon Accounting activity taking place in the world today, and explains how an archival research strategy is suitable for integrating the significant volumes of relevant information provided by organisations with the emerging academic literature.

Section **1.4** describes the ‘Aims and Objectives of the Thesis’, using an established method to categorize these according to the cognitive levels that are addressed by each. This helps communicate what the research covers and what the reader can expect to learn from each chapter of the thesis.

The fifth and final part of this introductory chapter describes the structure of the remainder of the thesis, describing how each of the objectives are met throughout.

1.1 Background

Climate change is one of the most pressing issues of our age, and one that has dominated much political discussion for the past 30 years or more. Since the industrial revolution, humans have been burning exponentially increasing amounts of fossil fuels, and releasing corresponding volumes of greenhouse gases (GHGs) to the Earth's atmosphere as a result.

Climate Science has provided fairly unanimous assessments of the scale and rate of anthropogenic climate change caused by these concentrations of GHGs (IPCC, 2013), but governments have struggled to respond, given the fundamental importance of fossil fuels to virtually all economic activity. Despite numerous high-profile international conferences, and an enormous variety of schemes and initiatives aimed at curbing global emissions growth, atmospheric concentrations of GHGs remain high, and this has led some to suggest that the issue presents an 'intractable problem' for global governance (Bulkeley & Newell, 2010).

The ability to accurately monitor, report and verify GHG emissions and climate change-relevant performance, at various governance levels, becomes of fundamental importance to the success of any of these initiatives. For the purposes of this research, these activities are described as 'Carbon Accounting'. Without it, progress cannot be tracked, and lessons cannot be learned about which methods are working, and which are not.

The scale of the challenge of mitigating dangerous climate change is such that all industrial sectors must play a part, and this research is concerned with how organisations within the defence sector account for carbon and report on their performance in helping to mitigate climate change.

The term 'mitigation' is important, as climate change debates are usually split between those focused on 'mitigation', and those focused on 'adaptation'. 'Mitigation' initiatives aim to reduce the amount of GHGs being released to the atmosphere and contributing to climate change, whereas 'adaptation' initiatives aim to manage the anticipated impacts of it (IPCC, 2013).

'Adaptation' debates are undoubtedly relevant to the defence sector (perhaps moreso than those concerned with 'mitigation'), particularly as the lines between defence, human security, and humanitarian aid and civil contingencies continue to blur (Kaldor, 2007). These debates are beyond the scope of this research, but would be a valuable area for potential further work.

In relation to activity to mitigate climate change and better manage GHG emissions, climate change impacts and Carbon Accounts can be created at numerous 'levels', covering international regions, independent nation states, individual organisations or projects. Whilst this research reviews 'Organisational Carbon Accounts' (OCA), understanding how these individual accounts cumulate to the 'sector-level' is also very relevant, as different sectors will have different roles to play in mitigating climate change. A sector that consumes significant volumes of fossil fuels (e.g. extractive industries such as mining or oil and gas, or airlines) might be expected to contribute by reducing its dependence on fossil fuels. In contrast, a sector that consumes relatively smaller volumes of fossil fuels but produces products that have the capacity to burn significant amounts (e.g. automotive), might be expected to reduce the GHG-impact of its products as the most constructive way to support climate change mitigation.

The Defence Sector sits somewhere in the middle of this spectrum, with defence departments being large consumers of fossil fuels that and tend to dominate government GHG emissions profiles (Deloitte, 2009). However, the sector is often characterised as a ‘technology-innovator’, with many authors noting the significant ‘technology spin-offs’ that have resulted from defence Research and Development (R&D), including radar, the internet, and space satellites and GPS to name just three (Hartley, 2011; Hambling, 2005). As a result, many commentators have espoused the potential for defence to support the development of low carbon technologies that are useful for its own operations but also have wider application in a more secure, low carbon domestic energy system (Lovins, 2010; Friedman, 2008). These advocates suggest that defence support for low carbon technologies could represent a ‘game-changer’ that might galvanise a transition to the wider energy system. This scenario is not without precedent, with military development of the jet engine crucial to the development of the combined cycle gas turbine that heralded a shift in how power was generated in all developed economies (Watson, 2004).

This research is concerned with how OCA practices can be best applied to the defence sector in order to support these ambitions, and encourage low carbon technology innovation.

1.2 Academic Context and Novelty

There is no strong consensus in the academic literature as to the definition of Carbon Accounting. Indeed, many terms are used to describe the same area of literature: 'Carbon Accounting'; 'Carbon Management Accounting'; 'Carbon Footprinting'; 'Greenhouse Gas Accounting'; 'GHG Reporting'; 'Climate Change Accounting'; 'Climate Change Management Accounting'; 'Monitoring, Verification and Reporting of Carbon (MRV)'. The issues are not purely semantic. Schaltegger suggests that 'Carbon Accounting' has a 'climate change mitigation' focus, whereas 'Climate Change Accounting' has an adaptation focus (Schaltegger et al., 2015). Similarly, Zvedov and Schaltegger discuss the difference between 'carbon management accounting' and 'carbon reduction accounting' in the context of the differing motivations of the reporting companies (Zvedov & Schaltegger, 2015). At the more technical level, others make the distinction between 'Carbon' and other greenhouse gases (Harangozo, Szechy & Zilahy, 2015).

Several authors attempt a formal definition (e.g. Stechemesser & Guenther, 2012), but Ascui and Lovell provide a useful summary diagram reproduced in Figure 1 below that captures the breadth of issues included under the term Carbon Accounting, and it is in this broad sense that the term is used in this research.

1		2	3		4		5	6	
estimation	of	carbon	emissions to the atmosphere	at	global	level, for	mandatory	research	purposes
calculation		carbon dioxide	emissions rights		national		voluntary	compliance	
measurement		greenhouse gas	emission obligations		sub-national			reporting	
monitoring			emission reductions		regional			disclosure	
reporting			legal or financial instruments linked to the above		civic			benchmarking	
validation			trades/transactions of any of the above		organizational			auditing	
verification			impacts of climate change		corporate			information	
auditing			impacts from climate change		project			marketing	
					installation			or other	
					event				
					product				
					supply chain				

Figure 1: Diagram (Reproduced) summarising the breadth of the field of Carbon Accounting (Source: Ascui & Lovell, 2011: p.980)

The breadth of this definition demonstrates the links that Carbon Accounting necessarily has to Climate Change governance at all levels. The vast majority of schemes or initiatives aimed at mitigating climate change involve some element of Carbon Accounting, and there is a rapidly growing set of academic literature dedicated to 'climate change governance' (Bulkeley & Newell, 2010; Hoffman, 2011; Newell & Paterson, 2010), which is underpinned by International Relations Theory and contemporary theories of governance (e.g. Brown & Ainley, 2005; Held & McGrew, 2007; Diehl & Frederking, 2010; Rosenau, 2000). This literature has been reviewed but is outside the scope of the final thesis.

This research is most interested in Carbon Accounting practices as they apply to organisations – or 'Organisational Carbon Accounting' (OCA) as it is described in this thesis. This represents an emerging but fairly distinct area of the Carbon Accounting literature often considered in relation to wider Sustainability Reporting practices by organisations. The first part of the Literature Review in section **2.1** is focused on OCA, but draws on other areas of the wider Carbon Accounting field where relevant. The research is also interested in how these OCAs cumulate to a 'sector-level' perspective on Carbon Accounting. Interestingly, there has been little 'sector-level' analysis in the Carbon Accounting literature to date, and the term 'sector' is conspicuous by its absence in column 4 of Ascui and Lovell's table in Figure 1 above.

Partly due to the lack of clear sector-level Carbon Accounting precedents to follow, this research also reviews two 'supporting literatures'.

The literature available on 'Defence Industrial Policy' is reviewed in order to connect relevant themes from the OCA literature to the contemporary defence industrial context. As mentioned above in relation to climate change governance, there are significant volumes of academic literature available that link International Relations Theory and the contemporary defence context – often referred to as the Strategic Studies or Security Studies literature (e.g. Collins, 2009; Kaldor, 2006; Smith, 2006). However, this research is concerned with the Carbon Accounting practices of a range of defence sector organisations (whether defence departments, supporting defence companies, or other related organisations), and therefore it is the 'Defence Industrial Policy' literature that best applies, and this is summarised in section **2.2** of the Literature Review.

In order to respond to the way that the defence sector is being characterised as a 'technology innovator' in climate change debates, the research also draws on various aspects of the Innovation Studies literature. The historical development of the Innovation Studies discipline is used to contextualise existing calls for defence to develop low-carbon technologies, with these mostly responding to out-dated (technology push / demand pull) models of innovation, as opposed to the 'network' perspectives that have most contemporary relevance (Fagerberg, Martin & Andersen, 2013a). It draws on the literature associated with 'socio-technical transitions' to explain the role that 'discourse' can have in encouraging change to existing systems. In this context, the field is relevant for exploring the potential that Carbon Accounting practices have to frame defence-carbon debates in ways that favour low carbon technology innovation.

In terms of the academic novelty of this research, it has relevance for its analysis of OCA at the sector level, within an under-developed field of literature more generally.

Bebbington, Unerman & O'Dwyer (2014b) confirm that the wider discipline of Sustainability Reporting is very much still developing as a field, and review papers have shown the topic of Climate Change within Sustainability Reporting to have 'surprisingly low take up…given its prominence as an issue' (Thomson, 2014: p.21-22). Specifically in relation to Carbon Accounting, Schaltegger et al. (2015) confirm that 'the question of how climate change accounting could be designed and developed has so far remained largely experimental and underdeveloped in the literature' (p.7), and Gibassier (2015) confirms that this is particularly the case in relation to how organisations account for carbon.

Within this emerging area of literature sector-specific analysis is particularly rare. Some precedents exist in the wider Sustainability Reporting literature that tend to be confined to sectors with significant local impacts such as mining and extractives (Fonseca, 2010; Fonseca, 2014; Perez, 2009), and several papers call for more sector-level emphasis (Beare, Buslovich & Searcy, 2014), with Weber emphasising the importance of this area for Sustainability Reporting as trends in 'sectoral difference' tend to be more relevant than 'national difference', despite the latter being studied far more comprehensively (Weber & Marley, 2012). In relation to Carbon Accounting there are very few academic studies focused at the sector-level[1], and where grey literature exists it tends to be focused on very 'production-intensive' (high scope 1 emission) industries[2].

The lack of sector-level analysis of Carbon Accounting could relate to the fact that many of the established responses to climate change have emerged in an era of heightened neo-liberalism. Bulkeley & Newell (2010) explain how this influenced the design of the most significant international agreements aiming to reduce GHG emissions, with the Kyoto Protocol including several 'flexibility mechanisms' that enable nation states to use market-based approaches to meet their obligations. The same authors describe the emergence of 'private carbon governance' initiatives such as the Carbon Disclosure Project (CDP), which gathered a large investor mandate in order to encourage organisations to provide information on their impacts and strategies associated with climate change. As a result, initiatives can be focused on individual organisations and how they compare to each other, as opposed to collaborative solutions at the sector-level. Bebbington, Unerman and O'Dwyer (2014b) describe how organisational responses have begun to focus on an increasingly small number of stakeholders, with investors being prioritised.

As regards Carbon Accounting practices specifically related to the Defence Sector, this research is not aware of any other academic studies that have covered it. Given the potential it is claimed to have by some for developing 'game-changing technologies that might galvanise a transition to the wider energy system', this is somewhat surprising, and this research hopes to redress this gap.

In doing so, it hopes to also provide another useful sector-level investigation of Carbon Accounting to add to the few existing studies, something which has been recognised as important by both academic[3] and non-academic audiences alike[4].

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[1] Examples exist but are rare. For example: Rugani et al (2013) discuss carbon footprints in the wine industry; Gibassier (2015) provides an investigation of Carbon Accounting that refers heavily to a French food multinational (Gibassier, 2016); and Lee (2012) provides some analysis relevant to the automotive industry.

[2] Relevant grey literature includes the guidance for producing national GHG inventories that support the UN Framework Convention on Climate Change and the Kyoto Protocol. The 'Common Reporting Format' tables that countries must report within require emissions to be reported across a number of activities characterised by high emissions production, and chapters 3-9 of all National Inventory Reports similarly focus on particular activities. Chang & Bellassen (2016) provide a thorough summary of these processes.

[3] Bebbington & Larringa describe how "it is…likely that sector focused research will emerge going forward, as dynamics created by both production activities and institutional settings will affect [climate change] responsiveness" (Bebbington & Larrinaga, 2014: p.208)

[4] For example The Carbon Disclosure Project or CDP (see section **2.1.2**) are currently trying to better accommodate the vastly different implications of climate change for different sectors via their 'Assesing Low Carbon Transition Initiative' (CDP, 2016a)

1.3 The Research Approach

This research is the result of an Industrial CASE Studentship between the University of Central Lancashire (UCLan) and BAE Systems, one of the world's largest aerospace, defence and security companies. The research began in late 2010 and will complete on a part-time basis in 2017.

The third part of this introductory chapter introduces the research approach taken. Both the academic context for the research and the way in which it has been carried out has made an exploratory, inductive approach highly appropriate. A flexible approach that allowed relevant patterns to emerge throughout the research made sense in a context where both the academic field and professional practice were still emerging.

As explained in the previous section, the field of Carbon Accounting is currently immature and still evolving, and therefore an exploratory approach to the research is appropriate for a field where relatively little is known. 'Supporting literatures' associated with Defence Industrial Policy and Innovation Studies were explored and reviewed, in order to ground key themes from the emerging Carbon Accounting literature with their sector-specific context.

The exploratory, inductive approach was also appropriate to the specific context of this study, with the researcher based with an industrial partner, and carrying out the research over a long period of time.

The Methodology chapter describes the research approach in more depth, and also elaborates on the relevance of an archival strategy to this research. Several authors describe the speed at which real-world initiatives to govern climate change are emerging, creating a huge plethora of sites of enquiry, as all inevitably involve some element of Carbon Accounting. New experiments are happening within climate change governance at a rate which any academic field might struggle to keep pace with. Bulkeley & Newell (2010) describe how this generates significant challenges of co-ordination, but should be seen as a positive thing in a context where solutions urgently need to be sought and identified:

> 'While the tremendous diversity and dynamism of climate governance generates huge challenges of co-ordination, accountability and effectiveness … the plurality of sites of action could also be a positive thing as actors move between arenas trying to advance action in the fastest and most effective way they can, working with whom they need to, wherever that happens to be.' (p.114)

Given this 'tremendous diversity and dynamism' in relation to the activities underway to mitigate climate change, an archival research strategy made sense in order to connect the themes from the emerging academic literature with the activities already underway in the defence sector, as evidenced by relevant public sources of information.

The research has reviewed both narrative and numerical information on energy use, GHGs and climate change mitigation across the UK MoD and US DoD, as well as the ten largest multinational defence companies, and relevant grey literature provided by think tanks and other organisations related to defence. It describes the quantitative and qualitative trends communicated by these public documents, and discusses these in relation to some key themes identified across the Carbon Accounting and supporting literatures described in the Literature Review.

1.4 Aims and Objectives of the Thesis

The title of the thesis describes the research aim:

> *"An investigation of Organisational Carbon Accounting (OCA) practices in the Defence Sector to determine how these can best support Low Carbon Technology Innovation"*

The following objectives have been designed to meet this research aim, and have been produced with reference to Blooms Taxonomy (Andersen, LW et al., 2001), which identifies several distinct levels of cognition that are addressed in an educational course, as follows:

- Remembering: which involves the recognizing or remembering of facts, terms and basic concepts
- Understanding: which involves organising or interpreting facts and ideas in order to demonstrate understanding
- Applying: which involves using acquired knowledge to solve new problems
- Analysing: which involves examining information; determining how component parts relate to each other, and noting potential motives or causes
- Evaluating: which involves presenting and defending opinions by making judgements about the information
- Creating: which involves reorganizing elements into a new pattern or structure

Though not a course, this research intends to achieve certain outcomes for both the reader and researcher, and this section summarises how the objectives for each chapter of the thesis address these different cognitive levels. Bloom's Taxonomy is designed as a hierarchy or pyramid, where each subsequent cognitive level builds upon the last. Therefore, the Literature Review inevitably focuses on the lower cognitive levels at the base of the pyramid (Remembering / Understanding), and the higher levels are covered in the Discussion and Conclusion towards the end of the thesis.

The objectives for this research are described in relation to each main chapter of the thesis below, with the relevant cognitive levels addressed in brackets alongside each one.

Literature Review (Chapter 2)

- Develop a broad knowledge of the history and key theories associated with three relevant academic fields: Carbon Accounting; Defence Industrial Policy; and Innovation Studies (*Cognitive Level: Remember*)
- For the 'themes' of Carbon Accounting identified as most relevant to this research, describe the gaps and areas of immaturity in the existing knowledge (*Cognitive Level: Remember*)
- Understand how the gaps in the Carbon Accounting literature are reinforced by contextual aspects of the Defence Industrial Policy literature (*Cognitive Level: Understand*)

- Understand how Carbon Accounting can influence technology innovation, and relevant implications for existing defence sector approaches to low carbon technology innovation (*Cognitive Level: Understand*)
- Understand the relevance of taking an interdisciplinary approach and using relevant supporting literatures to investigate Carbon Accounting at the sector level (*Cognitive Level: Understand*)

Methodology (Chapter 3)

- Understand the relevance of an exploratory archival research strategy for analysing Carbon Accounting and climate change information produced by defence sector organisations (*Cognitive Level: Understand*)
- Apply an exploratory archival research strategy to sector-specific grey literature, identifying relevant primary and secondary sources, and categorizing relevant quantitative and qualitative data associated with Carbon Accounting and climate change mitigation (*Cognitive Level: Apply*)

Results (Chapter 4)

- Use Correlational Research to analyse quantitative and qualitative data related to defence sector Carbon Accounting practices, making inferences and presenting relevant evidence (*Cognitive Level: Analyse*)
- Associate findings from the quantitative and qualitative analysis with information from relevant secondary sources to illustrate pertinent issues in defence sector Carbon Accounting (*Cognitive Level: Analyse*)
- Defend/justify the interdisciplinary approach taken to the academic literature, and exploratory archival research strategy used (*Cognitive Level: Evaluate*)

Discussion (Chapter 5)

- Relate the most relevant themes of defence sector Carbon Accounting that were identified in the Literature Review to the analysis of OCA practices presented in the Results chapter (*Cognitive Level: Evaluate*)
- Generate a set of recommendations for defence sector Carbon Accounting practices that will better support low carbon technology innovation (*Cognitive Level: Create*)

Conclusion (Chapter 6)

- Formulate some recommendations for the wider field of Carbon Accounting that can inform its ongoing development (*Cognitive Level: Create*)

Recommendations for Further Work (Chapter 7)

- Develop some suggestions of specific areas of further work that could effectively build on this exploratory research (*Cognitive Level: Create*)

Section **1.5** that follows below describes the structure of the thesis, and summarises how the objectives above are met throughout the remainder of the document.

1.5 Structure of the Thesis

Where section **1.4** above explained the 'Aims and Objectives of the Thesis', this section provides a more detailed description of the structure of the thesis. It aims to help navigate the reader around the document as a whole, and summarises how the objectives from the previous section are met throughout the remainder of the thesis.

The document follows an orthodox PhD structure, beginning with a Literature Review, followed by Methodology and Results chapters, and then a Discussion chapter that is followed by a Conclusion.

There are several objectives relevant to the Literature Review (chapter **2**) that follows this section. The first simply aims to provide the reader with a broad knowledge of the history and key theories associated with three academic fields that are dealt with in turn: Carbon Accounting (**2.1**); Defence Industrial Policy (**2.2**); and Innovation Studies (**2.3**). Given the emerging nature of the field of Carbon Accounting, particularly as regards sector level research, the supporting literatures of Defence Industrial Policy and Innovation Studies are reviewed to provide essential context to the Carbon Accounting debates discussed.

Section **2.1** identifies three 'themes' of Carbon Accounting that are most relevant to this research, and describes the gaps and areas of immaturity in the existing knowledge. The three 'themes' identified relate to the difficulty of attributing Scope 1 & 2 emissions to individual organisations with methodologies still evolving (**2.1.2**); the lack of mature Scope 3 emissions accounting and 'Project Level' Carbon Accounts related to the value chain despite their acknowledged importance to organisational reporting (**2.1.3**); and the relevance of little-known 'consequential perspectives' for OCAs that are increasingly informing organisational decision making (**2.1.4**).

The third objective for the Literature Review is to convey how the gaps in the Carbon Accounting literature are reinforced by specific aspects of the contemporary defence context. Section **2.2** on Defence Industrial Policy describes how the difficulty of attributing emissions to individual organisations is particularly challenging in the defence sector due to the increasing private sector involvement in nearly all defence tasks, to the extent that defence departments and their supporting industrial base can be highly integrated and difficult to separate for emissions accounting purposes (**2.2.2**). In contrast, 'Project Level' Carbon Accounting methods align well to a sector that is increasingly characterised by a small number of large, high profile international programmes supported by industrial 'teams' comprising multiple companies (**2.2.3**). Similarly, consequential perspectives on Carbon Accounting align well with concepts of 'defence capability' that are gaining traction in a period of defence reform in most western countries (**2.2.4**).

The Literature Review explains how Carbon Accounting can influence technology innovation (**2.3**), most notably in its discursive power to build coalitions of interests that can challenge established ways of working, and existing socio-technical regimes. It characterises the existing calls for defence to support low carbon technology innovation as based on outdated models of innovation (technology push, demand pull), and describes how Carbon Accounting is particularly relevant to more contemporary 'networked' models of innovation.

The final objective for the Literature Review is to convey the relevance of an interdisciplinary approach. The summary section (**2.4**) describes how the supporting literatures are necessary to effectively investigate Carbon Accounting at the sector level, given the way that strengths and weaknesses of existing Carbon Accounting methods can be amplified or reduced in the sector-specific context. Given that the defence sector is widely characterised as a 'technology innovator' in climate change debates, the innovation studies literature is also particularly relevant for reflecting on the purpose of OCA practices in the sector.

The Methodology (chapter **3**) immediately follows the Literature Review. The first objective for this chapter of the thesis is to understand the relevance of an exploratory archival research strategy for analysing Carbon Accounting and climate change information produced by defence sector organisations. The exploratory, inductive approach to the research makes sense given that relatively little is currently known about the subject, but there are increasing quantities of public information being made available by organisations across the world.

The second (related) objective is to apply an exploratory archival strategy, and the different parts of the Methodology explain in detail how relevant primary and secondary sources of data were identified and reviewed for quantitative and qualitative data. A sample of defence organisations was selected for inclusion in the research that included the UK MoD, US DoD, and the ten largest multi-national defence companies globally. The Methodology explains how this sample covered a significant proportion of the defence sector by spend, and allows the analysis to extend across different regions and types of defence company. The chapter describes a rationale for selecting relevant public documents for the organisations in the sample, and a systematic approach to identifying these. With a large selection of relevant documents selected, the Methodology then describes how quantitative datasets were established for GHG and energy data, as well relevant normalising data. Qualitative datasets were also established in relation to energy and climate change keywords used in the documents, and any public targets or ambitions being communicated by them. Secondary sources of defence-energy grey literature are also reviewed to provide some additional context to the data identified in the primary sources from the organisations in the sample.

The Results (chapter **4**) aims to present relevant correlational analysis in relation to the quantitative and qualitative datasets established in the Methodology. Comparisons of the quantitative data show that defence departments currently report the overwhelming majority of the overall emissions from the sector. Where scope 3 data related to the value chain is available it has a significant impact on these quantitative trends, and suggests that 'Project Level' Carbon Accounts could potentially account for a large proportion of the sectors total emissions, complicating the picture as to which organisations in the sample are the most quantitatively significant. By integrating the qualitative data, a connection can be demonstrated between the volume of emissions reported and the level of priority placed on the issue of climate change mitigation, suggesting that the technical accounting issues that drive reported volumes do potentially influence organisational responses to climate change, and therefore are significant.

The second objective for the Results chapter is to associate findings from the quantitative and qualitative analysis with information from relevant secondary sources to illustrate pertinent issues in defence sector Carbon Accounting. The Results chapter describes the emergence of some new 'strategic vectors' of 'resilience' and 'endurance' in the military discourse. The Fully Burdened Cost of Energy (FBCE) is a metric that could be described as a 'consequential approach' to Carbon Accounting that is helping to drive these new strategic vectors into military doctrine and improve decision making in relation to defence energy use. However, the implementation of the FBCE relies on robust 'Project Level' Carbon Accounts and less attributional mind-sets that are discussed in other parts of the thesis.

The final objective for the Results chapter is to defend/justify the interdisciplinary approach taken to the academic literature, and exploratory archival research strategy employed. Despite the lack of relevant precedents in the Carbon Accounting literature, and the evolving nature of existing OCA practices, relevant patterns are identified in the quantitative and qualitative data. When aligned to the secondary sources of defence-energy grey literature, strong trends can be observed that could begin to define some relevant ways forward for OCA practices in the sector, validating the research approach taken.

The Discussion (chapter **5**) aims to bring the preceding chapters of the thesis together in order to comprehensively evaluate OCA practices in the defence sector, and their potential to support low carbon technology innovation. The first objective for the Discussion from section **1.4** ('Aims and Objectives of the Thesis') is to relate the most relevant themes of defence sector Carbon Accounting that are identified in the Literature Review to the analysis of OCA practices presented in the Results chapter. The first of these themes relates to the difficulty of allocating emissions between organisations in existing OCAs, which is likely to be particularly marked in the defence sector due to close working relationships, and may result in abstract OCAs that do not connect effectively to the underlying activities causing emissions to be produced. This is likely to inhibit the extent to which the accounts engage new/relevant actors and support low carbon technology innovation. In contrast, the second theme running through the thesis relates to the potential for 'Project Level' Carbon Accounts focused on large-scale collaborative programmes, to better account for the emissions of the defence sector in a way that engages new/relevant actors to defence-energy debates. These accounts are therefore more likely than existing OCAs to support low carbon technology innovation. However, 'Project Level' Carbon Accounts cannot work effectively in isolation, which leads onto the third theme running through this thesis related to the potential for 'consequential carbon accounting' perspectives to align with concepts of 'defence capability', in order to inform wider strategic narratives that help construct a positive selection environment for low carbon technologies in the defence sector.

The other objective for the Discussion is to generate a set of recommendations for OCA practices in the defence sector that will better support low carbon technology innovation. The research concludes that if OCA practices in the defence sector are to effectively support low carbon technology innovation, then existing practices need to change; 'Project Level' Carbon Accounts need to be developed; and these need to be presented within an appropriate strategic framework. Existing OCA practices focused on attributing Scope 1 & 2 to individual organisations do have a legitimate role in the Carbon Accounting landscape, given their usefulness for policymakers and civil society across all sectors. However, for defence sector organisations these accounts should be seen as a means to a regulatory end, and any spare capacity should be focused on producing collaborative ‘Project Level’ Carbon Accounts that are more likely to widen participation in energy and climate change debates in the defence sector. Given that technology innovation is seen as the most valuable contribution that the defence sector can make to climate change mitigation, these ‘Project Level’ Carbon Accounts – by widening participation – are more likely to support the building of relevant ‘discourse coalitions’ that can challenge incumbent interests in the sector and encourage technology innovation. Finally, this research recommends that OCA practices in the defence sector need to be very conscious of the interplay between ‘Project Level’ Carbon Accounts and relevant strategic narratives. Alone, both the ‘Project-Level’ Carbon Accounts discussed in the second theme of this thesis and ‘system-level’ perspectives discussed in the third theme, are limited in the change that they can achieve. However, together they can have a transformative impact on the way that the sector views energy use and GHG emissions, and begin to construct a strong selection environment for low carbon technologies that effect positive change at the system level.

The Conclusion (chapter **6**) summarises the thesis as a whole and re-iterates how the objectives described in section **1.4** have been met. It also responds to another objective to “Formulate some recommendations for the wider field of Carbon Accounting that can inform its ongoing development”.

It emphasises the value of the ‘sector-level’ perspective on Carbon Accounting, examples of which are rare in the literature at present. The perspective proves particularly useful in this research for identifying relevant Carbon Accounting methods from other fields of practice that can improve ‘Organisational’ Carbon Accounting (OCA) specifically. The sector-level perspective is particularly relevant, as the strengths and weakness of different methods can be amplified by the sector-specific context. For example, this research shows that existing OCA practices focused on attributing scope 1 & 2 emissions to individual organisations do not align well to contemporary trends in the defence sector, but ‘Project-Level’ methodologies have considerable potential.

Perhaps more significantly, amidst calls for the field to become more radical and ambitious with its research questions in the context of an imminent environmental disaster (e.g. Thomson, 2014), the sector-level perspective is particularly useful for critically analysing existing practices and future trajectories. This research argues that ‘sector-level’ perspectives need to inform the Carbon Accounting literature as it develops, and these will inevitably drive the field to become more interdisciplinary. Just as it has been necessary to engage with the Defence Industrial Policy and Innovation Studies in this research, other sector-level studies will require engagement with other literatures relevant to the sector in question. The choice of relevant supporting literatures needs to be based on an understanding of the most effective contribution the sector in question is likely to make to the challenge of mitigating climate change, and an exploratory, inductive approach to the research can help ground the investigation in its unique context.

The thesis ends with a final chapter (**7**) that provides some ‘Recommendations for Further Work’, that would be beneficial to investigate but are beyond the scope of this research. It is often considered that exploratory research approaches in under-developed academic fields can be most valuable in the basis they create for further investigation, and chapter **7** responds by describing two areas related to Carbon

Accounting in the defence sector where further research could be particularly beneficial.

2) Literature Review

The introduction has explained the exploratory, inductive approach to this research, as it is a field where the academic literature and professional practices are still evolving. Just as this approach informs the research methods used that are described in chapter **3** (Methodology), it also informs the approach to the academic literature. Sector-level studies of Carbon Accounting are rare in the literature at present, and as such an exploratory approach has been applied that has reviewed three separate academic fields that are all relevant to this research.

The focus of this research is Carbon Accounting, which is comprehensively reviewed in section **2.1**, identifying several 'themes' which are particularly relevant for this study. The other two literatures reviewed represent 'supporting literatures'. Section **2.2** on Defence Industrial Policy grounds the research in its sector-specific context, and shows how the relevant 'themes' of Carbon Accounting can be significantly affected by characteristics unique to the defence sector. Section **2.3** reviews the Innovation Studies literature, which allows the research to engage with the way that the sector is currently characterised as a 'technology innovator' in climate change debates, and respond to the title question that is concerned with how OCA practices can best support low carbon technology innovation.

Section **1.4** introduced the 'Aims and Objectives of the Thesis', which are categorized into the different cognitive levels that they address according to Blooms Taxonomy (Andersen, LW et al., 2001). Bloom's Taxonomy is designed as a hierarchy or pyramid, where each subsequent cognitive level builds upon the last. Therefore, the Literature Review inevitably focuses on the lower cognitive levels at the base of the pyramid ('Knowledge' / 'Understand'), but these provide the essential context for the later stages of the thesis.

The objectives specific to the Literature Review were as follows:

The first simply aims to provide the reader with a broad knowledge of the history and key theories associated with three academic fields that are dealt with in turn across this chapter: Carbon Accounting (**2.1**); Defence Industrial Policy (**2.2**); and Innovation Studies (**2.3**).

The second objective is to describe the areas of immaturity in the existing knowledge of Carbon Accounting that are relevant to this research. The Organisational Carbon Accounting section of the Literature Review (**2.1**) provides an overview of the field before breaking it down into three 'themes' relevant to this research, each of which include areas where there is scope for further research. The first of these 'themes' relates to the difficulty of attributing Scope 1 & 2 emissions to individual organisations, in a context of ongoing efforts to standardise emissions accounting methodologies (**2.1.2**). The second 'theme' relates to the lack of mature Scope 3 emissions accounting and 'Project Level' Carbon Accounts related to the value chain despite their acknowledged importance to organisational reporting (**2.1.3**). The third focuses on the relevance of little-known 'consequential perspectives' for OCA practices that are increasingly informing organisation decision making (**2.1.4**).

The third objective for the Literature Review is to convey how the gaps in the Carbon Accounting literature are reinforced by specific aspects of the contemporary defence context.

Section **2.2** on Defence Industrial Policy describes how the difficulty of attributing emissions to individual organisations is particularly challenging in the defence sector due to the increasing private sector involvement in nearly all defence tasks, to the extent that defence departments and their supporting industrial base can be highly integrated and difficult to separate for emissions accounting purposes (**2.2.2**). In contrast, 'Project Level' Carbon Accounting methods align well to a sector that is increasingly characterised by a small number of large, high profile international programmes supported by industrial 'teams' comprising multiple companies (**2.2.3**). Similarly, consequential perspectives on Carbon Accounting align well with concepts of 'defence capability' that are gaining traction in a period of defence reform in most western countries (**2.2.4**).

The fourth objective for Literature Review is to explain how Carbon Accounting can influence technology innovation and the implications for existing defence sector approaches to low carbon technology innovation. Section **2.3** is focused on the Innovation Studies literature and addresses this objective, explaining the discursive power that Carbon Accounting has to build coalitions of interests that can challenge established ways of working, and existing socio-technical regimes. It characterises the existing calls for defence to support low carbon technology innovation as based on outdated models of innovation (technology push, demand pull), and describes how Carbon Accounting is particularly relevant to more contemporary 'networked' models of innovation.

The final objective for the Literature Review is to convey the relevance of an interdisciplinary approach. The summary section (**2.4**) describes how the supporting literatures are necessary to effectively investigate Carbon Accounting at the sector level, given the way that strengths and weaknesses of existing Carbon Accounting methods can be amplified or reduced in the sector-specific context. Given that the defence sector is widely characterised as a 'technology innovator' in climate change debates, the innovation studies literature is also particularly relevant for reflecting on the purpose of OCA practices in the sector. The summary section (**2.4**) also provides a link to the Methodology and Results chapters that follow, explaining how the exploratory approach to the academic literature is central to the research methods applied across the investigation as a whole. It also explains how the relevant themes identified in the literature are taken through to the Methodology and Results chapters.

2.1 Organisational Carbon Accounting (OCA)

This first section of the Literature Review provides an overview of the Carbon Accounting field before breaking it down into three 'themes' relevant to this research, each of which include areas where there is scope for further research. The first of these 'themes' relates to the difficulty of attributing Scope 1 & 2 emissions to individual organisations, in a context of ongoing efforts to standardise emissions accounting methodologies (**2.1.2**). The second 'theme' relates to the lack of mature Scope 3 emissions accounting and 'Project Level' Carbon Accounts related to the value chain despite their acknowledged importance to organisational reporting (**2.1.3**). The third focuses on the relevance of little-known 'consequential perspectives' for OCA practices that are increasingly informing organisation decision making (**2.1.4**).

2.1.1 Overview of the Carbon Accounting Literature

Bebbington and Larrinaga (2014) describe the Carbon Accounting field as an emerging body of literature that 'links concerns from the science and policy world with respect to concentrations of greenhouse gases in the atmosphere with management and accounting practices' (p.199).

Similarly, Bellassen & Cochran (2016) emphasise the importance of the connection with climate change science and policy, identifying this as one of the field's strengths:

> 'the monitoring, reporting and verification (MRV) of greenhouse gas emissions [is] all the more crucial, as the only concrete link between the physical world and…large but intangible markets and mandates…[it] stands as one of the few solid pillars of climate action. Indeed, the need for MRV is a common feature of all the possible future carbon pricing mechanisms, be they carbon taxes, cap-and-trade systems, environmental labelling or carbon footprint disclosure' (p.3)

This connection to climate change governance is also relevant for the close connections between the academic and grey literature on this topic. The relatively slowly emerging academic literature on Carbon Accounting is in contrast with the plethora of grey literature that has emerged on the topic over the last 10-20 years, associated with various carbon reduction schemes/initiatives that have been established at various governance levels across the world. Indeed, Bellassen & Stephan's (2016) recently published volume on Carbon Accounting presents itself as the first comprehensive summary of the topic, and is structured around a summary of the 15 most influential schemes put in place around the world, and their associated grey literature, as opposed to any structured approach to the existing academic literature.

Bebbington and Larrinaga (2014) describe how the 'policymaking architecture is a live experiment' (p.207), referring to the various schemes as 'natural laboratories' (p.206) where an extensive and dynamic set of activities is taking place.

Despite the emerging nature of the Carbon Accounting literature, some common organising principles do exist around different scales or categories of Carbon Accounting. Whilst some authors organise the Carbon Accounting literature around functional areas or similarly the management cycle (Glienke & Guenther, 2016), the topic is most commonly categorised according to the governance scale in question.

The following three Carbon Accounting scales are taken from Bellassen & Stephan (2016), but similar categorisations are used by other authors (e.g. Harangozo, Szechy & Zilahy, 2015; Gibassier, 2015):

- Territorial / Jurisdictional Areas;
- Industrial Sites and Entities;
- (Offset) Projects.

Each are briefly described below with their most relevant example schemes, as is their influence on OCA specifically, which is the focus of this research.

The most significant Carbon Accounting scheme at the **territorial scale** relates to the National GHG inventories associated with the UN Framework Convention on Climate Change or UNFCCC (United Nations, 1992), but this scale would also include various schemes and initiatives focused on specific regions or cities. Chang & Bellassen (2016) confirm that the national inventories associated with the UNFCCC are the 'longest standing implementation of monitoring, reporting and verifying GHG emissions' (p.21). Bulkeley & Newell (2010) provide a useful review of all of the relevant initiatives associated with the UNFCCC and Kyoto Protocol, and Chang & Bellassen (2016) provide a thorough description of the Carbon Accounting practices that support them.

They are significant for OCA due to some of the wider philosophical perspectives that they have helped establish. For example, they encourage reporting of emissions based on production, rather than consumption, and establish a flexible framework for Carbon Accounting that refers to various principles that must apply in each case. Both of these traits recur in the Carbon Accounting at other reporting scales, and are particularly relevant to the way that organisations account for their emissions.

The second Carbon Accounting scale listed above is very relevant to OCA practices, as schemes designed around **industrial sites and legal entities** will inevitably impact the reporting of the larger organisation to which they belong. For organisations, there are significant interactions between these different types of reporting, as organisational totals are often aggregated from site-level data, and legal entities often correspond to major operational regions. However, the rules of specific schemes and organisational reporting systems often don't align across these, meaning that organisations can sometimes be subject to a number of reporting drivers that require different Carbon Accounting practices – particularly large multinationals.

Perhaps the most influential example of a Carbon Accounting practice aimed at individual industrial sites would be the EU ETS, which includes any site that generates more than 20MW of power from fossil fuels. It operates on a cap-and-trade basis and is linked to the Kyoto Protocol mentioned above at the national level, highlighting the way that Carbon Accounting mechanisms can interact across all of these levels. The successes and failures of the different stages of the EU ETS have been comprehensively reviewed in the academic literature (Bulkeley & Newell, 2010; Jacquier & Bellassen, 2016), and other similar schemes have since been set up in California (Afriat & Alberola, 2016) and China (Chiquet, 2016). It should be noted that whilst the EU ETS is the most influential example, these 'industrial-entity' schemes are not always mandatory or constructed on a 'cap-and-trade' basis, for example the UK's Climate Change Agreements (Environment Agency, 2016) which allow industrial sites a discount on their energy bills if they meet agreed emissions reduction targets.

Carbon Accounting practices aimed at 'legal entities' are less common, and are usually responding to nation-specific schemes or initiatives that are aimed at an organisation's 'UK Operations' for example. France and the UK are the best examples of where these types of scheme have been introduced, with Article 75 of the Grenelle package in the case of France (Morel & Cochran, 2016), and the Carbon Reduction Commitment (CRC) in the case of the UK (Environment Agency, 2015). These types of scheme have been quite critically received due to the fact that the legal entity distinction is not 'adapted to the design and implementation of an action plan at the business unit level: several business units may be represented in the same legal entity while at the same time each business unit is active across several legal entities' (Morel & Cochran, 2016: p306).

In addition to these industrial site, and 'legal entity' focused practices, there are also schemes and initiatives that require organisations to account for their emissions across all of their operations. Some are mandatory, as in the case of France's Article 225 of the Grenelle II legislative package (Morel & Cochran, 2016), or the UK's 2013 amendment to the Companies Act (Companies Act, 2006) that requires large organisations to publish their operational emissions in their annual report. Others are voluntary, such as the CDP Climate Change questionnaire (CDP, 2017 and Appendix B), which asks organisations to report on the emissions associated with their entire operations. All tend to allow more flexibility in how emissions are reported than in relation to the site / entity-level schemes.

The types of initiative included at this reporting scale are most relevant to this research, given that most large defence sector organisations will be subject to several of the Carbon Accounting practices described above, whether relevant to their industrial sites, regional legal entities, or their entire operations.

The third common reporting scale by which to categorise Carbon Accounting practices relates to **individual (offset) projects**. There are a number of example schemes at this scale but the most well-established is the Clean Development Mechanism (CDM), that is again linked to the Kyoto Protocol and allows the emissions from specific 'projects' to be offset from national or organisational accounts. Shishlov (2016) describes how 'with over 6,500 registered projects and over 1.3bn tCO_2e of GHG emissions reduced in developing countries as of June 2013, the CDM is the largest carbon offset scheme in the world' (p.341). Again, much has been written about the successes and failures of the CDM (Bulkeley & Newell, 2010), and the technical Carbon Accounting practices that underpin it (Shishlov, 2016). However, this is a very broad category of Carbon Accounting, and indeed any individual business case for a low carbon intervention (that can vary enormously in practice) could be considered as a 'Project Level' Carbon Account. However, the methodologies used and governance structures around these projects can vary from the elaborate processes set up to manage CDM projects, to a simple excel spreadsheet within a facilities department.

Perspectives from the Life Cycle Assessment literature are very relevant to this type of ‘Project Level’ Carbon Accounting, and the practices often benefit from a strong link to organisational decision making due to their focus on justifying (or not) the investment in a specific project that will have a positive impact on emissions reduction.

Perhaps the most important point to make in relation to the summary of Carbon Accounting at the different scales described above, is the significant interplay between the ‘reporting scales’.

For example, Bebbington & Larrinaga (2014) describe how territorial/jurisdictional approaches can have an impact on the wider Carbon Accounting activity in a given region at lower levels (p.203). Similarly, site, entity or organisational Carbon Accounting can often be a response to regulation or initiatives articulated at a territorial scale. Likewise, ‘Project Level’ Carbon Accounts can be integral to building up useful corporate inventories.

This potential for learning between the reporting scales is highlighted in the academic literature on Carbon Accounting, with Brander & Ascui (2015) noting that:

> ‘methods of carbon accounting…have developed in a number of semi-isolated fields of practice, such as national inventory accounting, corporate carbon accounting, project level accounting, and product life cycle assessment, and there appears to be considerable potential for learning across these different fields’ (p.100)

There is also optimism about what can be achieved if these different ‘semi-isolated fields of practice’ can be brought together, given the weight of empirical activity happening in the Carbon Accounting field, as Bebbington & Larrinaga (2014) summarise:

> ‘this is an area…where there will be no shortage of empirical sites around which investigations might emerge. Likewise, it is possible that this area might provide a bridge between social and environmental accountants and the mainstream of accounting theorizing as well as being a site upon which insights from a whole variety of related disciplines might be brought together. The practice, policy and intellectual ramifications of the global climate change agenda and accounting for carbon, we would suggest, are only just starting to be realised.’ (p.208)

This research is very interested in the potential for improving existing OCA methods by integrating practices from other areas of the Carbon Accounting field. Whilst the next section (**2.1.2**) focuses in detail on existing OCA methods, the subsequent sections discuss relevant parts of the wider field that have the potential to improve how organisations within the defence sector account for their emissions.

2.1.2 Organisational Carbon Accounts (OCA) and their Limitations

As articulated above, Organisational Carbon Accounting (OCA) can cover a broad range of Carbon Accounting schemes and initiatives, relevant to industrial sites, individual legal entities, or regional groupings of legal entities, and these tend to require multiple (often unaligned) Carbon Accounting approaches from large organisations (Morel & Cochran, 2016).

However, the Carbon Accounting data that appears in most Sustainability Reports or on websites, and aimed at a wide-set of stakeholders tends to represent a broad Organisational Carbon Account (OCA), in which organisations strive to report as many of their relevant GHG emissions as possible, for as much of their operational activity as possible, wherever in the world those activities are taking place. Given the focus of this research on large multi-national defence organisations and their public Carbon Accounting practices, it is this type of accounting that is of most interest to this research. OCA is discussed in depth in this section, which notes the difficulty of assigning emissions to individual organisations in a pragmatic and comparable way, yet which still retains a clear and relevant link to the 'emissions producing activities' that underpin those accounts.

The CDP Climate Change Questionnaire (CDP, 2017 and Appendix B) is arguably the most influential global, voluntary initiative that is encouraging organisations to disclose their organisational emissions. Given its global emphasis, and the fact that it is focused on large, multinational companies, it has strong relevance to the broad type of OCA described immediately above, as it is not focused on specific regions, legal entities, or sites. Given its broad remit, it allows organisations flexibility in how they account for carbon, but it does recommend use of the World Resources Institute's GHG Protocol Corporate Standard (WRI, 2004), and the majority of large, global organisations tend to use this standard to produce their OCAs, whether for CDP or other external outlets. Bebbington & Larrinaga (2014) confirm that 'of the various investor led reporting regimes the Carbon Disclosure Project (CDP) is the one that has attracted the most attention and which has the most substantive impact on reporting practices [of companies]' (p.205). CDP built on the fact that numerous companies have been actively trying to calculate and communicate their GHG emissions for a number of years since the early 2000s, and by gathering a large investor mandate (representing trillions of dollars in assets), have requested that increasing numbers of companies provide the data to investors via their reporting platform. CDP analyse the company responses and score them based on 'disclosure' (how fully they have completed the questionnaire), and 'performance' (based on the quality of disclosure and how well the company is deemed to be managing their climate change impacts).

Take-up of the CDP Climate Change questionnaire (CDP, 2017 and Appendix B) is significant. In 2016, some 5,800 companies responded to its survey, representing close to 60% of global market capitalization (CDP, 2016c), and there is a set of academic literature emerging around CDP (e.g. Matisoff, Noonan & O'Brien, 2013; Eun-Hee & Lyon, 2011; Andromidas, 2013; Luo, Lan & Tang, 2012), although Bebbington & Larrinaga (2014) confirm that 'initiatives in this area are still evolving' (p.205) and the academic literature focused on CDP is certainly not as well established as that described above as emerging around the GRI framework.

CDP is not prescriptive over the perimeter or method that a company uses to report its GHGs but does recommend the GHG Protocol Corporate Standard for scopes 1 and 2 emissions (WRI, 2004), and the WRI's Corporate Value Chain (Scope 3) Accounting and Reporting Standard for Scope 3 emissions (WRI, 2011). It has supported the GHG Protocol Corporate Standard in becoming the most common standard that companies will use for reporting emissions, with Morel & Cochran (2016) confirming that although there are numerous explicit and implicit GHG reporting standards that apply to companies across different jurisdictions, there is convergence in reporting approaches for scope 1 and 2 emissions (even if the same can't be said for scope 3).

> 'at the international level, the GHG Protocol is perceived as the reference for GHG quantification – explicitly identified as the recommended methodology to use by the CDP. While no official guidelines are in place, increasingly the use of other methodologies is seen to deviate from common practice' (Morel & Cochran, 2016: p.299)

Importantly, the GHG Protocol has popularised the method of Carbon Accounting across three broad categories or 'Scopes', and these are now commonly referred to across the vast majority of Carbon Accounting methodologies in most regions and for most schemes or initiatives. Scopes 1, 2, and 3 are described as follows in the GHG Protocol (WRI, 2004):

- 'Scope 1 emissions occur from sources owned or controlled by the organisation (e.g. emissions from combustion or in owned or controlled boilers, furnaces, vehicles, etc.)
- Scope 2 accounts for GHG emissions from the generation of purchased electricity consumed by the organisation, but physically occur at the facility where electricity is generated
- Scope 3 allows for the treatment of all other indirect emissions. They are a consequence of the activities of the organisation, but occur from sources it does not own or control. Some examples of scope 3 activities are extraction and production of purchased materials; and use of sold products and services' (p.25)

Alongside these 'Scopes' of Carbon Accounting, the GHG Protocol has also popularised the following principles for generating GHG inventories (WRI, 2004)[5]:

- 'Relevance – ensure the GHG inventory appropriately reflects the organisation
- Completeness – report on all sources within the chosen GHG inventory boundary and justify exclusions
- Consistency – use consistent methodologies to allow for comparisons over time
- Transparency – address issues in a factual and coherent manner, explaining assumptions and using appropriate references
- Accuracy – ensuring that uncertainty is reduced as far as practicable' (p.7)

These are fundamental concepts that underpin most Carbon Accounting methodologies, and therefore the GHG Protocol does provide additional information and several methods by which to create an OCA.

[5] These 'principles' are reiterated in the guidance published for National GHG Inevtories (Chang & Bellassen, 2016), and CDM projects (Shishlov, 2016), and various other Carbon Accounting guidance documents in the grey literature (e.g. DEFRA, 2013)

The GHG Protocol (WRI, 2004: p.17) offers three broad methods for setting organizational boundaries that are summarised as follows:

- Equity Share Approach - Under the equity share approach, a company accounts for GHG emissions from operations according to its share of equity in the operation. The equity share reflects economic interest, which is the extent of rights a company has to the risks and rewards flowing from an operation
- Control Approach – Under the control approach, a company accounts for 100 percent of the GHG emissions from operations over which it has control
  - Financial control - The company has financial control over the operation if the former has the ability to direct the financial and operating policies of the latter with a view to gaining economic benefits from its activities
  - Operational control - A company has operational control over an operation if the former or one of its subsidiaries…has the full authority to introduce and implement its operating policies at the operation

The GHG Protocol confirms that both of the 'control' approaches above are likely to produce similar results in practice (WRI, 2004: p.17), however one can see the level of interpretation open to the statements above. The GHG Protocol does provide some explanatory guidance but it is fairly limited.

The Carbon Accounting literature discusses the potential variability of interpretation of the GHG Protocol, and by extension the potential variability of associated OCA methods. Schaltegger et al (2015) describe how 'the allocation of emissions…to scopes is a tricky issue and depends on how corporate boundaries are defined and may also depend on whether the company applies a financial control or an operational control approach' (p.11). Gibassier (2015) suggests that there are significantly different processes involved in producing a GHG inventory under the different methods available in the GHG Protocol, describing how:

> 'the GHG Protocol Corporate Standard is closely linked to the responsibility framework from financial accounting and the boundaries are based on equity or financial control. One last possibility is to base results on operational control, which is the most difficult to implement as it is very different from existing data collection systems based on traditional financial accounting' (p.124)

Whilst it is certainly true that in practice the different GHG Protocol methodologies can rely on very different data collection systems, the relative popularity of the different methods is open to dispute. Table 1 in Appendix A shows a survey of the emissions boundaries reported in the 2014 CDP Academic Dataset[6]. It underlines the pre-eminence of the GHG Protocol (96% of respondents refer to one of the three GHG Protocol boundary methods), but also shows a clear preference for the 'Operational Control Method' above the others.

This holds true for the Aerospace and Defence sector. Table 2 in Appendix A is discussed in more depth in the Methodology chapter (see **3.4.1** 'Establishing the Quantitative Dataset'), but shows the GHG accounting methodologies used by a range of defence sector companies, and the prevalence of the GHG Protocol's Operational Control method.

[6] See Methodology section **3.4** for more information on this dataset, which was purchased by UCLan for use in this research

Morel & Cochran (2016) summarise the variability of reporting that could be associated with this 'high-level' guidance under the GHG Protocol, in contrast with the reporting 'rules' associated with a scheme with market-implications like the EU ETS:

> 'as opposed to the exhaustive and directive Monitoring and Reporting Regulation attached to the EU ETS, the GHG protocol provides only limited guidance for specific sources and industries…it is up to each corporation to interpret and adapt the guidelines to the available data, reporting perimeter etc. As such the reported emissions…may significantly differ from same-sector companies following the availability of data, technical choices made and the willingness to disclose what could be perceived as sensitive information' (p.299)

The same authors explain that some companies have clearly identified this as an issue with the CDP Climate Change Questionnaire:

> 'It is important to note that a number of companies have expressed complaints about the CDP ranking process, particularly given the insufficient standardization of monitoring and reporting across competitors' (p.304)

However, when comparing reporting approaches for CDP to those in mandatory market-based schemes like the ETS, the most significant difference arguably concerns the 'verification' process, as Morel & Cochran (2016) explain:

> 'verification is focused on procedures rather than on the accuracy or comparability of the reported figures. As such…CDP verification is very different from verification [for other schemes]' (p.293)

Indeed, it is generally completed by the existing financial auditor as opposed to specialists, and is more focused on 'fairness' of reporting and transparency than actual comparability. This is a key conceptual difference in the approach to Carbon Accounting verification for companies, and Morel & Cochran (2016) summarise the implications:

> 'it should… be noted that even if verification has occurred, this does not ensure that companies in similar market segments are using similar reporting perimeters' (p.293)

Having identified the potential variability in interpretation of the GHG Protocol, and by extension the potential lack of comparability in the OCAs produced, there is an ongoing drive to better standardise OCA practices in a way that makes them useful to external audiences.

Bebbington and Larrinaga (2014) confirm that across myriad reporting practices by organisations at all levels, there is:

> 'a common problem identified in the literature [concerning] the tensions between accuracy, consistency and certainty, with reporting regimes yet to mature in terms of how to measure and report carbon in a way that is likely to be useful to stakeholders' (p.205)

Regional guidance for producing OCAs doesn't always need to be seen in competition with the GHG Protocol, and indeed can sometimes be read as an elaboration of it, attempting to standardise approaches within different jurisdictions (e.g. DEFRA, 2013). Similarly, NGOs such as the Climate Disclosure Standards Board have brought out guidance that again attempts to elaborate on the GHG Protocol and make OCA (and broader climate change reporting) practices more standardised and comparable (CDSB, 2015).

There is also a drive to standardise approaches within specific sectors. The GHG Protocol acknowledges that sectors will differ in the extent to which they may have issues of comparability using the standard. The GHG Protocol refers directly (WRI, 2004: p.17) to guidance from the International Petroleum Industry Environmental Conservation Association (IPIECA, 2003) that provides standardised guidance for organisations in the Oil and Gas industry in relation to how they should interpret the GHG Protocol and report their GHG emissions, conceding that the sector is likely to display significant differences in reported volumes without applying this supplementary guidance due to the complexity of its operational structures and activities. King refers to sector complexity as one of the key determinants of the cost of producing credible Carbon Accounts (King, Pye & Davison, 2010), and IPIECA are not alone in producing extended guidance for their sector that elaborates on the guidance from the GHG Protocol. The International Aerospace Environment Group (IAEG) – a self-governing trade association formed by several organisations in the Aerospace sector, has produced similar guidance (endorsed by the WRI and the GHG Protocol) for the Aerospace industry, acknowledging the need for more specific guidance on Carbon Accounting to resolve the complexities of producing these accounts in the sector (IAEG, 2016).

One of the challenges with this drive towards standardisation is to produce guidance (whether by DEFRA, CDSB, IPECA or IAEG) that encourages comparability but does not create significant barriers to entry for organisations wishing to produce OCAs (e.g. by making it too laborious or costly for organisations to apply). Bellassen et al. (2016) identify 'cost vs uncertainty' as a 'trade-off' that is common to all Carbon Accounting schemes, and provide a useful assessment of the costs associated with different Carbon Accounting schemes. The authors identify a difference in approach to this trade-off across different types of scheme. At one end of the spectrum, company reporting tends to be lower cost and more uncertain, owing to the often 'voluntary' nature of their inventories, and their less direct aims to inform a wide-set of stakeholders of their impacts. In contrast, schemes that relate to traded carbon allowances and with a more direct impact on certain financial sector actors (e.g. the EU ETS) tend to have more stringent accuracy requirements and associated higher costs to monitor, report and verify. The authors reiterate the findings from Morel & Cochran (2016) in distinguishing between 'fairness' of reporting and 'accuracy' of reporting, with the lower financial-stakes methods often more concerned with the former than the latter, and more concerned with issues of 'transparency' than 'accuracy'.

Schaltegger et al (2015) summarise the broader challenge that Bellassen identifies empirically:

> 'accuracy requires that reported information is sufficiently precise, representative and detailed for users to assess the organization's performance. The characteristics that determine accuracy vary according to the nature of information and the user. This complicates the management of accuracy in climate accounting, firstly, because of the complexity and the invariable needed value assessments of information creation, and secondly, because of the differences between the information requirements of users' (p.20)

Another trade-off identified by Bellassen et al (2016) is that as Carbon Accounts become more standardised or comparable (in a pragmatic and relatively low-cost way), they also become less 'relevant'. The authors articulate this as a challenge for all Carbon Accounting initiatives, and this research contends that this issue is particularly marked in relation to the OCAs of large organisations, where organisational totals (often aggregated many times from site level), can become fairly remote from the underlying emissions-producing activities that underpin them.

For example, the IAEG guidance for GHG Accounting in the Aerospace sector pragmatically advises that reporting aligns with 'energy measurement' points for static infrastructure, focusing on the main utility meters from which a site is billed in order to determine the data that it is reported by an individual organisation[7]. More recent legislative initiatives in the UK have also focused on the points where utilities are billed in order to determine reported volumes, with the simplified version of the UK's Carbon Reduction Commitment (CRC) scheme (Environment Agency, 2015) requiring companies to report their billed volumes of electricity and gas that have been delivered to the site.

These pragmatic approaches allow for comparable approaches between organisations, but have the potential to simplify the broad definition of 'operational control' above to the extent that the emissions from a large and complex site can be allocated in a fairly binary way to one organisation or another. Thus, the relevance of the resulting OCAs may be reduced as the reported total does not reflect the different organisations active on the site and their related emissions producing activities.

The 'Relevance vs Comparability' trade-off is noted across a lot of the Carbon Accounting literature and particularly in relation to the sustainability reports in which OCAs commonly appear. Keeble et al (2003) summarise how the need for organizations to produce a relevant report needs to be balanced by the use of prescribed methodologies:

> 'indicators should reflect the business realities, values and culture of the organization, and as such their development should not be constrained to prescribed methodologies or standards... [But] internationally recognised standards can play a role in informing the development of appropriate indicators.' (p. 151)

Bellassen et al (2016) conclude in the case of Carbon Accounting, that 'comparability often trumps relevance' (p.533). As efforts continue to make Carbon Accounting more standardised (and particularly if doing so while keeping costs low), it is a legitimate concern that these 'more comparable' accounts, could become less relevant still, as pragmatic means are used to allocate emissions between organisations that may not be representative of the underlying organisational activities that produce the emissions.

Morel & Cochran (2016) make the point explicit, suggesting 'frameworks that require reporting that does not match the operational realities of the company…decrease the usefulness of the regulation for reporting companies' (p.310).

[7] 'In short, companies shall report GHG emissions for all leased buildings for which the company directly pays the utility bills. In the event that the utility bills are a part of the rent and not independently available, an estimation of GHG emissions shall be derived consistent with the guidance identified in The Corporate Standard. Where utility data is directly available, the company shall report them.' (IAEG, 2016: p4)

The next section builds on these challenges to the ‘relevance’ of existing OCAs, by not only questioning the limitations of standardising methodologies, but also the scope of emissions that are being covered by existing accounts.

2.1.3 Scope 3 Emissions Inventories and the Relevance of 'Project Level' Carbon Accounts

The previous section challenged the 'relevance' of existing OCAs as they become more standardised, limiting their usefulness to the organisations reporting them.

There is another challenge to their 'relevance' in relation to the types of emissions that are included in OCAs, which often do not include emissions categories over which the organisation does not have full control. These types of emissions are described as Scope 3 emissions in the Carbon Accounting literature. This section discusses the state of Scope 3 emissions reporting, and explains how 'Project Level' Carbon Accounting techniques could be particularly useful in building up relevant Scope 3 inventories.

The CDP 2013 Global 500 Climate Change Report (CDP, 2013) confirms that 'current reporting of indirect scope 3 emissions does not reveal the full impact of companies' value chain' (p.7), and explains that 'only 25% of companies report emissions data for 'use of sold products' however, it is estimated that this represents up to 76% of scope 3 emissions' (p.9). Conversely, 72% of companies report business travel related emissions accounting for only an estimated 0.2% of total reported scope 3 emissions (p.9). This is no doubt linked to the availability of data and ease of categorising certain elements of scope 3 accounting over others for companies. CDP are certainly not alone in making this point, with numerous sources in the academic literature echoing the importance of scope 3 emissions to any realistic assessment of OCA (e.g. Huang, Weber & Matthews, 2009; Matthews, Hendrickson & Weber, 2008; Rosenblum, Horvath & Hendrickson, 2000). Schaltegger et al (2015) summarise these views:

> 'significant carbon mitigation strategies cannot be revealed if scope 3 emissions are neglected…The climate change impact of downstream industries, e.g. service industries, can be as big as the impact of manufacturing sectors, if indirect impacts are accounted for.' (p.11)

Morel & Cochran (2016) also emphasise the fundamental importance of Scope 3 emissions to credible OCA, but mention the lack of appropriate methodologies as a limiting factor:

> 'scope 3 emissions can represent the lion's share of emissions and cannot be ignored…however, due to more complex calculations and data needs, standardization of scope 3 emissions quantification approaches is ongoing' (p.310)

Bellassen et al (2016) confirm that:

> "for scope 3 – upstream and downstream emissions…company-level footprints remain very heterogeneous" (p.533)

Despite the existence of the GHG Protocol's Scope 3 Guidance (WRI, 2011), Morel & Cochran (2016) make clear that it is this area of Carbon Accounting where comparisons between organisations can be least instructive or indicative of performance, due to the limited amount of reporting, and the variability of sources and methods used where reporting does exist:

‘the methodologies used for scope 3 emissions are more complex and less standardised than methodologies on scopes 1 and 2. As such, a company going beyond current sector practice in terms of reporting scope 3 emissions would potentially be compared with companies reporting only a little more than emissions from scopes 1 and 2. Thus they could be seen in a negative light.’ (p.304)

Some examples do exist where sectors join together to agree a common approach to Scope 3 Carbon Accounting, facilitating effective comparison, with Morel & Cochran (2016) explaining the approach taken by the banking sector, but these are rare.

The wider challenge with scope 3 accounting relates to common definitions of organizational boundaries, as Harangozo Szechy & Zilahy (2016) describe:

‘beyond the general consensus that indirect impacts should be included in footprint calculations, the precise setting of the boundaries of the analysis remains a key issue. For example, upstream impacts are considered more often, while there is a greater variation regarding the inclusion of downstream impacts. Another open question is whether personal impacts generated by internal stakeholders (employees, managers, owners etc.) should be included in corporate footprint accounts…furthermore the practical difficulty of assessment of the indirect impacts concerning methodology and data requirements often leads to the omission of these impacts.’ (p.66)

…The most important future challenge is the definition of organizational boundaries.’ (p.67)

Matthews, Hendrickson & Weber (2008) complain that the Scope 3 criteria at present are far too vaguely defined, and offer a potential step forward in this area by introducing a ‘Scope 4’ in order to tighten definitions in this area. Scope 3 would then be reserved for indirect emissions for production, and the new Scope 4 used for indirect emissions that directly relate to the product lifecycle.

The introduction of a ‘scope 4’ may begin to break down the challenge of Carbon Accounting for companies, allowing them to use alternative methods for each and prioritise more material categories of emissions. The challenges of compiling these different types of scope 3 inventory are likely to be quite different in each case, and draw on different methodologies for estimating emissions. Two such methodological approaches that relate well to each of the ‘Scope 3’ and ‘Scope 4’ categories described above are ‘hybrid accounting’ (for Scope 3) and ‘use of Life Cycle Assessment (LCA) methods’ (for Scope 4). Harangozo, Szechy & Zilahy (2015) contrast these methods of producing a scope 3 inventory:

‘indicators can be quantified using a LCA-based ‘bottom up approach’…or an ‘input-output’ approach, where the mapping of direct and indirect material flows is following a top down approach…’Hybrid approaches’ mix bottom up and top down methods’ (p.49)

‘Hybrid Accounting’ methods are discussed in various aspects of the literature (Schaltegger et al, 2015; Lenzen (2009); Lenzen et al (2009), and recommended for use by CDP[8], but as

[8] These methods are encouraged by CDP, who refer to some software that they have developed in collaboration with Quantis that companies can use to make an initial assessment of their scope 3

they are based on statistical averages their usefulness can be limited in bespoke sectors, or the more bespoke categories of GHG emissions, as explained by Schaltegger et al (2015):

> 'the results are based on statistical average[s] and…depend on how typical the studied product or company is in relation to the sector where it appears…hybrid accounting should not be used for convenience reasons where physical emissions data is available at reasonable cost. Thus hybrid accounting can be seen as an auxiliary method to conventional…LCA studies and should be used when making a rough estimation is more rewarding than making no estimation at all' (p.12)

Thus, the characteristics of the specific sector, and the aspect of scope 3 in question are particularly relevant to the method used. From this perspective, one could make the argument that hybrid-accounting approaches are particularly well suited to Matthews, Hendrickson & Weber's (2008) 'Scope 3' definition above (indirect emissions linked to production), and initial calculations of emissions related to employee commuting or business travel. However, depending on the product, it may be less useful in relation to the authors' 'Scope 4' definition (emissions relevant to the lifecycle), and this would very likely be the case with defence, where low volume/bespoke products would undermine (unavailable) statistical averages.

The use of Life Cycle Assessments (LCAs) to generate a Scope 3 inventory is relatively common, and are recommended by the GHG Protocol Scope 3 Guidance (WRI, 2011). For defence and probably other sectors, they apply far better to Matthews, Hendrickson & Weber's (2008) 'Scope 4', where value chain assessments of products are being made.

The topic of LCA has its own longstanding literature (see e.g. Brander & Ascui, 2015), and though starting as a field dominated by engineers and natural scientists it has gradually become far more interdisciplinary.

The case of the Clean Development Mechanism (or CDM, introduced in section **2.1.1** above 'Overview of the Carbon Accounting Literature') is useful in establishing the essential variability of LCAs, even within the most well-established 'Project Level' Carbon Accounting scheme. Shishlov (2016) refers to several relevant published documents outlining how to align with the CDM scheme, but describes how methodologies can be very diverse in practice, because of the vast variety of potential projects that could apply within the 15 sectors identified by the scheme. Shishlov (2016) explains:

> 'the sectors [in which projects can take place] vary significantly…which explains the need for specific methodologies that reflect the peculiarities of different project types and sub-types. Methodologies are designed in a bottom-up manner: stakeholders, usually project developers, come up with a project idea and propose a methodology to monitor its emissions reductions' (p.352)

The Carbon Accounting methodologies have to align with the guidelines, but essentially can be bespoke to the relevant project. Shishlov (2016) explains that 'the bottom up approach to development of methodologies resulted in multiple project-specific methodologies not tailored to be applied across all projects of the same type' (p.353). This is something that

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emissions by entering some generic company data (related to company size, employee numbers, procurement spend etc.) (CDP, 2016b: p.173) the CDM Executive Board have tried to address by publishing the CDM Methodologies Booklet (United Nations, 2016), but this still includes over 200 active methodologies in use.

This section has described the clear relevance of Scope 3 reporting to organisations, but contrasted this with the relative immaturity of organisational emissions inventories, particularly in relation to the most relevant categories of scope 3 emissions where they relate to the value chain.

Methodologies underpinning these more relevant ‘Scope 3’ emissions can be highly variable, but this is in some ways inevitable, given their dependence on diverse Carbon Accounting methodologies linked to the field of LCA.

This research contends that a diversity of methodologies for ‘Project Level’ Carbon Accounting is not problematic in isolation – as Shishlov (2016) explains above in relation to the CDM, where projects are unique the processes used to account for their carbon may also need to be unique.

The issue of variability becomes more problematic when ‘Project Level’ Carbon Accounts are combined with OCAs to build up comparable Scope 3 inventories. Their essential variability challenges the ‘drive to standardisation’ and ‘attributional-emphasis’ that characterise the more established OCA methods described in section **2.1.2** above (‘OCAs and their Limitations’).

Despite these issues, Harangozo, Szechy & Zilahy (2015) note the increasing interest in this area of corporate OCA, and specifically the link between product footprinting and wider organisational inventories:

> ‘academic interest in the application of footprint type indicators in the assessment of organizational/corporate sustainability has increased markedly in the past 5-6 years’ (p.55)

The connection of ‘organisational footprints’ to ideas of product footprinting is significant, as it reinforces the interplay between the different scales of Carbon Accounting described above, and potentially provides a means for organisations to build up more relevant emissions inventories in a pragmatic way. Harangozo, Szechy & Zilahy (2015) pick up on this theme, describing how:

> “the building blocks of organizational footprints are typically product and process level footprints. In some cases, accounting and reporting focuses mainly on the footprint of the company’s products rather than the whole organization itself” (p.67)

Gibassier (2015) similarly looks at the connection between OCAs and ‘Project Level’ Carbon Accounts, confirming that: ‘to our knowledge, [no companies] have tried to devise a company-wide result using product footprints’ (p.124).

It is clearly possible to use LCA-driven product footprints to build up OCAs, and this does seem to have potential as a means to create more relevant Scope 3 inventories. However, this may require an approach to OCA that is less inhibited by the technical complexities of attributing emissions between organisations that characterises the Scope 1 & 2 Carbon Accounting practices described above (see section **2.1.2 ‘**OCAs and their Limitations’**)**, and an acceptance that standardised, comparable accounts may not always be available.

Interestingly, Harangozo, Szechy and Zilahy (2015) suggest that the lack of 'Project Level' Carbon Accounts do not only inhibit building up organisational Scope 3 inventories, but also inhibit the types of sector-level benchmarks that are lacking more generally in the field of Carbon Accounting (as discussed in **1.2** 'Academic Context and Novelty')

> 'comparisons within industrial sectors or industry specific benchmarks would be the most useful information to one organization's management accounting. However, in practice this is scarce due to the lack of application of the footprint concepts in organizational accounting, different methods of calculation and the lack of information on peer companies… Product level comparisons may play an even more important role in the future' (p.68)

The next part of this review explains some of the broader conceptual challenges raised for established 'attributional' perspectives on OCA by LCA-driven 'Project Level' Carbon Accounts. It describes how OCAs can better connect to decision making and positive change at the sector-level by incorporating wider Carbon Accounting perspectives linked to the field of LCA.

2.1.4 Attributional-Consequential Distinctions in Carbon Accounting and the Implications for OCAs

The discussion of 'Project Level' Carbon Accounting above – particularly as it relates to organisational emissions inventories – leads onto this fourth part of the review that introduces some alternative conceptual perspectives on Carbon Accounting that have their basis in life-cycle assessments (LCA). These perspectives place less emphasis on attributing emissions to organisations, and more on the consequential impacts their actions have at the system level.

One key feature of the types of 'Project Level' Carbon Accounting described above is their focus on decision making. Specifically, the real-world carbon impacts of decisions made at the outset of a project. In this sense they are future orientated and concerned with actual emissions reductions. Shishlov (2016) explains that this to some extent distinguishes them from the many other types of Carbon Accounting:

> 'unlike national inventories or cap-and-trade schemes, which require monitoring absolute levels of GHG emissions…the object of Monitoring, Reporting and Verification (MRV) in carbon offset projects is 'emissions reductions'. This means that a project developer has to monitor not only realized emissions within the project boundary, but also the hypothetical emissions that would have occurred in the absence of a project, which is usually referred to as a baseline' (p.351-352)

This focus of 'Project Level' Carbon Accounting on emissions reductions locates it far more closely to issues of organisational decision making, and connects it to some interesting wider parts of the Carbon Accounting literature, notably distinctions between 'attributional' and 'consequential' inventories of GHG emissions for a project or organisation. Brander & Ascui (2015) provide a useful review paper that summarises this topic. The authors explain how the distinction between attributional and consequential LCAs occurred around 30 years into the development of the field, as a result of the influence of new interdisciplinary links, particularly with economists:

> 'the consequential approach [brought] concepts borrowed from economics to a field previously dominated by engineers and natural scientists' (p.104)

It is easiest to explain the 'consequential approach' by contrasting it with the (far more common) 'attributional approach' to Carbon Accounting:

> 'attributional methods provide static inventories of emissions allocated or attributed to a defined scope of responsibility, while consequential methods attempt to measure the system-wide change in emissions that occurs as a result of a decision or action, such as the decision to produce one extra unit of a given product' (p.100)

It is this system-level emphasis, as well as the focus on decision-making and the consequences of decisions that are crucial to the 'consequential' perspective, as Brander confirms:

> 'emphasis on quantifying the consequences of a decision or action, as distinct from quantifying the total environmental burdens associated with the process directly used

> or connected with the entity studied, is the essence of the 'consequential' approach' (p.102)

Brander & Ascui (2015) provide the example of a project to build a Swedish Hydropower plant (amongst other examples) to demonstrate that the attributional emphasis of the majority of Carbon Accounting practices can misunderstand the system level impacts of actual decisions and result in unintended consequences. The authors draw the conclusion that 'the magnitude of difference between attributional and consequential LCA results clearly depends on the specific product that is studied. However, it is also clear that in some cases the difference can be very large' (p.108).

Despite a growing number of papers discussing the consequential approach with reference to LCA (e.g. Ekvall & Weidema, 2004), the '[attributional-consequential] distinction has not yet been widely appreciated or explored within the field of corporate carbon accounting' (Brander & Ascui, 2015: p.100).

Brander & Ascui (2015) argue that just as the distinction has significant implications for decision making in relation to environmental LCA at project-level; it has great significance more broadly, and could be applied to decisions taken at the national scale, and decision-making within organisations:

> "organization-level inventory of physical GHGs, typically produced for the purposes of voluntary carbon disclosure…[follow] standards such as the GHG Protocol…[that] guide the production of corporate carbon accounts that are attributional in nature…and thus it is probable that decisions based on such inventories may, like attributional LCAs, result in unintended consequences. Applying the attributional-consequential distinction to corporate carbon accounting may therefore be useful in choosing appropriate methods to inform decision making, and for understanding the nature and limitations of mainstream (attributional) corporate carbon accounting more generally" (p.100)

Brander & Ascui (2015) use the example of outsourcing activities to demonstrate the relevance of consequential perspectives and the type of 'unintended consequences' that can occur in relation to attributional methods. However, the application of consequential approaches to OCA is very rare and from this Literature Review it remains unclear as to whether any examples exist. The relevant grey literature also gives scant reference to the distinction. The GHG Protocol Corporate Standard (WRI, 2004) does not mention the actual terms but provides clear enough advice that inventories should be attributional. CDP's Guidance (CDP, 2016b) does mention the distinction, but in this case to make clear that inventories should be attributional (p.37).

Brander & Ascui (2015) do attempt an explanation of the lack of attention that the attributional-consequential distinction has received in relation to OCA practices:

> "we believe that the history of the emergence of the distinction [between attributional and consequential methods] in LCA demonstrates that thinking in terms of the systematic consequences of a decision or action, rather than thinking in terms of attributing responsibility for a given situation, involves a conceptual shift – a subtle change of emphasis with far-reaching implications – that is challenging and difficult to introduce when the dominant thinking is attributional." (p.101)

There are significant potential benefits to applying the ‘consequential’ perspective to OCAs, and these address some of the criticisms of existing Sustainability Reports in which OCAs are currently presented.

The emphasis on ‘system-level’ change directly addresses one of the main criticisms of existing sustainability reporting (including related OCA practices), that it ‘falls a long way short of understanding eco-systems / interactions beyond the individual organisation’ (Buhr, Gray & Milne, 2014: p.55).

Similarly, the emphasis on ‘decision-making’ and its consequences, addresses the issue that existing practices are ‘backward looking’ in emphasis, simply describing impacts and enhancements that have occurred in the period, as Zvedov & Schaltegger (2015) summarise:

> ‘the majority of…publications explicitly dealing with CMA [Carbon Management Accounting] discuss aspects not related to the management relevance of improved carbon performance. Most of the explicit CMA literature deals with past orientated and ad hoc information while focusing on decision support to secure legitimacy or profits. Sustainable development and corporate sustainability, however, would-in addition-require considering future orientated decision situations and the generation of routinely generated carbon information to create continuous management attention and to support management of decisions for improved carbon performance.’ (p.40) …
>
> ‘subsequent research is challenged to look into possibilities to harness the potential of CMA to actually reduce carbon emissions in view of an eminent ecological crisis. Expanding the currently limited set of carbon accounting tools at a management’s disposal thus constitutes a central challenge.’ (p.40-41)

Therefore, whilst the types of ‘Project Level’ Carbon Accounts discussed in section **2.1.3** might make OCAs more ‘relevant’ (by connecting better to actual emissions producing activities than specific organisations), it is arguably the application of the ‘consequential’ perspective that makes them ‘useful’ – that is it could connect these more relevant accounts to ‘decision-making’ and meaningful GHG reductions at the system level.

Creating the type of ‘Project Level’ Carbon Accounts discussed in **2.1.3** whose impacts span across different organisation would inevitably reduce the attributional emphasis of existing OCAs. They would also aggregate much more usefully to ‘system-level’ accounts for Carbon (e.g. several warship Carbon Accounts would provide a Carbon Account for the Fleet, or our Maritime Defences).

It is interesting that in the literature the additive nature of attributional inventories is highlighted as a benefit (e.g. for setting carbon budgets) over consequential accounts, which cannot be aggregated meaningfully (Tillman, 2000). However, adding together the type of (non-attributional) ‘Project Level’ Carbon Accounts as described above potentially provides a far more meaningful result than several individual organisational totals that may be fairly abstract in their relation to the underlying emissions producing activities.

The next part of this Literature Review explores the Defence Industrial Policy literature in order to expand on the themes that have been established above in relation to OCA, and ground this research in its sector-specific context.

2.2 Defence Industrial Policy

Despite the Carbon Accounting field being the focus of this research, the introduction explained how two ‘supporting literatures’ were appropriate for grounding the research in its sector-specific context and responding to the title question of the thesis. This second part of the Literature Review describes the Defence Industrial Policy literature, and its relevance to the ‘themes’ of Carbon Accounting identified in the previous section.

This section provides an introduction to the Defence Industrial Policy literature (**2.2.1**), before focusing on each of the themes from the previous section in turn, and explaining the sector-specific context. Section **2.2.2** describes how the difficulty of attributing emissions to individual organisations is particularly challenging in the defence sector due to the increasing private sector involvement in nearly all defence tasks, to the extent that defence departments and their supporting industrial base can be highly integrated and difficult to separate for emissions accounting purposes. In contrast, ‘Project Level’ Carbon Accounting methods align well to a sector that is increasingly characterised by a small number of large, high profile international programmes supported by industrial ‘teams’ comprising multiple companies (**2.2.3**). Similarly, consequential perspectives on Carbon Accounting align well with concepts of ‘defence capability’ that are gaining traction in a period of defence reform in most western countries (**2.2.4**).

2.2.1 Introduction to the Defence Industrial Policy Literature

It is first worth noting the substantial academic literature available on defence issues and foreign affairs. The majority of this is in some ways connected to the International Relations literature (e.g. Brown & Ainley, 2005; Weber, 2005), and the related fields of Security Studies and Strategic Studies (e.g. Collins, 2009; Kaldor, 2006).

Nearly all of these authors acknowledge the complexity of contemporary security studies and the end of the traditional conceptions of security and war. Smith (2006) describes the profound change in the context of contemporary conflict, declaring the end of old certainties:

> ‘War no longer exists. Confrontation, conflict and combat undoubtedly exist all around the world…and states still have armed forces which they use as symbols of power. None the less, war as cognitively known to most combatants, war as battle in a field between men and machinery, war as a massive deciding event in a dispute in international affairs: such war no longer exists.’ (p.1)

For Smith, we have entered a ‘new paradigm’ in global conflicts:

> ‘It is now time to recognise that a paradigm shift in war has occurred: from armies with comparable forces doing battle in a field to strategic confrontation between a range of combatants, not all of which are armies, and using different types of weapons, often improvised. The old paradigm was that of interstate industrial war. The new one is the paradigm of war amongst the people.’ (p.3)

Kaldor makes a similar contrast between 'old wars' and 'new wars' (Kaldor, 2007), and many authors link the 'old wars' paradigm to the 'old certainties' established during the Cold War (e.g. Dannreuther, 2007). These contrasting perspectives are not confined to the academic literature, and are well-established in the published security strategies of the US and UK. The UK National Security Strategy (Cabinet Office, 2010a) confirms that 'many future wars will be 'among the people' (p.17), and the US Quadrennial Defence Reviews (e.g. Department of Defense, 2014a) and National Military Strategies (e.g. Department of Defense, 2015a) also clearly recognise this changed paradigm.

These debates are well established in the academic literature, and provide some essential context to the Defence Industrial Policy literature that is most directly relevant to this research.

The Defence Industrial Policy literature is concerned with the interactions between different organisations in the defence value chain. It is most relevant to this research as it is these organisations who are accounting for, and publicly reporting their carbon emissions. It is a less well-established area of literature than the security or strategic studies literatures mentioned above, and where it does exist the lines between academic and grey literature can be blurred, with relevant academic sources often emerging from defence departments or related organisations.

In order to discuss Defence Industrial Policy, it is important to emphasise the close relationship between national defence departments and their supporting defence industry, as Dunn et al (2011) describe in the UK context:

> 'The MoD, the armed forces it oversees, and – arguably – the industry that supports it with goods and services are all best thought of as a single and complex organic entity; one that has changed considerably since the end of the Second World War. Changing it in a controlled manner is not straightforward, since amendments in one area can have significant and sometimes hard to discern consequences elsewhere' (p.2)

It is this notion of defence as 'one complex entity' that has led to the widespread use of the term 'military-industrial complex' to describe the relationship between defence and its industrial base. The term was coined by Dwight Eisenhower, who was concerned that industrial concerns might begin to influence defence strategy with negative consequences, when the opposite should be the case. There are many books concerned with this issue (e.g. Ledbetter 2011; Pavelec, 2010; Smith, 2009), and a number of critical analyses of the 'arms trade' in this context (e.g. Stohl and Grillot, 2009; Feinstein, 2011; Gilby, 2009), however many of these are perhaps best categorised as popular non-fiction. The sector attracts this type of literature, not just because of the ethical and philosophical dimensions of weapons and war, but because it is so clearly not a 'normal market'. Most nations have a single buyer (their defence department), and a small group of major suppliers. It is a highly structured market, with the defence departments often acting as the sole buyer and the regulator.

Gansler (2011) explains the uniqueness of the defence market in the US context:

> 'the US Dept. of Defence (DoD) is a single (monopsony) buyer that can make purchases from only a few, select suppliers in each critical sector of the economy…;

> and the market operates in an extremely regulated and transparent environment. Both of these characteristics are unlike anything in the commercial world, where many buyers and many sellers operate in a largely free market.' (p.156)

The author continues that the government is so involved 'in the day to day operating of the [defence] firms… [that the] defence market becomes totally unique and ceases to be a market in any traditional sense.' (p.157)

Despite the wide variety of political or philosophical positions from which to analyse Defence Industrial Policy, the idea of defence as a 'complex organic entity' is certainly helpful in understanding the nature of the modern defence context. Indeed, this does not just concern the relationship between defence departments and their largest industrial suppliers, but the whole system of organisations related to defence. For example, in the UK, as well as the single services and main civilian Ministry of Defence (MoD) offices, there are over fifty public sector organisations that are under the management of the MoD, ranging from the Met Office to the Defence Science & Technology Laboratory (DSTL), and the list of organisations is even larger and wider in the US context.

Another term used to describe this 'complex entity' is the 'Defence Enterprise', and as defence becomes a more global and inter-related concern, this term can increasingly be applied at multiple levels (e.g. the UK Defence Enterprise, the EU Defence Enterprise; the NATO Defence Enterprise; the Western Defence Enterprise).

All the organisations bound up within this complex organic entity, at whichever level it is defined, produce significant volumes of grey literature – whether annual reports, strategic visions and strategies, or performance reports and statistics. This grey literature has been reviewed and is discussed in more detail in the Methodology (section **3.5** 'Relevant Secondary Sources of Data').

The academic literature on the topic is also bound up within this 'complex organic entity' given that it often emerges from defence-academic institutions, think tanks, or policy organisations related to defence. For example, the UK and US armed forces tend to have 'academies' or 'colleges' that are either joint or linked to the single services, and a significant amount of academic literature is produced and published in close association with these organisations (e.g. Moore, 2011; Moore & Antill, 2014; Sorensen, 2008).

Similarly, the defence enterprise includes a number of well-regarded think tanks (e.g. Council on Foreign Relations, RAND Corporation, Royal United Services Institute, International Institute for Strategic Studies, CSIS, Brookings, Chatham House, Janes, Royal Institute for International Affairs, Pew), who also produce and publish academic literature (e.g. Markusen & Costigan, 1999; Lorell et al, 2003; Heidenkamp, Louth & Taylor, 2014).

The authors in both cases can be academics that work (or have worked) within the defence enterprise in some capacity, whether in industry or MoD civilian roles, or serving in the forces. And indeed, even when academic work is produced and published by more independent institutions, it is usually done by academics connected in some way to the defence enterprise (Gansler, 2015; Mathaisel, Manary & Comm, 2009). Arguably the exceptions to this rule are some of the work of applied economists analysing defence (e.g. Hartley and Sandler, 1995, 2007; Hartley, 2011; Markowski, Hall & Wylie, 2010), and these sources are used heavily in this review but backed up with sources more closely connected to the defence enterprise.

As with the Carbon Accounting literature, many authors note the under-developed nature of the research. The aforementioned applied economists are quite specific in mentioning this, describing their field as 'a relatively new sub-field of economics' (Hartley, 2011: p.1), and claiming that:

> 'despite the importance of defence policy, the opportunity costs of defence budgets and the implications of war for the future of civilisation, the field of defence economics has attracted relatively few economists willing to apply their 'tool kit' to the defence sector' (p.XV)

This has been a longstanding issue, with Markusen & Costigan (1999) noting in the late 90s - a time of significant change in the defence industrial context as will be discussed below, that the field had received little academic attention, and that 'the consequences of defence industrial restructuring through mergers, increased exports, and privatisation are surprisingly under-researched' (p.21).

As well as being under-developed, the research also tends to be cyclical, with academic debates occurring more vigorously in times of significant change to defence budgets. Gansler (2011) explains the understandable connection between defence procurement cycles and external events, with Figure 2 showing how the US DoD budget has varied since the 1940s, including annotations relevant to periods of conflict. The author confirms that defence spending has been sustained more recently to support the 'long war on terrorism' (p.18). These large swings in the size of the defence enterprise are a fairly unique feature of the sector, and the volume of research published tends to relate to these periods of significant change in the sector.

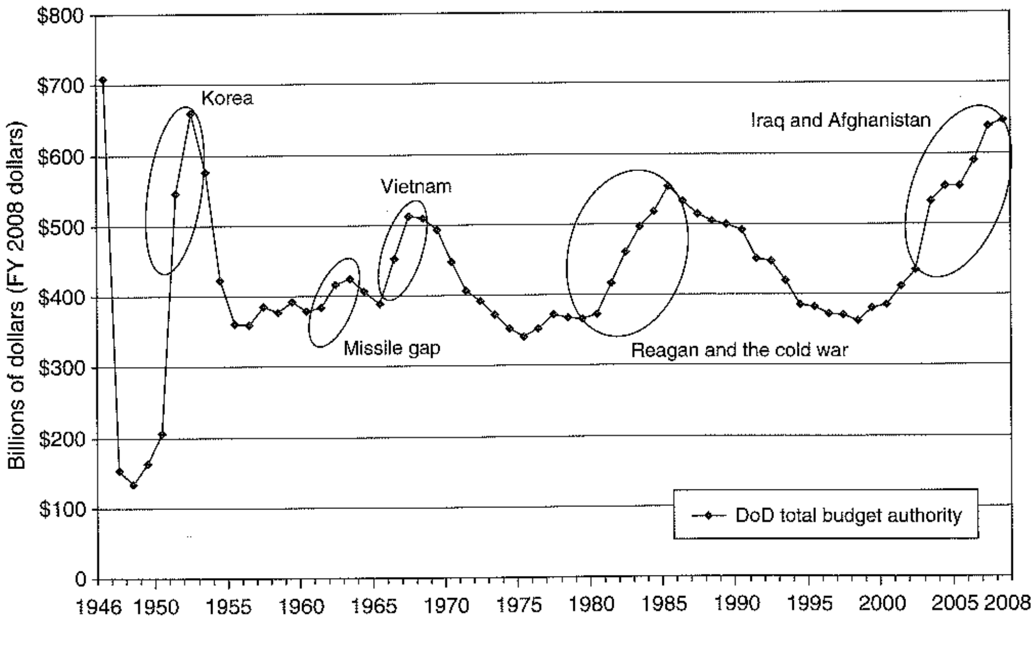

Figure 2: US DoD budget for the period 1946-2008, including annotations relevant to significant periods of conflict that show the impact of external events on defence procurement cycles. (Source: Gansler, 2011: p.10)

This section has briefly summarised the modern defence context and explained the unique nature of the defence enterprise. The associated Defence Industrial Policy literature has emerged from all parts of this enterprise, and is both under-developed and cyclical in nature. However, it clearly emphasises the need to analyse the themes of Organisational Carbon Accounting (OCA) that were described in the first part of the Literature Review with reference to the defence-specific context, and the next section is focused on the increasing role of the private sector in the contemporary defence enterprise, and the challenges this presents for appropriately allocating emissions to individual organisations within it.

2.2.2 The Increasing Role of the Private Sector in All Defence Tasks

Markusen & Costigan (1999) and Gansler (2011) both provide good summaries of the 'peace dividend' expected from the end of the cold war in the early 1990s. From an industrial perspective, the hope was for the existing (numerous) defence firms to commercialise, finding civilian markets for their technological expertise, and in doing so providing an innovation-boost to the global economy. Whilst some of this did occur, the majority of activity was focused on the merging and consolidation (and specialisation) of the existing defence firms around a shrinking volume of defence orders, who then looked to export markets (foreign military sales) for future growth. Gansler (2011) provides the diagram in Figure 3 to demonstrate the scale of this consolidation, describing how in the US 'five firms absorbed over fifty previous entities. These mergers and acquisitions occurred both horizontally (such as the McDonald Douglas and Boeing combination) …and also vertically (such as Lockheed's acquisition of Loral)' (p.32). The author explains that the amenable position of the US administration in the 1990s to the mergers is largely responsible for the result, but possibly also management theories related to 'core competence' and outsourcing that were also prevalent at the time, and remain so.

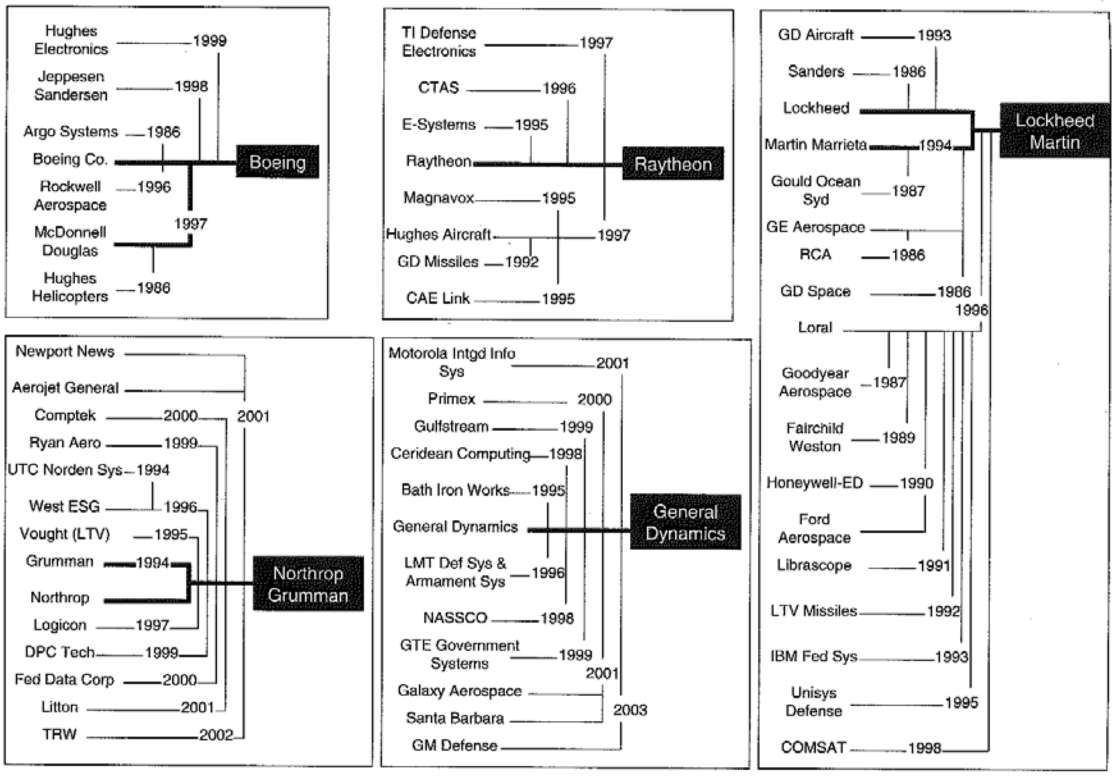

Figure 3: Diagram showing Defence Industry Consolidation 1986-2001, showing the scale of consolidation in the industry with over 50 firms absorbed into five large defence multinationals (Source: Gansler, 2011: p.33)

With shrinking domestic orders, these consolidated defence firms began to look for increasing volumes of exports (foreign military sales), something sanctioned by host countries on the basis of keeping skills available and costs down, and the security case justified on the grounds that it allows host countries' industries to stay ahead of the technology curve. Whether this approach has been successful or represents a case where industrial concerns are undermining strategic security, is a significant topic of debate in the defence industrial literature as well as the strategic studies field (e.g. Markusen & Costigan, 1999). Its significance to this research is the changed structure of the defence industrial base, concentrated around few large multinational defence companies that are international in structure and outlook.

One consequence of this more global defence industry supported by fewer, specialist multinationals, is that different countries have to make complex decisions about how much of their domestic industrial base they want to maintain. Hartley (2011) explains how national perspectives can vary significantly:

> 'nations differ with some not having a defence industrial base, whilst others have a small-scale industry offering repair and maintenance facilities or supplying ammunition and small arms, whilst some have a large-scale defence industry providing a range of high technology air, land, and sea equipment… within the world market, there are examples of defence industries of varying sizes and scope' (p.183)

Markowski, Hall & Wylie (2010) have produced a thorough analysis of the approaches to defence procurement taken by small, advanced countries, explaining that within this globalised industry, these countries need to make conscious decisions about how much capability they maintain domestically.

The question doesn't just occupy small countries though; even the UK with its established defence industrial base has to make decisions as to how much capability it maintains domestically. Hartley (2011) explains:

> 'traditionally, the UK has supported its domestic defence industrial base. If buying British means paying more for some defence equipment and waiting longer for delivery, the result is a smaller defence force and less protection for our citizens. Questions arise as to what the defence budget is buying: is it buying protection for our society or protection for UK defence industries' (p.27)

Between the two extreme positions of 'buying British' and 'Buying Foreign (American)', Hartley (2011) explains that there is lots of middle ground, and at present roughly 70% of MoD procurement is spent in the UK (p.27). The UK Defence Industrial Strategy (Ministry of Defence, 2005), was keenly aware of these issues:

> 'Companies now have more choice than ever before about which markets to enter, which secure the best return for shareholders, and where to base their operations. If we do not make clear which industrial capabilities we need to have onshore…industry will make independent decisions and indigenous capability which is required to maintain our national security may disappear. Equally, we do not seek to restrict the scope for international cooperation and competition where this is appropriate, and we cannot afford to maintain a complete cradle-to-grave industrial base in all areas.' (p.6)

Indeed, even the US with its dominance in global defence spending has to ask questions of whether it can or should try and maintain the capability to do everything alone. Markusen & Costigan (1999) confirm that:

> 'fortress America is no longer an option. American-designed arms will be bought and used by more nations in the future, and we may rely heavily on foreign suppliers for components if not whole weapons systems. Our leaders have no alternative but to explore with our allies international agreements and machinery to streamline the defence industrial base, share its output, and control access globally'. (p.6)

Gansler (2011) confirms that at present, autarchy (defence as a closed domestic economic system) is a false perception for the US defence industry:

> 'every weapon system built in the United States contains foreign parts, and many are based on foreign designs. This trend is growing as a result of globalization of both technology and industry'. (p.17)

Defence departments are clearly conscious of providing work for the private sector in order to maintain domestic capability in certain areas, and thus there is inevitably substantial overlap between the private sector and national defence departments in relation to defence activities. However, as well as this desire to maintain domestic capability, there is also more recently an economic necessity to further engaging the private sector related to 'defence austerity'.

This has been a key focus of most recent literature since the global financial crisis in 2008 and emphasises the links between economic security and national security[9] as the foundation for another period of significant defence reform[10]. The reality of this for defence departments in the US and Europe is increasingly squeezed defence budgets, and many commentators emphasise the need for this to be managed intelligently and cognisant of broader strategic objectives, as opposed to simply muddling through with lower defence budgets[11].

One area that is central to defence reform relates to acquisition and the defence departments' increasing interactions with the private sector.

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[9] Gansler (2011) explains how 'a strong US economy is needed to pay for the full range of 21st century security needs…the clear challenge is how to achieve an effective 21st century national security posture within an affordable budget' (p.2). The UK National Security Strategy (Cabinet Office, 2010a) acknowledges this: 'We cannot have effective foreign policy or strong defence without a sound economy and a sound fiscal position to support them' (p.14). The US National Security Strategy makes the same point (White House, 2010): 'At the center of our efforts is a commitment to renew our economy, which serves as the wellspring of American power' (p.2). See also Sharp (2011) and Berteau (2011).

[10] See Ministry of Defence (2011), Gray (2009), and Dunn et al (2011) for some useful documents on 'Defence Reform' in the UK context

[11] Various think tanks have produced papers critical of the mismatch of strategic objectives and resources in defence, and highlighted that this is all the more crucial in a period of 'defence austerity' (See Cornish, 2010; Cornish & Dorman, 2011). The UK 2010 Strategic Defence and Security Review (Cabinet Office, 2010b) highlighted this as a longstanding issue in UK defence

Hartley (2011) provides a useful summary of defence acquisition in the UK context, and Gansler (2011) provides a similar overview in the US context[12]. Since the post-cold war contraction in defence budgets, the proportion of acquisition spend related to services has been growing in both the UK and US contexts, and this has to some extent changed the nature of the tasks performed for defence departments by the private sector. Equipment expenditure accounts for around 40% of UK defence spending, with the remainder of the acquisition budget spent on services (Hartley, 2011: p.95), and the proportion is very similar in the US, where 60% of the 2009 defence procurement budget was spent on services (Gansler, 2011: p.46). As defence budgets shrank, priorities shifted to maintaining existing equipment, and 'in response, industry shifted much of its focus from production of weapons to support, upgrades, and services' (Gansler, 2011: p.31). These trends were very much encouraged by the Defence Departments who were keen to encourage provision of services and partnering arrangements with industry (Ministry of Defence, 2005).

As the emphasis of defence acquisition has shifted towards services, the role of the private sector has become increasingly important, with many previously 'military' tasks being outsourced to the private sector. Hartley (2011) provides some historical context in relation to these trends in the UK:

> 'military outsourcing has been a major feature of the UK's efficiency programme since 1983…in-house units in the armed forces can be regarded as public monopolies protected from competition. Examples include the armed forces training personnel and repairing equipment…competitive tendering, market testing and contracting-out were viewed as the solution to assessing the efficiency of 'in-house' public monopolies' (p.20)

By outsourcing some of these services, defence departments have introduced competition to previously protected in-house activities, and Hartley (2011) describes how this process has been widely regarded as a success.

Despite the successes, several authors believe that further military outsourcing to the private sector is possible, and is likely to become increasingly desirable in this next period of defence reform since the financial crisis. In the UK, Hartley (2011) describes how:

> 'despite the substantial progress which MOD has made in introducing and extending competition through the contracting-out and outsourcing of services and through equipment procurement policy, major barriers exist to further efficiency improvements in these areas… examples of services which have been subject to competition from private contractors include catering, cleaning, grounds maintenance, security guarding, managing and manning facilities, and equipment maintenance.

[12] The MoD is British industry's largest single customer. Hartley (2011) explains that in 2009 the UK MoD spent around £20 billion on all acquisitions, contracting with some 29,000 suppliers, although about 40% of this figure was spent with 10 companies (p.95). The situation is similar in the US, although of a scale of magnitude larger. Gansler (2011) describes how in 2006, DoD processed around 3.6 million procurement actions for $285 billion, and over 80% of these were with a few very large firms (Gansler p172-3). Gansler also provides a detailed account of the defence acquisition process (p158-192), but notes that whole books have been written on separate stages of it. The process is marked by complexity, efforts to introduce competition and efficiency where possible, and shifting power dynamics between the defence department (as a monsopony buyer), and the few potential large company suppliers that can provide the relevant products or services.

> Opportunities exist for a major extension of the policy in repair and maintenance work, air, land and sea transport, air traffic control, search and rescue, and training functions.' (p.26)

Similarly, in the US context, Gansler (2011) notes that 'for almost exclusively political and historical reasons…a large portion of the defence industrial base has been maintained in the public sector' (p.143).

UK Defence Reform proposals have been keen to maximise future military outsourcing. The UK Defence Reform Unit (DRU) restructured aspects of the MoD in part to allow the private sector to play a greater role in the organisation[13], and for Lord Levene (Chair of the DRU), the 'support' role of the defence industry in the UK can go far beyond upgrade and maintenance:

> 'on support, there is the potential to build on the trend over the last decade and move towards the greater involvement of industry in supporting military capabilities both at home and on operations and new models for contracting… [there is] scope for a more fluid and flexible mix of military, contractor and civilian staff in support roles and for integrated bases on which a range of functions are brought together to realise efficiencies.' (Ministry of Defence, 2011a: p.52)

As can be seen from the discussion in this section, the challenge of allocating emissions between defence departments and defence companies (see **2.1.2** 'OCAs and their Limitations') is likely to be particularly marked in the modern defence context, characterised by significant interaction between the defence departments and the private sector.

Section **2.1.2** ('OCAs and their Limitations') summarised some of the challenges that organisations have had in determining organisational boundaries using the GHG Protocol's 'Operational Control' method, with the guidance in the standard open to wide interpretation:

> 'A company has operational control over an operation if the former or one of its subsidiaries has the full authority to introduce and implement its operating policies at the operation…It is expected that except in very rare circumstances, if the company or one of its subsidiaries is the operator of a facility, it will have the full authority to introduce and implement its operating policies and thus has operational control…Under the operational control approach, a company accounts for 100% of emissions from operations over which it or one of its subsidiaries has operational control.' (WRI, 2004, p.18)

The statement above is likely to be very difficult to apply to large defence sites, with many organisations involved in the various activities taking place on them. The researcher was based for a significant part of this study on Portsmouth Naval Base, which is the largest energy user in the MoD estate and illustrates some of the challenges. The site occupies a large part of the city of Portsmouth. It is owned by the MoD but BAE Systems maintain a lot of the static infrastructure, as well as servicing the surface fleet of ships, which the company maintains and repairs. There are also numerous other companies working on the base day-in, day-out. Determining who 'has the full authority to introduce and implement its operating

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[13] For example, by creating some large 'shared services centres' within the MoD, such as Defence Business Services (DBS), and the Defence Infrastructure Organisation (DIO)

policies at the operation' is not straightforward, and may vary according to the activity in question. Similarly, BAE Systems support the operations of numerous other large defence sites across all domains (land, air, sea) in the UK, US, Australia and Saudi Arabia, and are likewise involved in temporary 'deployed' defence sites. In all these cases, the operating policies for particular activities will differ. Scenarios also arise where high-level policies established by one organisation can refer to more detailed policies that are maintained by sub-contractors. Therefore, at complex defence sites, there are likely to be many policies relevant to different operations, and maintained by different organisations. This inevitably results in a variety of stakeholders that cross organisational boundaries having some degree of influence.

Even at sites that ought to be more straightforward, where BAE Systems either own or lease them on a long-term basis, determining the extent of the company's 'operational control' can be complex. The researcher undertook a survey of the twenty BAE Systems sites that produced the highest volumes of GHGs (accounting for ~70% of the organisational Scope 1 & 2 emissions) in order to determine the extent of 'operational control' at each[14]. Table 3 in Appendix A shows the results, and confirms the complexity of control arrangements in that only 11 of the 20 sites could clearly say they were 100% in control of the facility.

Even if it were simple to determine which party controlled relevant activities, it is very unlikely that measurement infrastructure (whether utility meters, of various types and reliability across static infrastructure; or measurement devices associated with mobile vehicles) would neatly align to these distinctions, especially at large, often very old defence sites.

The next section explains the increasing number of collaborative programmes in the defence sector, often involving multiple defence departments or companies. This is partly the result of the economic necessities described above, but also the operational need for allied countries to increasingly work together in a complex, globalised threat environment. Whilst traditional OCA practices are difficult to apply to complex defence sites and activities, the type of 'Project Level' Carbon Accounts discussed in section **2.1.3** have the potential to better align with contemporary trends in the defence sector.

[14] The survey asked some simple prompting questions as follows, and then asked responding sites to then estimate on a scale of 0-100% the extent of Operational Control they had: Do BAE Systems own (or long term rent) the entire site?; Do BAE Systems control the capital expenditure for the site?; Do BAE Systems control the maintenance budget for the site?; Do BAE Systems occupy the whole site?; How much influence does BAE Systems have on the operating profile?; Do BAE Systems get the benefit of reducing energy, water and waste usage?; Do BAE Systems process the utility bills for the site?

2.2.3 International Collaborative Programmes and Industrial Teaming

In discussing globalisation, Diehl and Frederking (2010) describe contemporary governance and security interdependence in the modern world:

> 'the most important issues in world politics today – poverty, terrorism, weapons proliferation, disease, regional conflict, economic stability, climate change, and many others – cannot be solved without multi-lateral co-operation. World politics is characterized by "security interdependence": no one state, not even the most powerful state, can manage these problems alone.' (p.1)

The security strategies of the UK and US acknowledge the need for a multi-lateral approach and both stress the need for 'collective security' (Cabinet Office, 2010a; White House, 2010).

Therefore, as well as the economic realities driving increased integration in the defence sector between defence departments and defence companies, there are also operational necessities driving the same trend. Allies are responding to a globalised threat environment with an increasing number of joint operations that are addressing complex 'wars amongst people'. In this defence industrial context, having inter-operable equipment becomes increasingly important.

It is worth noting that the standardisation of defence equipment and the preference for national defence industrial capabilities are strongly linked issues, as Hartley (2011) explains:

> 'nations purchasing defence equipment [can choose between] … the extremes of complete independence (nationalism) and buying everything from overseas…clearly, the more nation's buy each other's equipment, the greater the extent of standardisation: hence national independence is a major barrier to equipment standardisation' (p.127)

The standardisation of defence equipment has been of particularly concern to NATO, both for economic and operational reasons, as the same author explains:

> 'NATO is often criticised for being an inefficient organisation both in providing armed forces and supplying defence equipment. The allies are criticised for failing to agree on common tactics, common training and common weapons, with adverse effects on NATO's military effectiveness and an associated waste of resources. The estimates of wasted resources appear staggering…by failing to standardise, NATO is apparently incurring substantial economic and military penalties' (p.116-117)

Defence products, with fixed R&D and development costs, benefit enormously from economies of scale. Large numbers of orders and longer production runs also allow learning in the manufacturing phase to be exploited. Hartley (2011) shows the higher costs of European combat aircraft when compared to their US equivalents as a result of their smaller numbers of orders. He argues that if the aircraft used by NATO allies were standardised, the unit costs associated with the aircraft could be significantly reduced, and inter-operability between the allies enhanced.

These challenges are best illustrated in the European context, and the same arguments above in relation to NATO (the economic and operational benefits of standardising) apply to the main defence industrial nations in the European Union. In fact, NATO's standardisation challenges are essentially defined by Europe's standardisation challenges (Hartley, 2011).

Much has been written about the EU's defence integration challenges, by the European institutions (European Commission, 2001; 2007; European Parliament, 2016), as well as some of the defence enterprise think tanks mentioned above (e.g. Kiss, 2014) and by wider academic texts (Britz, 2008; Kurowska & Breuer, 2011; Howorth, 2007).

As with the allegations of inefficiency and waste in relation to the NATO countries as regards defence spending, the same has been levelled particularly at the countries of the European Union. Within the context of increasing political integration over the last 50 years, the opportunity to integrate around defence has been argued for by many.

Hartley (2011) explains the scale of European defence inefficiency by comparison to the US:

> 'the USA has a competitive advantage through its large home market compared with the large number of small scale national defence markets in Europe. Critics point to massive inefficiencies in Europe' (p.131)

> 'the EU is characterised by fragmented defence markets and defence industries with each member state protecting its national defence industry… national independence is preferred for reasons of security of supply, access to information, jobs and technology with member states unwilling to accept mutual dependence. The result is duplication of costly weapons programmes with the development of 89 different weapons projects in the EU compared with only 27 in the USA' (p.132)

The author elaborates on the inefficiencies, complaining that 'there is massive duplication of defence ministries, procurement agencies, armed forces, training, infrastructure and military bases' (p.133), as well as describing how European defence markets are characterised by duplication of costly R&D programmes. He compares the major European programmes related to the land and sea domains (11 types of naval frigate, 16 national programmes for infantry vehicles) to the US where there is one naval frigate, one main battle tank, and three types of infantry fighting vehicles. This duplication 'results in small scale production for national markets', where the opportunity for learning in the manufacturing phase is diminished (p.133).

Whether in the NATO or European context, the question remains unanswered as to why this potential 'pot of gold' in economic efficiency (alongside the attendant benefits of increasingly inter-operable equipment) has not been realised. Lovering (1999) suggests that it may be because the customers simply don't want it to happen, contrasting some of the cultural mind-sets of defence industries across Germany, France and the UK.

However, some specific policy issues can be identified, such as the caveats around EU single market rules that apply to defence. Article 296 allows member states to exempt defence contracts from single market rules. Markusen & Costigan (1999) highlighted this issue in the late 90s, commenting how:

> 'defence sectors are exempt from the integrative processes and market discipline imposed on other industries. Even on the security front, tensions over sovereignty are far from resolved, and domestic regime changes can sabotage progress. In the

> defence sector, a preference for creating and defending national champion firms places roadblocks on the path to an efficient, integrated European military industrial complex.' (p.25-26)

In the late 90s, Lovering (1999) raised the prospect that disarray in the European market might result in transatlantic mergers instead, and this prediction has proved prescient with BAE Systems aggressively acquiring US defence businesses in the early 2000s, whilst a more recent proposed merger with EADS (now Airbus) was blocked by the relevant political forces in Europe.

Indeed, industrial activity has arguably driven some of the trends towards integration as much as political activity at governmental level. With NATO and European defence integration proving intractable challenges for the western industrial powers, one seemingly obvious solution has presented itself over the past 20 years in relation to international collaborative projects and industrial teaming. These projects can involve multiple defence departments and/or multiple defence firms joining together around a specific project in order to create a better product at lower cost. The rationales are fairly clear, with joint projects allowing partners to share the costs and risks of developing high-tech equipment, and achieve economies of scale in production runs (and the associated learning benefits of longer production runs).

Hartley (2011) explains how teaming has certainly proved an attractive proposition in the European context:

> 'Europe's high technology defence industries are frequently criticised for the wasteful duplication of costly R&D programmes and for relatively short production runs reflecting dependence on a small domestic market. International collaboration between EU states is often presented as the ideal solution.' (p.169)

There are now many such examples in the European context, perhaps most notable among these being the Eurofighter Typhoon programme, where the UK, Germany, France, Italy and Spain formed a multinational collaboration to develop a new multi-role fighter aircraft in the early 1980s (France subsequently exited the collaboration). It is manufactured by a consortium including BAE Systems, Airbus, and Alenia Aermacchi.

Gansler (2011) explains that the concept has also made sense in the US defence industrial context:

> 'because fewer and fewer new defence programs were being initiated during [the] downturn, the small number of remaining firms in a given sector often attempted to team to ensure they would get at least part of each program.' (p.38)

The author provides an example where US defence industrial firms had successfully joined together to present the US Navy with a 'dream team' of Lockheed Martin, Bath Ironworks, and Ingalls Shipbuilding to design and build its next Destroyer (Gansler, 2011, p.38). Gansler (2011) is a strong advocate of industrial teaming in the defence industry and also enthusiastic about international teaming between the US and European defence firms, as it presents an opportunity to increase competition, and therefore increase efficiency and reduce costs (p.63).

This type of ‘international industrial teaming’ is now becoming commonplace in the defence sector, with for example, BAE Systems providing key sub-systems for the international F-35 programme (where Lockheed Martin are the prime contractor), and the work to develop the next generation of US trainer aircraft likely to be contested by a number of joint international teams, including one made up of BAE Systems (UK) and Northrop Grumman Corporation (US).

Despite the clear dominance of these collaborative approaches to major defence projects, Hartley (2011) notes that ‘surprisingly, there is an absence of publicly available information on the magnitude of the benefits and cost savings from collaborative programmes.’ (p.169) As explained above, the rationales for collaborative programmes are clear, but they are not without problems and have attracted criticism, as Hartley (2011) summarises:

> ‘the UK and Europe have substantial experience of collaborative projects, especially in both military and civil aerospace… international collaboration is dominated by myths, emotion and special pleading, often lacking independent economic analysis, critical evaluation and empirical evidence. Supporters regard all collaboration as good and more desirable, regardless of costs. Critics point to bureaucracy, compromises, delays in decision making and design by committees, leading to uncompetitive products, the loss of valuable technology to rivals and, ultimately, the loss of national independence.’ (p.168)

The author articulates some of the key problems associated with collaborative programmes, including the difficulty of stopping the collaborative programmes once underway, and the tendency for work to be allocated between partner nations based on political and equity criteria as opposed to economic criteria of efficiency and competitiveness (p.171-2). The costs of controlling the necessary institutional structures can be large, and even the anticipated design improvements by pooling scientific knowledge can be undermined by ‘design by committee’ approaches (which also lead to delays). On top of this are the difficulties associated with aligning production with varying national operational and replacement schedules, alongside the need to accommodate modifications at the national level. With the increased volume of large collaborative programmes, Gansler (2011) describes how defence-industrial firms can be put in strange positions where they may be teaming with rivals on one project, and competing on another. For all of these reasons, some authors contend that collaborative programmes between nations and/or defence industrial firms often don’t realise the benefits that one might expect from them, and Hartley (2011) provides a good case study of Typhoon in this context.

However, as explained above, international collaborative approaches to major defence projects certainly seem to be the direction of future travel, and in a context of increased defence integration globally, ought to become increasingly efficient in delivering effective, more standardised defence products at reduced costs.

The trends towards increased defence integration, both via international collaborations and industrial teaming are very significant for the second theme relevant to OCA that was explained in section **2.1.3;** the relevance of ‘Project Level’ Carbon Accounts for building up relevant ‘Scope 3’ inventories for organisations. It is clear that this has particular relevance for the defence sector, which is characterised by relatively few large, collaborative programmes, and Carbon Accounts of these would be very tangible and relevant for understanding the sector's emissions profile.

Section **2.1.3** made the point that developing these more relevant 'Project Level' Carbon Accounts may require an approach to OCA that is less inhibited by the technical complexities of attributing emissions between organisations and an acceptance that standardised, comparable accounts may not always be available. One can see how this is particularly relevant to the defence industrial context, given the extent to which organisations across the defence sector are integrated and working together.

The next section explains the increasing focus on 'defence capability' in the Defence Industrial Policy literature. This builds on the discussion above of increasing collaboration, and explains the priority to understand the aggregated effect of increasingly inter-operable individual defence products, and joint/allied military operations in complex 'wars amongst people'.

2.2.4 Concepts of Defence Capability

To address an increasingly complex and globalised threat environment, in a period of defence reform characterised by diminishing economic resources, many authors have stressed the importance of understanding 'defence capability' from a system-level perspective. Cornish (2010) explains how:

> 'Capabilities are much more than assets, they are the 'interconnected people, knowledge, systems, tools and processes that establish a company's right to win'. (p.22)

The author stresses the need to move defence debates from second order questions in relation to specific items of equipment, to conversations about strategic outputs and capabilities:

> 'What is required is a shift in emphasis from defence 'inputs' – weapon systems, equipment and force postures – to strategic 'outputs' – the functions required to ensure national security and defence in a challenging and changing environment.' (p.vii)

Gansler (2011) explains how in the US context:

> 'by 2005, the Defense Science Board…observed that the defence industry's independent research and development (R&D that is funded by the firms and not by the Department of Defense) was declining significantly; that resources needed to be shifted from weapons platforms (such as ships, planes, and tanks) to information and systems thinking' (p.5).

Hartley (2011) notes how the UK government has attempted to define defence output in terms of capability, setting the strategic ambition to be able to 'undertake one large scale operation as part of an international alliance, or three small to medium scale operations' (p.22). However, the author confirms that the concept of 'defence outputs' in an economic sense, and by extension 'defence capability', are incredibly difficult concepts to define. When discussing declining force numbers in the UK, he confirms that:

> 'since 1990, there have been substantial reductions in the UK's front-line forces; but published data do not allow any assessment of the effectiveness of these smaller forces and the impact on aggregate defence capability.' (p.12)

Despite the lack of any clear definition of defence 'capability', the concept is widely referred to, and most authors agree that the impact of technical changes on defence strategy can be very significant. Hartley (2011) explains how:

> 'defence is a classic example of technical change and substitution effects. Nuclear weapons have reduced the traditional military advantages of large concentrated land and naval forces; guided weapons, cruise missiles and inter-continental ballistic missiles have replaced some of the roles of fighter, strike, and bomber aircraft, artillery, anti-aircraft guns, battleships and cruisers; and jet transport aircraft which can fly out reinforcements quickly have meant that home bases have replaced many

overseas garrisons. These technical developments have been reflected in strategy' (p.67)

In this context, authors such as Cornish (2010) stress the need for the type of 'joint enabling technologies' being developed in the commercial world as crucial to maximising the 'defence capability' of existing assets, and calls for smaller conventional forces that are more agile and capable:

> 'Expensive 'heavy metal' weapon systems, often a Cold War legacy with little obvious relevance to 21st-century international security, can have a distorting effect on the function/cost value ratio… this ratio could be improved by investing in intelligence, surveillance, reconnaissance and communications technologies; not as 'force multipliers' for a dwindling conventional force configured for a narrow range of contingencies, but as 'output maximizing' strategic assets that enable conventional forces to be put to better use.' (p.vi)

There is widespread recognition across the grey and academic literature of the increasing importance of rapidly developing commercial technology, and how this is key to enhancing defence capability in its wider sense.

Interestingly, the debates in the 1990s had largely been characterised by debates about how the defence sector could most effectively 'spin off' technologies to the commercial sector, thereby justifying the enormous costs of defence to taxpayers via its wider economic benefits. The relevant term in this paradigm case was 'dual use' technologies, and how best to encourage the development of these by defence firms in the post-Cold War period, whilst at the same time limiting proliferation of dangerous technology (e.g. Markusen & Costigan, 1999). These perspectives are indebted to relatively outmoded 'technology push' models of innovation, but nevertheless persist in some of the literature (e.g. Hambling, 2005).

However, over the past twenty years, the increasingly rapid pace of commercial technology development arguably outpaced that in defence, 'a trend that reversed what was typical during most of the 20th century' (Gansler, 2011: p52-53). As a result, more recent concerns have moved away from encouraging 'spin offs', and instead ensuring that defence technology is effectively integrating relevant commercial-off-the-shelf (COTS) technologies into its products, both for the economic and capability benefits they can bring.

This is particularly the case in relation to 'joint enabling technologies', on which there is some specific defence-technological literature (Dombrowski & Gholz, 2006; Adams et al, 2012). The UK Defence Industrial Strategy (Ministry of Defence, 2005) recognised that Command, Control, Communication and Computers, Intelligence, Surveillance, Target Acquisition and Reconnaissance (C4ISTAR) technologies in particular require specific focus, as they are increasingly important to defence but their growth and development are not driven by the defence sector. The US Quadrennial Defence Review recognised similar trends (Department of Defense, 2010a). However, despite this recognition in key strategic documents in the UK and US, there is certainly a perception in the literature that defence is not effectively integrating COTS technologies, and using them to develop defence technology appropriate to the types of 'new wars' described above.

Reasons given for this deficit are partly cultural and relate to institutional resistance to new products in defence and 'cold war equipment' mind-sets. They are partly technical, with

Gansler (2011) explaining the increasing complexity of defence acquisition systems making it particularly unattractive to commercial firms[15]. They are also a consequence of the increasing ‘defence dependence’ of the defence industrial base.

Just as defence departments rely on their domestic defence industry to supply them with the equipment and capability, the defence industry relies on the defence department of its home country (and defence exports allowed by that home country) in order to sustain itself. In this latter sense, defence companies can be characterised by different degrees of ‘defence dependence’. Hartley (2011) defines ‘defence dependent companies’ as those where arms sales represent more than 70% of total sales, but this is not a clearly established threshold on which all authors and commentators agree. In terms of the trends in the largest global defence companies, they are clearly becoming more ‘defence dependent’, in both the US and the European contexts.

This increasingly specialised nature of the defence industrial base is of concern to the sector, given the increasingly rapid development of commercial technology, and its importance to defence products and enhancing their wider capability at the ‘system level’. Perversely, the inability of defence to acquire certain commercial technologies (whether for cultural, technical, or defence industrial reasons) and adjust its product portfolio can undermine military capabilities, just as they can be more easily available to adversaries not subject to the same mind-sets and procurement processes. Many authors in the security studies literature note a ‘levelling’ of the playing field in defence technology, given the potential that commercial technology has to support the intentions of non-state actors. These concerns are echoed in the national security strategies of both the UK and US (Cabinet Office, 2010a; Department of Defense, 2010a).

This section has explained how concepts of ‘defence capability’ are difficult to define, but are acknowledged as increasingly important in the context of rapidly emerging ‘joint enabling’ commercial technologies, and the increasing cost of defence products in an enduring period of budgetary pressure. They emphasise the need to understand ‘defence capability’ at the system level and make appropriate decisions, as opposed to seeing it as a series of individual pieces of equipment.

The debates are very relevant to the discussion of ‘consequential approaches’ to Carbon Accounting, which seek to similarly focus on decision making and positive change at the system level (see section **2.1.4**). One could argue that having some ‘joint enabling’ concepts and/or metrics that could aggregate the carbon impacts of individual defence products in order to determine the ‘system-level’ impacts of defence operations would enable effective decision making in the sector that could better accommodate lower-carbon approaches.

The next part of this Literature Review explores the Innovation Studies literature in order to understand the implications for low carbon technology development that might result from OCA practices in the defence sector.

[15] Gansler (2011) explains that as commercial technology was becoming more advanced, defence procurement regulations were growing increasingly complex. The result was that the defence market was becoming increasingly unattractive to the commercial firms that were producing some of these significant technological advances, both because of export control regulations (p76-77), and some of the cost accounting requirements and profit policies imposed by defence customers (p140-142).

2.3 Innovation Studies

Section **2.1** of this chapter reviewed some key themes of the Organisational Carbon Accounting (OCA) literature, and section **2.2** grounded these themes in the contemporary trends relevant to the Defence Sector. This section reviews the literature associated with Innovation Studies in order to explore the extent to which Carbon Accounting can encourage or inhibit innovation, and the implications for low carbon technology development in the Defence Sector.

2.3.1 Historical Development of the 'Innovation Studies' Literature

'Innovation studies' is a large and complex field that has grown in prominence over the last 50-100 years. As one would expect, is has an established academic literature, with a number of summary works that catalogue the historical development of the field and contemporary context (e.g. Fagerberg, Martin & Andersen, 2013a).

The history of 'innovation studies' is entwined with developments in the defence sector, and some of the key early authors in the field (e.g. Kenneth Arrow, Richard Nelson, Sidney Winter) worked for the RAND Corporation as research consultants to the US military establishment (Hounshell, 2000). The discipline originally had a focus on collecting information and statistics on R&D activities. In the 1950s, it existed 'towards the fringes of the academic world… drawing on existing disciplines, particularly economics and sociology' (Fagerberg, Martin & Andersen, 2013b: p.3). However, this began to change in the 1960s with the establishment of dedicated academic units focused on the study of science, Research & Development (R&D), and innovation. Over the decades that followed, a lively and heterogeneous scientific field evolved drawing on methods, theories and knowledge from several disciplines. This heterogeneity expanded the field from traditional 'linear' models of innovation to 'a more 'systemic' understanding of innovation… which emphasised the complementarities between firms' innovation activities and the characteristics of the environments (national, regional, sectoral) in which they are embedded' (Fagerberg, Martin & Andersen, 2013b: p.4).

However, a theme that seems to recur strongly across all reviews, and that holds particular relevance to this thesis is the contrast between the linear model and the systemic model of innovation.

The linear model is most prevalent in the early 'innovation studies' literature, and particularly the period up to the 1970s. Lundvall (2013) refers to this as the techno-economic perspective in his classification of the innovation literature, and describes this as a complementary perspective to other more recent models, but it is clearly most prevalent in the early years of the field. The linear or techno-economic model has developed as the innovation studies literature has evolved. Schumpeter (1942) was one of the most important authors in early innovation studies, and Lundvall (2013) explains his 'technology push' perspective on how innovation occurs:

> ‘Schumpeter assumed that the demand side does not play an active role in innovative change…he thought that it was the supply side that persuades consumers and users to adjust their prevailing routine behaviour.’ (p.39)

These theories were challenged in the 1960s, with Schmookler (1966) taking the opposite view, as Lundvall (2013) summarises:

> ‘[Schmookler] used a host of empirical data on inventions as well as secondary sources to demonstrate that inventions and innovations tend to flourish in areas where demand is strong and growing. One important outcome of the ensuing debate was a new perspective on innovation as reflecting the interplay between technology-push and demand-pull’ (p.39)

This interplay between ‘technology push’ and ‘demand pull’ can also be described as the ‘chain linked’ or ‘coupled’ model of innovation (Watson, 2009).

However, alongside these developments in the 1970s and 1980s, Freeman (1988) and others were producing work that ‘gave strong emphasis to the role of networking and to the importance of organization of work…preparing the ground for the innovation system perspective’ (Lundvall, 2013: p.41).

Lundvall (2013) comments that it is this ‘innovation systems’ perspective (or socio-economic perspective) that gets closest to a theoretical core of the contemporary innovation studies field:

> ‘the closest we get to a core in innovation studies is the conceptualization of innovation as an interactive process involving many actors and extending over time. The focus of the analysis is upon individuals with heterogeneous skills or upon other organizations with heterogeneous capabilities that interact with one another. They typically engage in information exchange, problem solving, and mutual learning as part of the process of innovation. In the course of this, they establish ‘relationships’ that may be interpreted as forming organizations, networks, clusters, or even ‘innovation systems’’ (p.33)

The author describes how this ‘innovation systems’-perspective is central to all of the most recent ‘top-cited’ works in innovation studies, and therefore to some extent can be seen to have superseded the linear model, although they can also be seen as complementary models to use.

In practice, this means that organisations wishing to innovate are more likely to be successful if they can successfully engage widely and specifically beyond the skills that exist within their own organisation or ‘firm’:

> ‘in general, during the last few decades, the strongly firm-centric focus from the field’s early years has given way to a broader perspective that places more emphasis on the environment in which firms operate, in particular the innovation system(s) in which they are embedded…these insights have led to the development of ‘systems’ approaches that put interactions, between firms as well as between agents in the private and public centres, at the very centre of the analysis’ (Fagerberg, Martin & Andersen, 2013b: p.6-7)

This is also the context in which we hear references to ‘network society’, or ‘open innovation’, as Lundvall (2013) describes:

> ‘flat organizations with extensive horizontal communication are more efficient than hierarchical organizations with barriers between functions…One can see references to ‘the network society’…and ‘open innovation’…as pointing to another important dimension of the learning economy. In an era of growing complexity and rapid change, it is becoming increasingly difficult to locate all the necessary competencies inside the organisation.’ (p.52)

The next section reflects on these different stages of development in the Innovation Studies literature, and uses them to characterise existing calls for the defence sector to engage in low carbon technology innovation.

2.3.2 Contextualising calls for the Defence Sector to Develop Low Carbon Technologies

The development of the academic discipline of 'innovation studies' provides some useful context to the way that the defence sector is being characterised as an 'technology innovator' in climate change debates. Most of these arguments can be related to earlier 'technology-push' and 'demand-pull' models of innovation, and therefore are arguably not the most appropriate arguments for how the defence sector can support innovation in contemporary socio-economic models of innovation.

From a 'technology push' perspective, the simple idea that defence could develop 'game-changing' low carbon technologies through basic R&D for energy technologies would be challenging in the modern context described above where innovation is no longer assumed to take place within the 'firm', but rather as part of a broader 'networked' landscape. To underline the significance of this point, defence R&D spending has been decreasing relative to the commercial sector for some time. Hartley (2011) explains how the drive to standardise defence products explained in section **2.2** ('Defence Industrial Policy') inevitably reduces the emphasis on R&D, as defence firms seek to build on existing knowledge rather than reinvent. Gansler (2011) explains how in the US context:

> 'by 2005, the Defense Science Board…observed that the defence industry's independent research and development…was declining significantly' (p.5)

R&D spend within the defence departments themselves remained higher (particularly in the US, where defence department R&D is significantly higher than in Europe[16]), but Gansler (2011) shows how federal R&D has been rapidly outpaced by commercial R&D since the 1990s (see Figure 4 below):

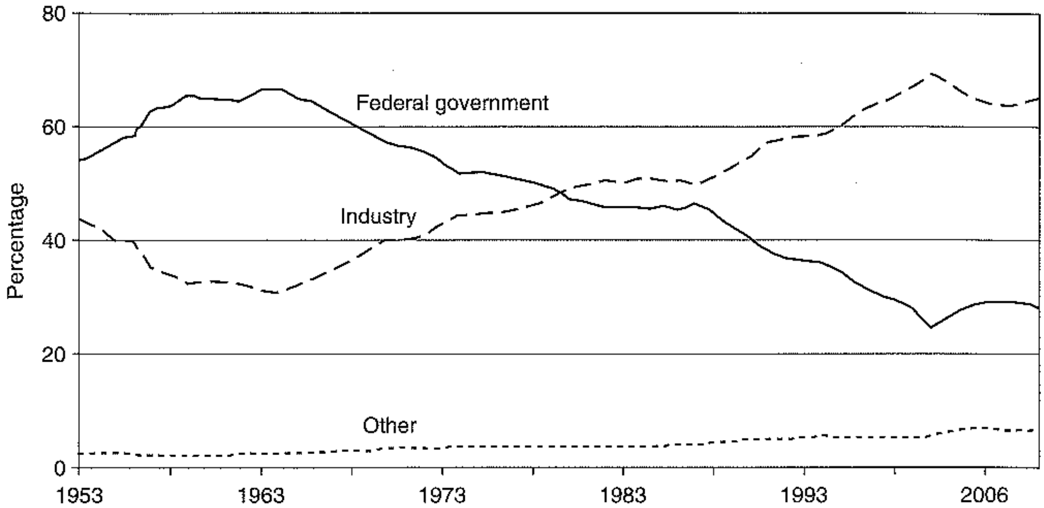

Figure 4: Showing the R&D expenditures by funding sector, 1953 to 2007. Commercial activity can be seen to gradually out-pace federal activity to become the major source of R&D spending. (Source: Gansler, 2011: p.257)

[16] Gansler (2011) suggests that 'US R&D is typically three to four times as large as all of Europe combined' (p.18)

Despite these trends, Defence R&D spending remains high (particularly in the US), and Gansler (2011) still expects technological 'spin-offs' from the sector, but the author encourages the majority of resources to be focused on avoiding technological surprises in an era of rapidly developing commercial technology. Some commentators have noted the scale of commercial R&D going specifically towards energy technology, and the challenge that defence has of simply keeping up to date with this area of research, let alone shaping it (Stein, 2009).

The second more popular, and possibly more relevant call for defence to engage in the development of energy technologies refers to the purchasing power that defence has to 'pull through' relevant emerging energy technologies and help support them in the period between demonstration and commercial deployment ('demand pull' models of innovation). These calls begin by providing some context on the Fully Burdened Cost of Energy to defence. The US Defence Science Board (Department of Defense, 2008b) confirms that the military has a strong internal rationale to help support emerging energy technologies through 'demand pull':

> 'If DoD were to invest in technologies that improved efficiency at a level commensurate with the value of those technologies to its forces and warfighting capability, it would probably become a technology incubator and provide mature technologies to the market place for industry to adopt for commercial purposes.' (p.36)

Amory Lovins of the Rocky Mountain Institute has perhaps championed the issue of US DoD leadership on energy technology development through demand pull most fervently. For Lovins (2010), DoD should act as:

> '[A] Catalyst for leap-ahead fuel savings in the civilian sector, which uses more than 50 times as much fuel as DOD. Valuing saved military fuel at FBCF [The Fully Burdened Cost of Fuel] will drive astonishing innovations that accelerate civilian vehicle efficiency, much as past military investment yielded the Internet, Global Positioning System, and jet-engine and microchip industries. Such efficiency leapfrogs in cars, trucks, and planes could wean the United States, ultimately the world, from dependence on oil—the biggest security win of all.' (p.6)

His calls have been repeated by a number of think tanks that recognise the mutual benefit of the military buying and using these emerging technologies (e.g. Posner, 2010). A Deloitte study (2009) asserts that 'the DoD will necessarily become a test bed for large-scale trials and validation for new alternative energies, due to the significant usage of fossil fuel energy requirements' (p.27). There are real institutional precedents in the US for this, with the Defence Advanced Research Projects Agency (DARPA) regarded as having been very successful in taking emerging technologies from the demonstration stage to successful commercial deployment (Watson, 2009).

However, the question remains as to the extent to which 'demand pull' approaches in defence can incubate emerging energy technologies to the extent that they can compete commercially. The DSB Task Force on Energy Security (Department of Defense, 2008b) concede that 'the overall national outcome of changing DoD business processes to accurately value efficiency is difficult to predict' (p.36), and Posner (2010) raises similar questions:

> 'from an economic standpoint, it remains to be seen whether DOD's buying power will be sufficient to bring renewable and alternative energy prices down to competitive levels in the U.S. marketplace absent policy action at the national level.' (p.3)

These uncertainties have particular resonance given the context of 'defence austerity' discussed in section **2.2** on Defence Industrial Policy.

This research contends that an acknowledgement of the more complex, networked landscape for innovation described in the previous section would be welcome in these debates about defence's role in developing low carbon technologies.

Lehtonen and Kern (2009) describe how a useful perspective from which to analyse change in these types of broad 'innovation systems' is to base the discussion around 'transitions to socio-technical regimes'. The next sections introduce this concept and discusses the potential interaction with Carbon Accounting in the defence sector.

2.3.3 Transitions to Socio-Technical Regimes

Lehtonen and Kern (2009) introduce the concept of Socio-Technical Transitions as a means to understand change at the 'system-level':

> 'A…useful perspective, which would identify the possibilities and obstacles to more fundamental system transformations, is to focus on transitions in 'socio-technical regimes'. Analysis from this perspective can help to understand the dynamics, mechanisms and patterns through which transitions come about, instead of seeing change as a function of supply and demand structures and individual responses to market incentives.' (p.104)

The authors discuss the energy system as a 'socio-technical regime' in this context:

> 'The 'socio technical energy regime' consists of a set of technologies embedded in a social, political and institutional context, with its associated regime-specific set of rules, procedures, habits and practices…Together these aligned elements of the regime provide services such as electricity or heat, but also have undesired consequences such as GHG emissions.' (p.104)

No doubt a similar description could be derived for the 'defence enterprise', which similarly will have a 'regime-specific set of rules, procedures, habits and practices'. These 'rules, procedures, habits and practices' are not fixed but are seen to 'evolve', as Scrase & MacKerron (2009) describe in relation to the 'evolution' of the automobile industry:

> 'private and often non-commercial organisations emerged to facilitate, and to lobby for, expansion of private automobile use. Organisations were formed to train auto engineers, and academic disciplines and departments created to provide higher-level technical know-how. Unions, users' clubs and journalists all joined a 'large, self-sustaining network of like-minded professionals and institutions that are invaluable to the growth of the system'…This creates a political constituency for further growth of road transport. Meanwhile societies co-evolve with technologies, and social norms, behaviour and even settlement patterns adapt such that people depend on (and therefore naturally have a preference for) car ownership and private transport.' (p.94)

However, directing the 'evolution' of these 'socio-technical regimes' (for example, to encourage the adoption of low carbon technologies within them) is not straightforward. The energy system in particular is seen as a 'socio-technical regime' that is fairly resistant to change, as Woodman & Baker (2008) describe:

> 'As the UK's energy systems became increasingly centralised from the 1950s onwards, technical approaches to network design and operation, embodied in various engineering standards and codes, were developed to reflect the characteristics of centralised generation. Following privatisation, the energy system also influenced the way in which electricity markets were designed to reward large-scale, flexible and predictable generation, and the design of regulations to govern the financial operations of monopoly network operators. In economic theory, these two trends can be seen as centralised generation becoming 'locked in' to the system…The technology gradually influenced the design of institutional and economic aspects of the system, and excluded other, increasingly less viable alternatives. The 'increasing returns of adoption' enjoyed by centralised plant acted

> as a disincentive to invest in smaller projects, which became locked out by the economic, political, social and legal support for locked in, centralised generation.' (p.2)

This research has not uncovered a similar description of the 'defence enterprise' as a socio-technical regime, but the development of defence acquisition process over a similar time period could likely be described in similar terms, particularly with respect to their acceptance of disruptive narratives in relation to their energy use, as Lovins (2010) describes in calling for strong leadership from DoD on the issue:

> 'Often the very technology that can provide the United States with a disruptive advantage is itself disruptive to DOD's culture, and antibodies rapidly and reflexively form to reject it. Yet such disruptive concepts can be so clearly beneficial that masterful and resolute leadership breaks through hesitancy and resistance. This is the Department's imperative today.' (p.7)

However, changing socio-technical regimes (for example, to better develop and accommodate low carbon technology) can be difficult due to the power acquired by incumbent actors in them, who are likely to favour an extension of the status quo[17]. It goes beyond Lovins call above for 'strong leadership' alone, and Smith (2009) explains how existing power relations need to be acknowledged to understand transitions to socio-technical regimes. Smith (2009) argues (in relation to the energy system) how the authority and interests of incumbent actors can be challenged:

> 'When sufficient political will combines with public authority and widespread legitimacy, then powerful actors can be challenged, and resources redistributed toward other policy goals. Change comes about when the legitimacy of practices, often underpinned by powerful, economically, and technologically resourced actors, is widely called into question. Under such circumstances, the importance of the incumbents is no longer considered to outweigh the problems caused by their practices. New problems, like climate change, and new ideas, like sustainable energy systems, cast the 'status quo' in a troubling light. They throw open possibilities for change.' (p.70-71)

Gaining 'sufficient legitimacy' is complex however, and requires participation in the energy debates (or 'defence energy debates' in our context) to be widened beyond the incumbent actors; to other sectors, different companies, new institutions, or individuals.

It is in the sense of 'widening participation in order to gain sufficient legitimacy for change' that Carbon Accounting is relevant to the prospects of changing socio-technical regimes.

[17] Scrase & MacKerron (2009) note in relation to the energy system how 'market structures tend to favour incumbents, who will be well adapted to the existing energy system, with all its inevitably locked in characteristics' (p.97)

2.3.4 Discourse Perspectives and the Link to OCA Practices in the Defence Sector

Publicly reported OCAs – as the means by which information (quantitative and qualitative) is presented to both internal and external stakeholders – is fundamentally relevant to the topic of ‘widening participation’ in defence-energy debates. It is the main information source available to these parties about defence sector organisations carbon impacts, and activities to mitigate climate change.

Scrase & Ockwell (2009) discuss ‘discourse perspectives’ as particularly relevant to ‘widening participation’ in the ‘socio-technical energy regime’, and the concepts are very relevant to the themes of this research. Dryzek (1997) describes discourse as:

> ‘a shared way of apprehending the world. Embedded in language it enables subscribers to interpret bits of information and put them together into coherent stories or accounts. Each discourse rests on assumptions, judgements and contentions that provide the basic terms for analysis, debates, agreements and disagreements’ (p.8)

Most public policy debates (whether Energy Policy, Carbon Policy, or Defence Industrial Policy) can be seen as ‘as a struggle for ‘discursive hegemony’ in which actors seek to achieve ‘discursive closure’ by securing support for their definition of reality’ (Scrase & Ockwell, 2009: p.41). Whilst this is a very broad concept, the way in which carbon is accounted and reported in the defence sector clearly plays a part in determining this ‘definition of reality’.

Lengyel (2007) refers to similar academic literature relevant to the ‘myths by which organisations operate’, and notes the following in relation to DoD energy use:

> ‘As an organization matures, it develops a positive ideology and a set of myths about how it operates. The organization continues to operate by the shared tacit assumptions that have worked in practice, and it is not unlikely that the espoused theories, the announced values of the organization come to be, to varying degrees, out of line with the actual assumptions that govern daily practice. In the case of DOD energy use, this assumption would be the assumption that energy is cheap, plentiful, and for someone else to worry about…Where these differences exist, scandal and myth explosion become relevant as mechanisms of culture change. Left to themselves, change will not occur until the consequences of the actual operating assumptions create a public and visible scandal that cannot be hidden, avoided, or denied.’ (p.34-35)

Of course, better that change can be encouraged without the need for a public and visible scandal. The themes of OCA most relevant to the defence sector that have been discussed in this chapter each relate to the way that defence sector Carbon Accounts are ‘presented’ to external stakeholders, and as such they form the basis for the ‘analysis, debates, agreements and disagreements’ that follow, and by extension the extent to which new companies, institutions or individuals participate in defence-energy debates. They play a role in determining the ‘definition of reality’ that they cumulatively help create. In this sense, this research is exploring how Carbon Accounting practices can best ‘frame’ defence-carbon problems and solutions in ways that favour low carbon technology innovation.

Scrase & Ockwell (2009) describe how the concept of 'storylines' is very relevant to the way that debates are framed. These storylines can when established, rapidly evoke a whole discursive system and 'frame' debates that might support or undermine low carbon technology innovation:

> 'actors do not draw on a comprehensive discursive system, instead this is evoked through storylines. By uttering a specific word or phrase, for example, 'global warming', a whole storyline is in effect reinvoked; one that is subtly different, for example, to that of the 'anthropogenic greenhouse gas effect' or 'climate change'.' (p.41) …
>
> 'Storylines are therefore much more than simply 'arguments'. The meanings and connotations of familiar storylines are often recognised at an almost subconscious level. They can thus act to define policy problems while obscuring underpinning interests, values and beliefs. They can add credibility to the claims of certain groups and render those of other groups less credible. They therefore act to create social order within a given domain by serving as devices through which actors are positioned and ideas defined and linked together.' (p.41)

Scrase and Ockwell (2009) discuss the nature of, and the need to, create new storylines in the UK – citing acid rain as one example that took over a decade to change the storyline:

> 'in this view, to shape policy, a new discourse must dominate in public and policy discussions, and penetrate the routines of policy practice through institutionalisation within laws, regulations and organisations. In terms of policy change then, promoting a new storyline is a difficult task, involving dismantling those promoted by those actors who were able to achieve prominence for their claims and viewpoint originally…and which may have become embedded in institutions.' (p.42)

In the defence context, we might expect that the task of establishing relevant storylines that support low carbon technology innovation is therefore made more difficult by existing OCA practices that do not easily relate to underlying emissions producing activities. The fact that organisational GHG totals can in aggregate appear fairly abstract and opaque means that their potential to create relevant storylines is significantly undermined.

Scrase & Ockwell (2009) discuss how 'storylines' and the discursive systems they evoke, can recruit a range of actors into 'discourse coalitions'. The following quote stresses the interpretative capacity of 'storylines', which means that various potential audiences can interpret them (or misinterpret them) at different levels:

> 'Institutional arrangements are important in structuring discourses, forming routine understandings. Complex research findings or logical arguments are often reduced to an eye-catching visual representation or memorable one-liners. These gloss over real complexities and uncertainties, and entail significant loss of meaning. This allows considerable flexibility in interpretation, which helps recruit people with differing views into a 'discourse coalition'.' (p.41-42)

'Project Level' Carbon Accounts certainly still have the potential for mis-interpretation, given the complexity of defence products, but regardless offer the potential to create much more compelling 'storylines' than existing OCAs that can seem far more abstract. In this sense, they have the potential to 'recruit' new and relevant actors into a 'discourse coalition' that can begin to challenge the status quo in relation to defence energy issues.

Lehtonen & Kern (2009) describe how socio-technical systems can experience structural change as a result of interactions between different levels:

> 'The 'landscape level' encompasses factors beyond the control of individual actors, such as demographic developments, culture or external events (e.g. oil shocks). 'Niches' are protected spaces where novel technologies, ideas or practices emerge, some of which can come to challenge the dominant regime… Structural change occurs over extended periods of time through interactions between these landscape- and regime-specific levels and niches' (p.104)

Thus, efforts to support the development of low carbon technologies from the perspective of an individual Carbon Account should be aware of these 'niche' and 'landscape'-level interactions. The 'storylines' at the 'niche' and 'landscape' level could become mutually reinforcing, in order to best support the creation of a supportive selection environment for low carbon technology.

Reiterating the themes from **2.3.3** above ('Transitions to Socio-Technical Regimes'), Watson (2004) explains how a 'prevailing technological paradigm' (or socio-technical regime as described above) 'embodies strong prescriptions on the directions of technical change to pursue and neglect' (p.1068) and introduces the concept of a 'selection environment' for individual technologies in this context. Glynn (2002) applies the 'network perspective' also mentioned above to the 'selection environment' concept, explaining that:

> 'An alternative way of looking at the idea of the selection environment is from a network perspective. Innovation becomes a 'seamless web' where the political, economic and technical cannot be separated…There is no distinction here between an internal and external environment; both are part of the same network and, hence, if an innovation is to be successful then the market has to be constructed just as much as the technology.' (p.937)

Glynn goes on to describe how important 'negotiation' is to network building, in this context:

> 'Negotiation lies at the heart of network building as actors attempt to define roles through translation into a particular network. In attempting to translate users, i.e. getting them to adopt a particular technology, it can be argued that expectations play a crucial role. In marketing an innovation firms will situate their product within a wider context. However, expectations are ambivalent as they express what can be a matter of fact (in the future), but what they express is not (yet) a matter of fact, and users are rarely faced with one view of the world. Hence, there is a need to examine how users interpret the context in which they are making selection decisions when they are faced by multiple networks and differing expectations regarding possible technologies.' (p.937)

Hughes (1983) sums up how the micro-selection environment for an individual technology needs to be seen in the context of the wider socio-technical regime, and therefore how crucial are the 'niche' and 'landscape-level' interactions emphasised in this section:

> ‘As cultural artefacts, [technologies] reflect the past as well as the present. Attempting to reform technology without systematically taking into account the shaping context and the intricacies of internal dynamics may well be futile. If only the technical components of systems are changed, they may snap back into their earlier shape like charged particles in a strong electromagnetic field. The field must be attended to: values may need to be changed, institutions reformed, or legislation recast.’ (p.465)

Therefore, in order for Defence Sector Carbon Accounting practices to encourage low carbon technology innovation, they need to create relevant storylines in isolation (e.g. by developing relevant ‘Project Level’ Carbon Accounts), but these also need to interact with – and mutually reinforce – consequential carbon accounts relevant to the wider ‘landscape-level’ and narratives around defence capability.

2.4 Summary of the Literature Review and Key Themes

The introduction explained the exploratory, inductive approach to this research, as it is a field where the academic literature and professional practices are still evolving (see section **1.3** 'The Research Approach'). Just as this approach informs the research methods used that are described in the Methodology (**3**), it also informs the approach to the academic literature. Sector-level studies of Carbon Accounting are rare in the literature at present, and as such an exploratory approach has been applied that has reviewed three separate academic fields that are all relevant to this research.

The first part of the Literature Review began by contextualising Organisational Carbon Accounting (OCA) specifically within the wider field of Carbon Accounting, that can be categorised over a number of reporting 'scales' (**2.1.1**). Each of sections **2.1.2-2.1.4** then introduced a key theme of the OCA literature that is relevant to this research, and some associated maturity gaps in the existing literature and their potential consequences.

Section **2.1.2** described the difficulty in attributing emissions to different organisations in a standardised way that retains relevance. It introduced the GHG Protocol as the most commonly used standard for OCAs, which is open to wide interpretation in practice (WRI, 2004). The literature notes the significant potential for variance in the ways that existing OCAs are produced (Morel & Cochran, 2016). There is a drive to standardise approaches within specific sectors (e.g. IPIECA, 2003; IAEG, 2016) in ways that do not create significant barriers to entry for organisations wishing to produce OCAs. Bellassen et al. (2016) identify 'cost vs uncertainty' and 'comparability vs relevance' as two trade-offs that are common to all Carbon Accounting schemes, and suggest that as Carbon Accounts become more standardised or comparable (in a pragmatic and relatively low-cost way), they could also become less 'relevant' to the underlying organisational activities that produce the emissions.

Section **2.1.3** described the potential of 'Project Level' Carbon Accounts to make organisational reporting more meaningful. Existing OCAs tend to be immature in terms of their reporting of scope 3 emissions and therefore the full carbon impact of an organisation across the value chain is rarely explained. Organisations tend to focus on certain categories of scope 3 reporting that are not the most relevant ones (CDP, 2013). Some authors suggest that the scope 3 category of emissions is too broadly defined at present, and that a 'scope 4' should be introduced to distinguish the aspects of scope 3 relevant to the product lifecycle (Matthews, Hendrickson & Weber (2008). This concept is currently rare in the academic literature and receives very little take-up in practice. Life Cycle Assessment (LCA) is very relevant to any 'scope 4' account, but the variability of LCA methodologies conflicts with the drive to standardisation in existing OCAs. There is lots of interest in applying LCA and project level assessments to corporate footprints (Harangozo, Szechy & Zilahy (2015), but no companies are known to have used product footprints to devise company-wide results as yet (Gibassier, 2015).

Section **2.1.4** introduced a third theme of the Carbon Accounting literature, explaining the usefulness of 'consequential accounting' perspectives for connecting OCAs to decision making and positive change at the system-level. Where 'attributional methods [of Carbon Accounting] provide static inventories of emissions allocated or attributed to a defined scope of responsibility … consequential methods attempt to measure the system-wide change in emissions that occurs as a result of a decision or action' (Brander & Ascui, 2015, p.100). The distinction has emerged in the field of LCA and is little known in the field of OCA due to the dominance of attributional mindsets (Brander & Ascui, 2015). The authors note its relevance for OCA however, given that organisational accounts can and do inform decision making.

These three 'themes' of OCA that have been highlighted in the Literature Review' recur through this thesis as a whole. The summary above clarifies some existing gaps in the literature that will be explored throughout the remainder of the thesis.

Whilst the focus of this research is Carbon Accounting, the second and third parts of this Literature Review summarised some essential supporting literatures to the investigation. The maturity of these literatures and their relevant gaps was of less interest than with the Carbon Accounting literature above. Instead, they were reviewed for content linking to the themes described above for the Carbon Accounting literature, which can inform the research more broadly.

The second part of the Literature Review provided a focused review of the Defence Industrial Policy literature, introducing the literature (**2.2.1**), and then functioning to connect the themes from the OCA discussion with some of the key trends that are relevant to the defence sector. Section **2.2.2** explained how the challenge of attributing emissions to individual organisations is particularly marked in the defence sector due to the very close working relationships between defence departments and their supporting industrial base. Section **2.2.3** described how 'Project Level' Carbon Accounts would be particularly useful in the defence sector, as multiple organisations often collaborate and 'team' around large scale industrial programmes. Section **2.2.4** explained the relevance of concepts of 'defence capability' to the debates concerning consequential approaches to Carbon Accounting, due to their mutual focus on understanding system-level impacts in order to make effective decisions.

The third part of the Literature Review provided an overview of the Innovation Studies literature (**2.3.1**), and used this to characterise existing calls for the defence sector to develop low carbon technologies as being based on outdated models of innovation (**2.3.2**). It explained how contemporary innovation can be understood in the context of transitions to established 'socio-technical' regimes (**2.3.3**), and Carbon Accounting can play a discursive role in establishing coalitions that can challenge incumbent interests and the accepted status quo (**2.3.4**). With reference to the themes described above, the review suggests that Carbon Accounting methods that are abstract in nature (such as existing OCAs) are unlikely to engage the most relevant organisations to the task of reducing GHGs, whereas 'Project Level' Carbon Accounts have the potential to better represent underlying emissions-producing activities, and therefore would be more likely to recruit new/relevant actors to defence-energy debates and support the development of low carbon technologies in the sector. Moreover, by connecting 'strategic narratives' around defence capability with OCAs that are informed by the type of 'Project Level' methodologies discussed above, it could be possible to construct a positive selection environment for low carbon technologies in the defence sector.

The introduction summarised the relevance of an exploratory approach to this research (see **1.3** 'The Research Approach'), which applies throughout the thesis. Just as this section has described the broad interdisciplinary approach to the academic literature, the Methodology chapter (**3**) that follows explains how an exploratory interpretivist approach was applied to relevant sources of public information about GHGs and climate change that have been produced by a sample of defence sector organisations. Section **1.3** ('The Research Approach') remarked on the speed at which real-world initiatives to govern climate change are emerging, creating a huge plethora of sites of enquiry, as all inevitably involve some element of Carbon Accounting. This 'tremendous diversity and dynamism' (Bulkeley & Newell, 2010, p.114) in relation to the activities underway to mitigate climate change makes an exploratory archival research strategy highly appropriate for connecting the themes from the emerging academic literature above with the activities already underway in the defence sector, as evidenced by relevant public sources of information.

The next chapter describes how the themes from this Literature Review have informed the design of the archival research strategy, and the relevant quantitative and qualitative methods used.

3) Methodology

This research is the result of an Industrial CASE Studentship between the University of Central Lancashire (UCLan) and BAE Systems, one of the world's largest aerospace, defence and security companies. The research began in late 2010 and will complete on a part-time basis by January 2017.

This Methodology chapter describes in detail the research approach taken. Both the academic context for the research and the way in which it has been carried out has made an exploratory, inductive approach highly appropriate. A flexible approach that allowed relevant patterns to emerge throughout the research made sense in a context where both the academic field and professional practice were still emerging.

The 'Aims and Objectives of the Thesis' section (**1.4**) established two objectives relevant to the Methodology chapter.

The first was to understand the relevance of an exploratory archival research strategy for analysing Carbon Accounting and climate change information produced by defence sector organisations. The exploratory, inductive approach to the research makes sense given that relatively little is currently known about the subject, but there are increasing quantities of public information being made available by organisations across the world.

The exploratory, archival research strategy is also particularly relevant for analysing the three 'themes' established in the Literature Review.

The first theme related to the difficulty allocating emissions between organisations in existing OCAs, which is likely to be particularly marked in the defence sector due to close working relationships, and may result in abstract OCA that does not engage relevant actors to the task of reducing GHGs. This theme clearly requires a detailed review of organisational documents across the defence enterprise in order to understand all relevant OCAs that exist in the sector at present, and will inevitably involve some element of quantitative analysis. However, qualitative datasets and analysis will also be required to understand levels of 'engagement' with climate change mitigation in order to investigate this theme.

The second theme discussed the potential for 'Project Level' Carbon Accounts, focused on large-scale collaborative programmes to better account for the emissions of the sector in a way that engages new/relevant actors to defence-energy debates, supporting low carbon innovation. This necessitates a review of all relevant Scope 3 Carbon Accounts that exist in the sector at present, as well as gaining some understanding of the maturity of 'Project Level' Carbon Accounts in defence organisations.

The third theme related to the potential for 'consequential carbon accounting' perspectives to align with concepts of 'defence capability', and inform wider strategic narratives that help construct a positive selection environment for low carbon technologies in the defence sector. This theme would benefit from a broad review of relevant grey literature across the defence enterprise in order to identify and understand any relevant concepts or metrics that might link to consequential carbon accounting approaches. These might be primary data sources from the organisations included in the research or secondary data sources from think tanks and consultants active within the defence enterprise.

Taken together, all three themes present a clear need to conduct a broad review of relevant public documents available across the defence enterprise, and therefore an archival approach supports the core of the research strategy. The research has reviewed both narrative and numerical information on energy use, GHGs and climate change mitigation across the UK MoD and US DoD, as well as the ten largest multinational defence companies, and relevant grey literature provided by think tanks and other organisations related to defence.

The second objective for the Methodology from section **1.4** ('Aims and Objectives of the Thesis') was to apply the exploratory archival strategy, and the different parts of this section explain in detail how relevant primary and secondary sources of data have been identified and reviewed for quantitative and qualitative data.

In terms of the structure of this Methodology chapter, the next section (**3.1**) provides a thorough overview of the research approach that has been applied with reference to the Research Onion (Saunders, Lewis & Thornhill, 2015), which is a method of breaking down the different stages of a research strategy. Section **3.1** summarises the broad research philosophy, approach and strategy, before subsequent sections focus on more detailed stages of the Research Onion. It justifies the inductive approach taken within an interpretivist research philosophy, and reiterates the relevance of a strongly archival strategy to this research. Section **3.2** describes how the sample was selected, and explains which defence sector organisations have been included in the research. It explains how this sample covered a significant proportion of the defence sector by spend, and allows the analysis to extend across different regions and types of defence company. Despite several complimentary strategies being used, the research is fundamentally underpinned by an archival strategy and section **3.3** describes how this was designed, with reference to the organisations included within the research sample. It explains a rationale for selecting relevant public documents for the organisations in the sample, and a systematic approach to identifying these. With a large selection of relevant documents selected, section **3.4** then describes how quantitative datasets were established for GHG and energy data, as well relevant normalising data. Qualitative datasets were also established in relation to energy and climate change keywords used in the documents, and any public targets or ambitions being communicated by them. Section **3.5** describes relevant secondary data sources that have been identified and used in the research. These sources of defence-energy grey literature provide some additional context to the data identified in the primary sources from the organisations in the sample. The summary in section **3.6** re-iterates some of the key aspects of the research philosophy and describes the suitability of the datasets established for the correlational analysis that follows in the Results chapter (**4**).

3.1 The Research Approach

The research approach is described with reference to different layers of the Research Onion, as described by Saunders, Lewis & Thornhill (2015). This section focuses on the outer layers of the Research Onion, focusing on the research philosophy, approach, and strategy. Subsequent sections of the Methodology explain the more detailed stages of the research.

Research philosophies are often grouped into two main ontological frameworks that can be broadly described as positivist or interpretivist. Bryman (2012) summarises different descriptions for these opposing frameworks but explains how the underlying assumptions are broadly similar. Where positivist approaches assume that reality exists independently of the thing being studied and is interpreted consistently, interpretivist approaches never presume that what is observed is interpreted in the same way between participants and it is their responses that create the inherent meaning of social phenomena.

This research is situated on the interpretivist end of this spectrum. It is clear from the Literature Review on Organisational Carbon Accounting (**2.1**) that methodologies are not standardised and allow significant interpretation, therefore numerous value judgements will be required by users in order to produce an OCA. Perhaps more significant is the significant room for interpretation in relation to how these OCAs are used, and the literature on consequential carbon accounting perspectives (**2.1.4**) described how attributional carbon accounts can be used for purposes to which they are not suited, potentially generating unintended consequences. It is the interpretative nature of OCAs that make the subject interesting and relevant in the defence context, and this research is concerned with how they can be made more useful so that more people engage positively in defence-climate change debates.

The two ontological frameworks that help define the research philosophy have an impact on the research approach taken. There are many ways to define a research approach and therefore no fixed rules, but positivist philosophies can align well to deductive approaches to research. Deductive approaches develop hypotheses upon pre-existing theories and then formulate research approaches to test these. In this context, scenarios where reality is assumed to exist independently of the thing being studied and consistently interpreted can be supportive. In contrast, interpretivist philosophies can align well with inductive research approaches. Inductive approaches assume that observations are the starting point for the researcher, and patterns are looked for in the data. There is no framework or theory that initially informs the data collection and instead new theories and hypotheses can be generated after that data has been collected – or appropriate existing theories identified.

It follows that this research uses an inductive research approach that aligns well with the interpretivist philosophy that defines it.

An inductive research approach has made sense given the industrial nature of this research with significant opportunities for participatory learning, as well as the long length of time over which it has taken place within a field where both professional practice and academic analysis are still relatively immature and evolving.

Inductive approaches are also supportive of mixed-method and multi-method approaches to establishing a dataset, and the latter approach (distinguished by the creation of separate datasets rather than one consolidated dataset) has been essential to use in this research given that there are some limitations on the volumes of quantitative data available, and therefore all data (quantitative and qualitative) is relevant. A wide exploration of both types of data is also relevant for avoiding bias, as certain organisations in the defence sector may favour quantitative information over qualitative, and within these categories certain indicators might provide contrasting results.

Having understood the need for an inductive research approach within an interpretivist philosophy, there were several research strategies that were relevant.

Grounded Theory is relevant to the research (Birks & Mills, 2015), and techniques commonly used in Grounded Theory do inform the way that documents have been analysed and datasets established. For example, the 'constant-comparative' approach for reviewing documents for codified energy and climate change keywords. However, the research could not be described as Grounded Theory is this implies a specific methodological approach where patterns are derived from the data as a precondition for the study, whereas the strategy used here has been more flexible than that and sought relevant theories and frameworks from the literature alongside analysing the data.

Aspects of the research could be linked to 'Action Research' approaches (Bryman, 2012), given the unique 'community of practice' within which the research is located (defence), and the focus on finding a practical approach to a specific real-world problem (how OCA practices can support low carbon technology innovation).

Similarly, 'Ethnography' (Bryman, 2012) inevitably has some impact on the research strategy in a part-time industrial PhD where the researcher is embedded within an organisation that is part of the study. Close observation of people and their cultural interactions across the defence sector has been inevitable, and alongside this a necessary requirement to see things from their perspective. There are some precedents in the literature for industrial PhDs that have been focused on GHGs and Climate Change (Gibassier, 2015), and there are a number of considerations relevant to the industrial researcher, as whilst it is an ideal environment for participatory learning and provides a more detailed contextual understanding of specific issues (Schensul, Schensul & LeCompte, 1999), it can influence the independence and impartiality of the researcher, and associated findings can be subjective (Bluhm, Harman & Lee, 2011). This raises issues of ethics and bias. The issue of bias is discussed more fully in section **3.2** that discusses how the research sample was selected. The issue of ethics is largely countered by the strongly 'archival' strategy that has been applied to this research, with the analysis founded upon information available in the public domain, and a common approach applied to each organisation in the sample (see section **3.3** on designing the archival research method).

Indeed, despite the numerous research strategies above all having some relevance, it is the 'Archival Research Strategy' that has been by far the most influential one to this research. Despite the evolving nature of the Carbon Accounting field, both professionally and academically, there is a sufficient volume of public information being produced by organisations across the defence enterprise that there was a clear benefit to reviewing this material in a focused and systematic way.

This section has described some of the key layers of the Research Onion (Saunders, Lewis & Thornhill, 2015) relevant to this research: namely the research philosophy, approach, and strategy. Subsequent sections analyse different layers of the Research Onion, and the next one focuses on selecting an appropriate sample of organisations from the defence enterprise to include in the research.

3.2 Selecting an Appropriate Sample

This section of the Methodology describes how an appropriate sample of defence sector organisations was selected for inclusion in the research. Given the somewhat unique nature of the defence sector as explained in the Literature Review (see **2.2** on Defence Industrial Policy), the number of organisations available to research in relation to their Carbon Accounting practices is smaller than other sectors, and this trait has been exacerbated by the industrial consolidation that has occurred in the sector in the past 20-30 years. This would arguably pose challenges to a highly deductive research approach that is wholly reliant on quantitative methods, but is suitable for the inductive research approach taken here and the multi-method approach to the data. Therefore, the sample used in this research focuses on twelve specific institutions that have been selected because together they can be seen as being largely representative of a significant part of the defence sector.

The Literature Review on 'Defence Industrial Policy' (**2.2**) explained the importance of understanding the defence enterprise as one complex entity. It was clear therefore, that the research should include grey literature from both defence departments and the supporting defence companies. However, as explained in section **2.2**, the concept of the 'defence enterprise' can be applied at numerous scales, e.g. the 'UK Defence Enterprise'; the 'European Defence Enterprise'; the 'NATO Defence Enterprise'; the 'Western Defence Enterprise' etc. Therefore, selecting a pragmatic boundary to the research became an important methodological choice.

This research has reviewed both quantitative and qualitative information on energy use, GHGs and climate change mitigation across the UK MoD and US DoD, as well as the ten largest multinational defence companies, and relevant grey literature provided by think tanks and other organisations related to defence. The organisations included in this research are therefore as follows:

- The US Department of Defense
- The UK Ministry of Defence
- Lockheed Martin
- Boeing
- Raytheon
- General Dynamics
- Northrop Grumman
- United Technologies
- BAE Systems
- Airbus
- Finmeccanica
- Thales

The selection of these organisations has elements of 'convenience sampling'. The decision to include defence departments from English-speaking countries only has made the archival research strategy easier to applier for an English-speaking researcher. Similarly, the use of large multi-national organisations is convenient for their active distribution of climate change information in mandatory and voluntary public reporting, that also aligns well with an archival research strategy. Smaller defence sector organisations are subject to fewer drivers to report climate change information and therefore would not align as effectively with an archival research strategy.

The use of ‘convenience sampling’ in this way does introduce elements of bias and raises questions as to whether the findings can be generalised across the defence sector as a whole. The remainder of this section provides an overview of the contemporary defence sector in order to demonstrate that the organisations selected are representative of a significant proportion of the sector as a whole. It is split into two further sub-sections. The first (**3.2.1**) provides some helpful context by summarising some key trends in global defence spending, both within and between countries, and with specific companies. The second sub-section (**3.2.2**) then defends the rationale for a ‘convenience sample’ that includes the UK MoD and US DoD, and the ten largest multinational defence companies, headquartered across the US and Europe, arguing that these organisations are representative of the wider defence sector.

3.2.1 Context: Key Trends in Global Defence Spending

The Stockholm International Peace Research Institute (SIPRI) publish useful annual datasets that summarise trends in defence spending globally, both within countries, between countries, and with specific companies (e.g. SIPRI, 2011). Table 4 in Appendix A is taken from SIPRI's 2011 Yearbook Summary (SIPRI, 2011) and shows the top 10 defence spending countries, their budgets and their share of the total spending worldwide by governments on defence. These top 10 defence spending countries represent over 75% of the total worldwide defence spending (SIPRI, 2011), and the table underlines the clear dominance of the US in global defence spending. This military spending data is often communicated in relation to a country's GDP, or in more sophisticated summaries by their level of 'militarisation', as published by the Bonn International Centre for Conversion (BICC – see e.g. BICC, 2009).

SIPRI also provide annual updates on arms sales between countries – or Foreign Military Sales (FMS), which underline the global nature of defence markets. Gansler (2011) provides a useful summary of this data between 1981 and 2005, which is reproduced in Table 5 in Appendix A.

As we might expect, the US is clearly the leader in defence exports, with by the largest domestic industrial base. However, all countries with established defence industries are keen to export, with Gansler (2011) confirming that there are proportionally higher levels of FMS in the EU context than the US. Other trends show that where US FMS were mainly to European allies in the 1980s, the proportion exported to Middle East and Asian countries has steadily increased. The nature of these sales has also changed, from simply buying military products, to buying associated services, and more recently recipient countries are paying to develop the products further themselves (Gansler, 2011).

In terms of the relatively small numbers of consolidated companies that make up this global 'defence industrial base', SIPRI also provide annual updates. Table 6 in Appendix A shows sales and profit data for the top 10 global defence companies in 2013, as published in SIPRI's 2015 Yearbook Summary (SIPRI, 2015). The overwhelming influence of the US is very clear, occupying 6 of the 10 places (Lockheed Martin, Boeing, Raytheon, Northrop Grumman, General Dynamics, United Technologies). The other four companies are all Europe-based (BAE Systems, Airbus, Finmeccanica, Thales).

Despite the locations of the defence companies articulated in the table above the reality is actually much more complex and again underlines the global nature of the industry. All of these companies operate as publicly traded multinational companies with international investors. Gansler (2011) mentions BAE Systems in this context, commenting how:

> 'even though BAE's headquarters was located in London, the company had a large percentage of its employees in the United States, and at any given point, a majority of its stockholders could be US citizens' (p.42)

However, FMS are tightly regulated by host countries, and governments have 'golden shares' that allow them to dictate any significant changes in organisational structures. The companies themselves all tend to prioritise FMS, and have various percentages of ‘international sales’, as shown in Table 7 in Appendix A, which is derived from the annual reports of the ‘top 10’ defence companies listed above.

The defence firms are obviously keen to export, arguing that it reduces costs for host countries and maintains domestic skills and industrial advantage, but FMS represent complex foreign policy decisions for host governments. Gansler (2011) describes the advantages and disadvantages of FMS, and these competing concerns need to be weighed carefully[18].

Perhaps the other key indicator published regularly by SIPRI in relation to defence companies relates to their ‘defence dependence’, which is derived by comparing their volumes of defence and civilian sector sales. Table 8 in Appendix A shows the percentage defence sales of the ten largest defence companies globally that were mentioned above.

Gansler (2011) and Hartley (2011) provide useful summaries of the trends towards increasing ‘defence dependence’ of the world’s largest defence firms in both the US and European context respectively. The variety of ‘defence dependence’ values across the top 10 defence companies above prompt interesting questions as to how similar they are in practice. For example, Boeing and Airbus, with their large civil aircraft businesses, are clearly quite different companies to more defence-focused peers such as Lockheed Martin, Northrop Grumman and BAE Systems. In reality, the former type of companies are often split quite explicitly into defence and non-defence entities, given the regulatory mechanisms required by the modern defence acquisition process.

[18] Advantages include: strengthening the domestic industrial base; providing political support to allies; balancing military capability in a region; preventing countries from aligning with others. Disadvantages include: weapons could be used against the country selling them; third country transfers can occur and contribute to proliferation; they can be supporting politically less desirable nations; they can contribute to regional ‘arms races’

3.2.2 Is the Sample Representative?

As explained above, the organisations included in this research were partly selected for their ‘convenience’, given the availability of sufficient volumes of English-language material that could support a strongly archival research strategy.

The use of ‘convenience sampling’ does introduce elements of bias and raises questions as to whether the findings can be generalised across the defence sector as a whole.

However, as can be seen in the SIPRI data above, the use of the US DoD and UK MoD means that the first and third largest defence spenders globally are included, representing around 47% of total global defence spending.

As regards the large defence multinationals, the inclusion of the top 10 defence multinationals meant that both US and European defence industrial bases were included (with 7 of these companies headquarted in the US, and three in Europe), aligning appropriately with the defence departments selected for inclusion. Due to the consolidation of the defence multinationals described in the Literature Review (See section **2.2 ‘**Defence Industrial Policy’), these companies actually cover the vast majority of the western defence enterprise by revenue.

The importance of the large number of smaller companies that support the large defence multinationals should not be understated[19], but their exclusion is partly explained due to their lack of published information on energy and climate change, with very few mandatory drivers or pressure to enrol in voluntary initiatives. Therefore, it is unlikely that significant value would have been added by including them.

Another concern in terms of the companies selected related to their degree of ‘defence dependence’. This concept was explained in section **2.2** (‘Defence Industrial Policy’) and elaborated above, and given that defence multinationals can be characterised by varying degrees of ‘defence dependence’, it seemed appropriate that both types (‘defence dependent’ and not) should be included in the research. Fortunately, the top 10 companies identified by SIPRI did include examples of both types.

With an appropriate sample of organisations selected for inclusion in the research, the next section describes how the archival research strategy was designed, and relevant information sources were identified and reviewed.

[19] Gansler (2011) describes the separate ‘tiers’ of the defence supply chain, and explains how firms tend to become less ‘defence dependent’ further down the supply chain, and these also tend to be characterised by higher levels of innovation and efficiency. The US QDR (Department of Defense, 2010a) acknowledges the value of the defence supply chain, and is keenly aware of the ‘cascading impact’ on these companies from policy decisions taken at high level.

3.3 Designing the Archival Research Strategy

The previous sections have explained how this research is based on a strongly archival research strategy that focuses on the US DoD, UK MoD, and the ten largest multinational defence companies in the world. This section describes how this archival research strategy has been designed.

There are a number of accepted research designs, and these are often grouped into categories and characterised as either ‘descriptive’, ‘explanatory’, or ‘exploratory’ research designs. Descriptive and explanatory designs can often be associated with deductive research approaches using quantitative research methods and significant sample sizes, whereas ‘exploratory’ designs are better suited to issues where there is insufficient existing theory or data to support a formulaic research project. This research certainly falls into this latter category, being conducted in a field where both professional and academic practices are relatively immature and still evolving.

The objective of the archival research strategy defined in this section is to identify a selection of information sources for each of the organisations included in the sample, from which relevant quantitative and qualitative datasets can be established. These information sources might be directly concerned with energy use and climate change mitigation, or represent broader organisational information that has relevance for an investigation of energy use and climate change mitigation. Note that energy and climate change are treated equally in this research as they are intrinsically linked, despite the fact that different cultures or scenarios might lead to an emphasis on one over the other.

One major challenge to systematically selecting appropriate documents for this analysis related to the definition of a ‘document’ in this context. The way that large organisations publicly report information is variable and changing. An increasing amount of information is available online in a more fluid format than a traditional ‘document’, and where documents do exist, there are a variety of ‘types’ potentially relevant to this research (directives / standards / policies / technical manuals / videos / awards / internal magazines).

This research focused on traditional ‘corporate reports’, but it is worth noting that organisations embracing emerging online content over traditional methods (most relevant to the companies), or with a significant quantity of public document ‘types’ (most relevant to defence depts.), may not always be optimally represented in the analysis.

In order to focus this review further, it is only concerned with ‘public documents’ as these will benefit from another layer of consideration and conservativeness as regards their content, and allow any findings to similarly be made publicly available. In addition, the review is concerned with public documents that are communicating to an external audience as well as their own employees. Limiting the research to public documents also helps to eliminate bias, where the researcher may have access to greater volumes of information on some organisations than others by virtue of their contacts and levels of access.

The reporting approaches of public sector organisations and private companies can be significantly different, owing to different legal obligations, expected common practices, and stakeholder groups that they have to engage with.

The Defence department reporting was characterised by sprawling web presences, and unstandardized reporting practices – even among the public corporate documents. Systematic searches therefore became very important in order to provide some assurance that the most relevant documents had been selected.

In contrast, defence company reporting practices are far more standardised, and their web presences far more concise and coherent. Therefore, retrieving the relevant documents for defence companies was relatively straightforward.

As a result, this research applied different archival designs to the defence departments and private companies in the sample. This section is split into two sub-sections that focus on the defence departments (**3.3.1**) and defence companies (**3.3.2**) in turn, followed by a summary of the most relevant documents for analysis at the end (**3.3.3**).

3.3.1 Defence Department Documents

As explained above the defence department reporting was characterised by sprawling web presences, and unstandardized reporting practices – even among the public corporate documents. The organisations are enormous (particularly the US DoD), and therefore understanding the organisational structures and related agencies represents a significant challenge before attempting to understand the web presences and reporting outlets. Systematic searches therefore became very important in order to provide some assurance that the most relevant documents had been selected.

The same broad approach was used to identify relevant documents for both the UK MoD and US DoD, and the process for identifying relevant documents for each of the organisations is described below.

3.3.1.1 UK MoD

As discussed above, the UK MoD publishes widely across numerous sources and mediums.

This review attempted to get an overview of UK MoD reporting to understand where energy or climate change mitigation issues may feature either in mainstream reports, or standalone ones. Identifying the best places to find these relevant documents was challenging, and involved a lot of web searching, and familiarisation with how the MoD presented itself online.

The UK MoD web presence is extensive. As might be expected from the description of Defence Industrial Policy in **2.2**, with the UK MoD such a complex entity, made of multiple agencies, the potential areas to retrieve relevant information spans multiple websites that are all organised differently. The single services all have their own sophisticated web presences and reporting, as do civilian organisations within the MoD, such as Defence Equipment and Support (DE&S). Other agencies connected to the MoD are extensive and likewise have their own web presences and corporate reports (DSTL, Hydrographic Office, Defence Academy etc.).

Familiarisation with the relevant websites revealed that they did not contain the quantity of UK MoD documents held on the main gov.uk website[20] (which has a very good browsing functionality and contains most documents published by all government departments), or the National Archives website[21] (which performs a similar function as the gov.uk site for documents that predate 2010). Where documents were only held on the websites of the multiple UK MoD organisations, these were often best accessed via Google searches that provided web links to parts of their websites that would not have been easily found due to the un-standardised and often cumbersome ways that the sites are arranged.

Fortunately, the UK MoD does publish a very useful orientation document called the Defence Framework (Ministry of Defence, 2010a). This provides a good overview of the

[20] https://www.gov.uk/government/publications
[21] http://www.nationalarchives.gov.uk/

organisational structure, and the various areas from which different types of reporting might originate.

With the best places to retrieve relevant documents identified, a systematic process for finding relevant documents needed to be established. Table 9 in Appendix A shows the steps taken in a systematic search for relevant documents, which began with the main websites containing government documents, and then used Google searches to try and find additional sources. Documents identified in each step of the search would be logged and marked with the relevant 'search number', so that the process was replicatable and the document ought to be locatable by the same means (subject to websites changing). Where a document was located multiple times by different searches, the first 'search number' that it was located by would take precedence.

The process below was not pre-conceived, and therefore documents identified in earlier steps would be reviewed for relevance and contribute to a broader understanding of the organisations' reporting practices as the search was taking place. Therefore, subsequent research steps would be informed by the findings of earlier ones, until the final category included specific google searches for documents known to exist and have relevance to the research from the review work that had already taken place.

In terms of arranging and analysing the documents identified, they were then reviewed for relevance with the main criteria as follows:

- Does it represent a 'Vision' or 'Strategy' document defining the overall direction for the organisation?;
- Does it represent a 'Regular Business Report', offering a high-level summary of the organisation's progress against its main strategic objectives (e.g. annual reports), or providing some key information on 'defence reform'?;
- Is the document concerned with energy, environment, or sustainability (whether related to 'operational energy' or 'facilities and infrastructure')?;
- Is the document concerned specifically with climate change?

In line with the interpretivist research philosophy and inductive approach taken, these criteria were refined as the document search developed, and tended to highlight the most established 'mainstream' corporate documents and relevant 'specialist' documents.

A number of UK MoD documents (38) were deemed relevant using the criteria above, and categorised and plotted on a timeline so that shifts in emphasis over time could also be identified. This 'long list' identified relevant grey literature for the research, but was additionally reduced to a 'shortlist' of documents (7) deemed most relevant for use in the creation of relevant quantitative and qualitative datasets, as they best met the criteria defined above (described in section **3.4** 'Establishing the Primary Datasets' below).

The shortlisted and long-listed documents are shown on a timeline in Tables 10 and 11 respectively (see Appendix A), including a short summary of each and a reference to the search approach that located it.

The timeline format was used to explore trends that can be identified in the UK MoD reporting over time. Perhaps most obvious is the impact of governmental cycles. Key strategic documents tend to be published when a new government comes to power (e.g.

National Security Strategies (Cabinet Office, 2010a), Strategic Defence and Security Reviews (Cabinet Office, 2010b)), and all of the related planning documents tend to be refreshed and overhauled at this time, whether relating to the organisation as a whole (e.g. MoD Business Plan (Ministry of Defence, 2012a), or sub-strategies related to specific functional areas (e.g. the MoD Sustainable Development Strategy (Ministry of Defence, 2011b). New governments can also make amendments to the style and substance of related (and more regular) statistical or performance reports.

Looking at the longer list of relevant documents reviewed, significant events (such as Gray's review of Defence Acquisition) can have corresponding impacts on reporting practices, with the review documents themselves leading to medium-term improvement plans, and regular dedicated performance reporting.

Interestingly in the UK context, reporting from the single services tends to be ad hoc and inconsistent. This is actually helpful in providing more coherence to the strategy documents from the organisation as whole, but somewhat surprising given the independence that they tend to maintain. It is unclear whether using the MoD restricted link to search for relevant documents from the single services might provide more relevant, coherent reporting, but that is beyond the scope of this investigation.

3.3.1.2 US DoD

A similar process was followed to identify, review and select relevant US DoD documents.

As with the UK MoD, the US DoD web presence is sprawling, and a scale of magnitude larger. This is unsurprising given that the US DoD budget is roughly ten times that of the UK MoD (SIPRI, 2011). There are a couple of relevant websites that attempt to collate and present the majority of US DoD documents[22], however from wider searches it was clear that these were not particularly well organised and did not necessarily present the most relevant documents. There is also a relevant website for US DoD internal manuals and issuances[23], containing a huge number of working documents aimed at internal employees, but as discussed above these types of documents are outside the scope of this review.

In contrast to the UK, the single services in the US have a more substantial web presence, and produce far more public documents, with their own 'publishing directories' for external reports, as well as relevant internal field manuals or technical documents[24].

Beyond the main websites and the single services, the other agencies linked to the US DoD, or complex networks of organisations within it, are very difficult to understand and contextualise. Unlike the UK, there is no equivalent of the Defence Framework document to orientate around this complex network of organisations, and no place listing them on the main DoD central websites. These other agencies (e.g. Defence Logistics Agency, the

[22] http://www.defense.gov/pubs/ and http://www.dod.mil/pubs/
[23] http://www.dtic.mil/whs/directives/corres/pub1.html
[24] US Army Publishing Directorate (http://www.apd.army.mil/); US Navy Personnel Command (http://www.npc.navy.mil/bupers-npc/reference/publications/Pages/default.aspx); US Air Force (http://www.e-publishing.af.mil/).

Engineering Corps, Defence Advanced Research Projects Agency (DARPA) etc.) are more numerous and larger than their UK-equivalents and likewise publish more documents. Such is the scale of US DoD energy use, some agencies are concerned directly with the topic (e.g. the Office for Operational Energy), and publish their own documents from their own independent websites.

With no equivalent of Gov.uk or the National Archives reliably pulling the majority of government documents together into one place, navigating all of these web presences posed a significant challenge. Google searches actually proved far more successful in the context of US DoD documents, and therefore a similar systematic approach was used as in the UK context above, but relying more on these google searches to identify relevant websites, parts of websites, and documents from the sprawling DoD web presence. Again, the process was not preconceived but each search informed the next, as the links and documents identified provided additional information and understanding.

Table 12 in Appendix A shows the systematic search used for DoD documents. An extra layer of review was included in this process to allow for the fact that with such an overwhelming number of websites associated with US Defence, initial google searches would inevitably prompt other lines of enquiry – sometimes identifying new websites that held a number of relevant documents.

For example, if the Google search term was ‘Department of Defense Energy’, this might generate a number of links to relevant files, but may also provide links to the websites of other relevant organisations within or connected to the DoD. In these cases, the ‘other relevant website’ was noted as a ‘sub-search’ of the initial google search and given a corresponding reference (e.g. if the original search was number 5, documents identified by the subsequent websites would be given a reference 5.1 or 5.2 depending on which of the subsequent websites they came from).

As with the approach taken with the UK MoD, documents identified were reviewed for relevance with the same set of criteria:

- Does it represent a ‘Vision’ or ‘Strategy’ document defining the overall direction for the organisation?;
- Does it represent a ‘Regular Business Report’, offering a high-level summary of the organisation’s progress against its main strategic objectives (e.g. annual reports), or providing some key information on ‘defence reform’?;
- Is the document concerned with energy, environment, or sustainability (whether related to ‘operational energy’ or ‘facilities and infrastructure’)?;
- Is the document concerned specifically with climate change?

A number of documents (33) were deemed relevant for the US DoD using the search approach and relevance criteria above. These documents were similarly categorised and plotted on a timeline so that shifts in emphasis over time could also be identified. As above, this ‘long list’ identified relevant grey literature for the research, but was additionally reduced to a ‘shortlist’ of documents (8) deemed most relevant for use in the creation of relevant quantitative and qualitative datasets, as they best met the criteria defined above (described in section **3.4** ‘Establishing the Primary Datasets’ below)

The shortlisted and long-listed documents are shown on a timeline in Tables 13 and 14 in Appendix A respectively, including a short summary of each and a reference to the search approach that located it.

The results above for the US DoD contrast with UK MoD reporting approach in several ways. The impact of governmental cycles is undoubtedly there in the US review (e.g. the Quadrennial Defence Review (Department of Defense, 2010) and National Military Strategy (Department of Defense, 2015a) are roughly analogous to the UK Strategic Defence and Security Review (Cabinet Office, 2010b) and National Security Strategy (Cabinet Office, 2010a)). However, where in the UK there is a clear hierarchy of documents underpinning these main strategies (that are usually refreshed alongside them), the US document hierarchy is not so clear.

There were many financial documents noted in the US review including plans, budgets, reports etc. but these did not necessarily follow a coherent structure linked to the strategies. Similarly, there is not the same coherent reporting of ‘major defence reform plans’, with associated regular reporting against these. This could be due to the sheer scale of any defence reform plans in the US context, or that at the time of the search, this issue had not gained as much momentum as in the UK context.

One possible reason for the lack of a clear hierarchy of DoD documents linked to the strategies could be related to the increased strategic reporting by the single services in the US context. As noted above, the single services produce far more corporate reports than their UK equivalents, and are arguably therefore less dependent strategically/culturally on the main DoD strategic documents. Although the single services’ documents have been used in this research, for comparability it is only the DoD-level documents included on the shortlist for creating the datasets.

3.3.2 Defence Company Documents

By comparison with the defence departments, the process for selecting relevant documents for the defence companies was relatively straightforward. They tend to have more standardised reporting, all for example producing an annual report, and the vast majority producing a ‘sustainability report’ (although the titles can vary). More complex was understanding the voluntary initiatives on energy and climate change to which they subscribed that may provide additional sources of data, but again the majority also subscribe to similar global voluntary reporting initiatives (e.g. CDP). Their reporting also tends to be more focused, in that beyond these standard documents, not a lot more is available. By comparison to the defence departments they also tend to report more consistently over the longer term, not being subject to a four or five-year cycle of governmental change or specific reform issues and the resultant changes in strategic direction (and consequently, changes in reporting).

This section is split into three sub-sections, with each reviewing the most common reporting types by the companies included in this review:

- Annual Reports
- Sustainability Reports
- Mandatory and Voluntary Reporting Initiatives effecting Defence Sector Organisations

3.3.2.1 Annual Reports

A company’s ‘Annual Report’ tends to be a comprehensive report of a company’s activities throughout the preceding year and associated financial statements. It is aimed at shareholders and other interested parties, and is a regulatory requirement in most jurisdictions.

All companies selected for inclusion in section **3.2** (‘Selecting an Appropriate Sample’) produce some form of annual report, and these reports for the years 2013-2015 (inclusive) have been reviewed as part of this research.

Some regional differences were noted between the documents. US annual reports tend to follow a more consistent structure, linked to regulatory requirements for large companies (>$10m in assets / >500 owners) to produce a ‘Form 10k’ document, the contents of which are fixed. Most of the US defence multinationals included in this research tend to include their Form 10K as a regulatory document that makes up the vast majority of their annual report, simply preceding it with some introductory comments about the business and messages from the Chairman and Board. An exception is United Technologies, who publish their Annual Report (e.g. United Technologies, 2015a) and Form 10K (e.g. United Technologies, 2015b) separately, with the former acting as a more joined up Annual Report and Corporate Responsibility Report, and the latter as a standalone regulatory document.

The European annual reports can be quite different, as the regulatory requirements can differ between national jurisdictions. The UK, for example, has a separate set of requirements for company annual reports split between a 'Strategic Report' designed to give users a high-level initial summary of what the companies does and the risks it faces, and a subsequent more detailed 'Directors Report', which more detailed information on various aspects of the organisation's governance.

Table 15 in Appendix A reviews all the annual reports for how closely they align to a 'generic contents' list that applies fairly well to all of the reports reviewed. Despite regional/format differences they are very comparable documents, and contain a variety of quantitative and qualitative data relevant to this research.

3.3.2.2 Corporate Responsibility / Sustainability Reports

Most large companies also tend to publish a 'Corporate Responsibility (CR)' or 'Sustainability' Report, that tends to be reported alongside their annual report providing a detailed summary of a company's activities throughout the preceding year that within the context of its social and environmental impacts. Like the annual report it is aimed at shareholders and other interested parties, but unlike the annual report it is not a mandatory requirement in most jurisdictions and most large companies now produce these voluntarily.

As voluntary publications, take up and content of these reports can be more variable, however most of the companies selected for inclusion in section **3.2** ('Selecting an Appropriate Sample') produce some form of CR / Sustainability report, and the contents of all available CR and Sustainability reports for the years 2013-2015 (inclusive) have been reviewed.

There are some notable differences in approach, with United Technologies (as mentioned above) producing a joint Annual and CR Report separate to their Form 10K, and therefore not publishing a standalone CR / Sustainability Report. Boeing is notable for producing two standalone reports – an 'Environment Report' (e.g. Boeing Company, 2015b) and a separate 'Corporate Citizenship Report' (e.g. Boeing Company, 2015c), topics that the other organisations include together in one report.

Reporting is also less consistent year-to-year, with General Dynamics not appearing to produce a CR / Sustainability Report for all years investigated. Formats can change too, with BAE Systems changing from an 'Integrated Annual Report' in 2013 (BAE systems, 2014) to a standalone 'CR Performance Summary' in 2014 and 2015 (BAE Systems, 2015b; 2016b), and Airbus substituting a hard-copy report for online content in 2015, and therefore directing users to its website instead.

Lengths of these reports can vary significantly, with the shortest 19 pages (Raytheon 2013b), and the longest 216 pages (Finmeccanica 2014b). As with all grey literature, the length of the report doesn't necessarily indicate better or more relevant content, and is likely to be linked to how repetitively (or not) companies report across the different mediums that they use (Annual Report, CR Report and Website).

Table 16 in Appendix A reviews all the reports for how closely they align to a 'generic contents' list that applies fairly well to all of the CR / Sustainability reports reviewed. Despite the differences outlined above, and various title changes between organisations and years, these are very comparable documents, and contain a variety of quantitative and qualitative data relevant to this research.

3.3.2.3 Mandatory and Voluntary Reporting Initiatives

In addition to their Annual Reports and CR Reports, the global defence companies selected for analysis in section **3.2** ('Selecting an Appropriate Sample') are all subject to a variety of mandatory and voluntary reporting initiatives to which they provide GHG data and climate change-relevant information.

Table 17 in Appendix A provides a list of some of these schemes, many of which were discussed in the OCA Literature Review in section **2.1**. Note that this list is not exhaustive, but reflects those schemes mentioned in the defence sector grey literature analysed.

Some apply to the US; and others to Europe as a whole, or individual European countries. The list includes schemes aimed at numerous scales of Carbon Accounting, and both mandatory and voluntary schemes. Some of these schemes require public reporting of data, whereas with others submissions can be private.

Given the variability of schemes listed in Table 17 (see Appendix A), the matrix in Figure 5 shows how comparable each of these initiatives are – both in the region that they relate to, and the carbon accounting 'scale' to which they apply. The diagram shows that the two that are most relevant to the entire footprint of all companies in our selection are the CDP Annual Climate Change Questionnaire and the Dow Jones Sustainability Index (DJSI) Annual Questionnaire. Given that the former is a public document[25]; is directly related to this research topic (DJSI has a wider remit); and is participated in reasonably well by the organisations selected, it makes the most sense to include in this review.

[25] Most organisational responses to the CDP Climate Change Questionnaire (CDP, 2017 and Appendix B) are made public, however organisations have the option of making their response private

	Europe	US	Global
Site	*EU ETS; Climate Change Agreements*	*EPA GHG Reporting Programme; California ETS*	
Regional Legal Entity	*Grenelle II - Article 75; Carbon Reduction Commitment; ESOS (Implementing EU Energy Efficiency Directive (2012/27/EU))*		
Whole Organisation / Group	*Companies Act Mandatory Carbon Reporting (UK); Grenelle II - Article 225 (France); UK Greening Government Commitments*	*US Executive Order 13514 on Federal Sustainability; Climate Registry*	*Carbon Disclosure Project (CDP); Dow Jones Sustainability Index*

Figure 5: Matrix demonstrating which mandatory and voluntary schemes are most relevant to the organisations included in this research, for their global emphasis and focus on the whole organisation or corporate group.

The CDP Climate Change Questionnaire (CDP, 2017 and Appendix B) has changed and developed over the last decade since it was first sent to relevant companies included in its investor request, but the latest contents are summarised in Table 18 in Appendix A, and a copy of the questionnaire is included as Appendix B. Most of the companies included in this research now complete a public response to the Climate Change questionnaire as shown in Table 19 in Appendix A.

CDP's 'academic dataset' from 2007-2014 was acquired by the University of Central Lancashire for the purposes of this research, and provides a summary of all data provided to CDP by all companies involved. It has been a key source of quantitative and qualitative data used in this research.

3.3.3 Summary of Key Documents

With an appropriate sample of organisations for the research determined in section **3.2**, this section has explained how the corporate reports of defence departments (**3.3.1**) and defence companies (**3.3.2**) have been reviewed and appropriate ones selected for further quantitative and qualitative analysis.

Table 20 in Appendix A shows a summary of the documents selected for inclusion for the defence departments and defence companies, categorised as ‘general reports’ and ‘specialist reports’. As these documents have all been produced directly from the organisations included in the sample, they represent sources of primary data.

Taken together, these documents provide a wealth of information for analysis, and the next section (**3.4**) describes how appropriate datasets were created from the quantitative and qualitative data contained in them.

3.4 Establishing the Primary Datasets

Section **3.3** summarised the archival research design used to identify relevant documents for the organisations in the sample, which could be used to review the existing OCA practices in the defence sector and their approach to climate change mitigation more generally. As these documents have all been produced directly from the organisations included in the sample, they represent sources of primary data.

This fourth part of the Methodology (**3.4**) describes how relevant datasets were established from these primary data sources. Section **3.4.1** describes how the 'Quantitative Dataset' of GHG and Energy data was established for all organisations included in the review, taking GHG or energy data from a variety of sources and applying various conversion or emissions factors to make the data as comparable as possible. It also explains how certain 'normalising' data was identified and processed and can be used to support comparisons (correlational research) between organisations. Section **3.4.2** describes how the 'Qualitative Dataset' of keyword terms and published targets was established, and provides narrative as regards the comparability of the data.

Section **3.3** also explained how this archival research design can be characterised as 'exploratory' (as opposed to 'descriptive' or 'explanatory'), and therefore various quantitative and qualitative research methods have been used to establish and analyse the data. This multi-method approach to the data is common to exploratory research designs where the subject being studied is not currently well known.

The quantitative and qualitative datasets themselves are included in Appendix A but referred to throughout.

3.4.1 Establishing the Quantitative Dataset

This section describes how the 'Quantitative Dataset' of GHG and Energy data was established for all organisations included in the research. It is split into two sub-sections, with the first describing the GHG and energy data, and the second describing the relevant normalising data.

The main quantitative research method used has been Correlational Research. This aligns well with the exploratory nature of the research, looking for interesting patterns in the quantitative data as opposed to causal relationships or testing pre-conceived hypotheses. Gathering GHG and energy data, as well as relevant normalising data, should allow effective correlational analysis to be presented in the Results chapter.

It should be noted that time horizons were considered in the creation of the quantitative dataset, and a longitudinal approach was taken given the inductive nature of the research, and the desire to look for any patterns that might emerge. This means that the quantitative datasets in Appendix A contain data for multiple years. However, the analysis presented in the Results chapter is largely cross-sectional, as these patterns proved most relevant to the themes described in the Literature Review. The longitudinal nature of the quantitative datasets does make them useful for future research though, and therefore the datasets are presented in full in Appendix A.

3.4.1.1 GHG, Energy, and Energy Cost Data

As discussed in section **3.3** ('Designing the Archival Research Strategy'), reporting practices can be quite different between defence departments and defence companies, and this is certainly the case in relation to their GHG and energy data.

Tables 21-43 in Appendix A provide historical summaries of all available GHG, energy, and energy cost data for the UK MoD (Tables 21-23), US DoD (Tables 25-28), and companies (Tables 29-43) included in this analysis respectively.

The following explanatory notes and guidance are relevant to the types of data included in these tables.

GHG data can be produced via a variety of methodologies that can substantially impact the organisational boundaries to which the data relates (see **2.1** 'Organisational Carbon Accounting'). Table 2 in Appendix A shows a summary of the GHG Accounting methodologies used by the defence organisations included in this research to produce the quantitative emissions data that was analysed in the Results chapter. It demonstrates that the methodologies for producing OCAs in the defence sector are reasonably well aligned. The Greenhouse Gas Protocol Corporate Standard (WRI, 2004) is referred to by all the companies included in the research except General Dynamics, and though not mentioned specifically by the MoD or DoD, they do refer to Scopes 1, 2 and 3 in the relevant sources that either report, or mandate the reporting of GHG information (Ministry of Defence, 2014m; 2015a; 2016b; Department of Energy, 2009). Also, seven of the twelve organisations refer specifically to the GHG Protocol's 'Operational Control' method as the means by which they determined the boundary to their GHG inventories. There is clearly potential for further standardisation, with four of the nine companies mentioning the GHG Protocol also referring to other methodology documents that they use alongside it. Also, there can be significant discrepancies in relation to the Global Warming Potentials used within the reported GHG totals, with just over half of the (7 of 12) organisations in the table above reporting all of the 6 Kyoto Protocol gases as a minimum, but others not disclosing some of these. Emission factors used can also differ, with the UK Department for Environment Food & Rural Affairs (DEFRA), the US Environmental Protection Agency (EPA), and the European Commission mentioned by those organisations that provide a clear reference to the source of their emission factors. Finally, the 'Emissions Boundary' of the OCAs can also vary quite significantly amongst the organisations not using the GHG Protocol's Operational Control method. These methodological differences are noted in the GHG and energy tables in Appendix A wherever possible (Tables 21-43), but converting relevant GHG methodologies between organisations to make them comparable is often not possible due to the fundamental differences in how the data has been compiled.

Comparisons between 'Scope 3' GHG data can be more problematic still, as methodologies and boundaries can be completely bespoke. This data is included in the dataset where possible, with adjacent notes describing what it represents.

As a general point it should be noted that publishing GHG data is a relatively recently established practice for organisations, and as such data quality has been improving over time – both in relation to the methods used to determine relevant organisational boundaries to the data or the activities to be included, and the accuracy of the data itself. This may mean that comparability between reporting years is not always assured, and that data may be subject to error particularly the further back one looks in the dataset. Third party assurance details – where available, are included in the dataset.

Often energy data is published as opposed to GHGs, as different organisations can emphasise one or the other depending on the focus of the organisation or document. Where no published GHG data exists, energy data can be converted to a relevant GHG value. GHG and energy data are inextricably linked, and conversion factors for company GHG reporting are produced annually for DEFRA by a company called carbonsmart, and have been recently made available at the gov.uk website[26]. The conversion factors can be used to convert published energy data to comparable figures in tonnes of carbon dioxide-equivalent (tCO_2e), and relevant conversions have been made to establish the datasets for this research, but numbers established via conversion factors (as opposed to direct from information sources) are displayed in red for clarity of the process used to derive them. These conversions are unlikely to make the resulting GHG data much less accurate, as similar conversion factors will have been used to produce the published GHG data from other organisations.

Energy data tends to be published in different units depending on the region from which the data is originating (e.g. MWh, Barrels of Oil, Tonnes of Oil Equivalent), but conversion factors can be applied to convert from one unit of energy to another and make the energy data comparable. Depending on the conversion, some assumptions may have to be made. For the purposes of the datasets in Appendix A all energy data has been converted into MWh, but where figures have been converted they are displayed in red, and appropriate notes included in the table.

A key distinction relevant to published energy data is that between 'bought energy', and 'consumed energy'. The distinction can be significant as defence organisations tend to hold relatively large inventories of fuel in order to be able to respond rapidly to changing demands on their resources. For example, the UK MoD publishes consumed energy data, whereas the US DoD publishes 'procured' energy data. Publication of the latter can be symptomatic of a lack of maturity as regards energy management, as without accurate (actual) consumption data, it is difficult to manage energy use effectively. The US Defense Science Board (DSB) Task Force on Energy Security (Department of Defense, 2008b), and Warner & Singer (2009) have both highlighted the lack of energy monitoring infrastructure available to the US DoD. The US DSB Task Force also suggest that corporate measurement techniques are more advanced, citing Walmart, but it is difficult to extend this comparison to defence sector companies who generally have more complex, shared ownership sites with significant amounts of historic legacy infrastructure. The 'type' of energy data published is listed in the tables where possible, but conversions are not possible in relation to this data due to the fundamental differences in how it has been collected (i.e. from procurement spend as opposed to measured energy consumption).

[26] https://www.gov.uk/government/collections/government-conversion-factors-for-company-reporting#conversion-factors-2016

As with the GHG data, the collection and publication of energy data is a relatively recent phenomenon and as such data quality has been improving over time – both in relation to the methods used to determine relevant organisational boundaries to the data or the activities to be included, and the accuracy of the data itself. Metering infrastructure (particularly at large, historic campus sites which can be common to the sector) can be poorly established or flawed, resulting in data accuracy issues if the data reported is 'measured consumption' by the organisation (as opposed to 'bought energy' metered by suppliers). As above, third party assurance details, where available, are included in the tables.

Energy cost data is also available in the documents identified in section **3.3** ('Designing the Archival Research Strategy'). This data is less easily converted to actual energy or GHG data due to unknown prices or aggregated fuels. 'Energy cost' data is provided by some of the sources in this research and included in the dataset as an additional field for reference, but the data is not converted

3.4.1.2 Normalising Data

Despite the relevance of the organisations included in this research for comparison, they are quite clearly different. The defence departments undertake a very different range of activities to the defence companies, and the defence departments themselves are very different, with the US DoD some ten times larger than the UK MoD (by budget) and with strategic ambitions to match. Likewise, companies can be characterised by differing degrees of 'defence dependence' as discussed above, and at any given time can be subject to different operational demands.

As such, relevant datasets of 'normalising data' will be relevant to contextualise some of the GHG and energy data explained above.

Tables 44-50 in Appendix A provide some relevant normalising data identified in the documents reviewed, and each type of data is given a brief explanation below

The two simplest ways to normalise energy and GHG data is by total budgets/revenues and headcount (Tables 44-47). GHG or energy use normalised by these values represent widely accepted metrics that are requested in the CDP dataset and published in many organisational CR Reports. Their relevance can be heavily dependent on the activities of the specific organisation, and the variability and cyclical nature of defence activity makes them less reliable in this context, but nonetheless they provide a simple means to quickly compare organisations.

In addition to the revenue data analysed in **3.2.1** ('Context: Key Trends in Global Defence Spending') that was used to determine the research sample, further data on the revenue breakdown of the defence companies is useful to draw some simple comparisons between organisations in this research, and relate different organisations to each other.

Tables 48-50 additionally provide revenue data split between their sales related to 'products', and sales related to 'services' (Table 48), and details of who their major customers are, and the percentage of revenues received from these customers (Table 49 / Table 50).

3.4.2 Establishing the Qualitative Dataset

Section **3.4.1** above explained how the quantitative datasets have been established, but the majority of data included in the documents selected for review is narrative, and qualitative research methods will be required to analyse this information.

Section **3.1** ('The Research Approach') explained how this research has a strongly archival strategy, but mentioned the relevance of several other strategies including Grounded Theory. Whilst this exploratory research doesn't meet many of the characteristics of a Grounded Theory project, the qualitative research methods used are quite common to it, such as keyword counts and the coding of documents to establish patterns and comparisons.

Section **3.4.2.1** below describes the 'keyword-count' qualitative dataset. Keyword counts are a common qualitative research method used in document analysis (Dawson, 2009) and the documents will be analysed in this manner, but first an appropriate list of keywords needs to be established, and a relevant 'count' performed on all relevant documents.

Another qualitative summary that seemed relevant whilst reviewing the documents selected for analysis related to 'published targets' in relation to GHGs, energy, or climate-change relevant performance. These are summarised in section **3.4.2.2** below ('Relevant Public Targets Qualitative Dataset'), and required an element of 'coding' of the documents from different organisations in the sample to allow useful comparison.

A third qualitative summary concerns some external accounts of organisational performance. Outside of the CDP academic dataset discussed in the previous section, CDP publish numerous narrative reports annually that describe trends in the various sectors, and identify the leading companies on energy and climate change performance. They also publish 'scores' for the companies based on the information submitted in the CDP Climate Change questionnaire (CDP, 2017 and Appendix B), and these are described in section **3.4.2.3** below ('External Accounts of Organisational Performance').

The inclusion of several 'qualitative datasets' is relevant for avoiding bias, as different qualitative indicators might provide contrasting results. The relationship between some of these indicators is discussed in the correlational analysis provided in the Results chapter (see **4.2** 'Integrating the Qualitative Data').

3.4.2.1 Keyword-Count Qualitative Dataset

The selected documents were reviewed in detail to allow the keywords to emerge from the document content. This was considered preferable to using a formal document set (e.g. words associated with indicators in the Global Reporting Initiative (GRI, 2016)), as it created a keyword set relevant to the type of reporting, and the sector.

Keywords (mostly nouns) relevant to energy and climate change were captured across the specialist environment/sustainability document set (under the assumption that the more mainstream documents were unlikely to introduce new terms to this taxonomy), and then categorised into various higher-level topic areas.

The selected keywords were then converted into a relevant search term for an automated search of a document, using the Adobe Acrobat 'advanced search' function. The search term was then reviewed for whether it might 'count' inappropriate results. A decision was then made as to whether data for the search term should be gathered automatically, or manually (Note the documents were also reviewed for images that might undermine an automatic search for the term).

The final selected term-set, and associated search terms are shown in Table 51 in Appendix A, and organised into those associated with 'energy' and those associated with 'climate change', to allow analysis of the relative emphasis on these linked but distinct topics in the documents.

Tables 52-55 in Appendix A summarise the results of the keyword-counts on the documents included in the research. This forms the 'Keyword-Count Qualitative Dataset' that is analysed and discussed in the Results chapter (**4**) that follows.

Relevant excluded terms included a wider set of 'environment' and 'sustainability' keywords (~150) that were identified in the documents and grouped into broad categories as follows:

- Wider Environment Keyword Categories: Ecology; General Pollution; Water; Waste and Resources; Lifecycle Planning and Circular Economy; Materials; Biodiversity; Land Use and Remediation
- Wider Sustainability Keyword Categories: Technology and Innovation; Health and Safety; Ethics and Business Conduct; Communities and Charitable Giving; HR Issues and Diversity; Supply Chain Management; Information Security

These keywords have not been used in this research but could provide an opportunity to analyse the wider emphasis beyond energy and climate change in the public documents. They were not necessary for this research as it is concerned with the relative emphasis on energy and climate change between different organisations, rather than how the emphasis differs across a broad range of sustainability topics.

There were some wider 'types' of term that were also categorised and consciously excluded to avoid distortion of the results.

Different organisations tend to produce subtly different types of documents, both in terms of their style and emphasis on specific types of issue. The following terms were excluded in order to focus the analysis on energy and climate change as broad topics, and reduce the impact of these stylistic differences.

- Facilities Terms (E.g. Heat, cooling, Heating, Ventilation and Air Conditioning (HVAC) etc.): The environmental sections of documents differ in the extent to which they provide detailed information about their estate, or specific case studies about facilities management. These terms were typically mentioned in the context of energy, power or carbon that would be captured by the keyword-set. This was deemed sufficient for an assessment of their general emphasis on energy and climate change, without allowing the more facilities-focused narratives to appear dominant in the results.

- Business Travel Terms (E.g. flights, business travel, air travel etc.): Some organisations go into particular detail about their business travel, and as such results could be distorted by documents that are more focused on this. As above, these terms are usually mentioned in the context of energy, power or carbon that would be captured by the keyword-set.
- Units of Energy / Carbon (E.g. Tons, MWh, Gallons etc.): Some reports are more technical than others, both in relation to their prose and visual material. Again, these terms were typically mentioned in the context of energy, power or carbon that would be captured by the keyword-set. Additional Inclusion of them in the keyword-set could produce very high counts where information is presented technically, rather than capturing the general emphasis of the document on energy and climate change.
- Specific Standards or Relevant Legislation (E.g. LEED; ISO14001; GHG Protocol etc.): As above, some documents are more technical in relation to their discussion of legislative compliance or specific methodologies. Again, these terms were typically mentioned in the context of energy, power or carbon that would be captured by the keyword-set. Additional Inclusion of them in the keyword-set could produce high counts where there is a focus on technical compliance with legislation or standards, rather than capturing the general emphasis of the document on energy and climate change.

The following terms were excluded because they were not appropriate to the type of analysis being conducted. These were as follows, with the rationale explained alongside in each case:

- Terms Referring to Processes (E.g. Risk Management; Corporate Governance etc.): Not interpretable via a 'keyword-count' approach to the data: A ‘keyword-count’ was deemed to be inappropriate to these types of term, as the narrative around such terms would need to be fully understood to infer a relationship with the organisations’ attitude towards energy and climate change.
- References to Specific Events (E.g. Fines, Discharge, Leak etc.): As above a ‘keyword-count’ was deemed to be inappropriate to these types of term
- Generic References to Sustainability (E.g. Corporate Responsibility; Sustainable Development etc.): These terms are used frequently throughout all of the documents but were considered to be too broad in their interpretation to be included in the keyword-set, as their inclusion might dilute the emphasis of the counts on energy and climate change specifically.
- Relevant 'Proximity Terms' (E.g. Efficient; Reduce; Clean; Low etc.): These terms often appeared near those from the keyword-set, but the dataset was not large enough for ‘Proximity Analysis’ to provide meaningful insight, and therefore the terms were excluded.

3.4.2.2 Relevant Public Targets Qualitative Dataset

There are many ways that we might judge 'engagement with the challenges of climate change' other than the keyword count above. Understanding the types of targets being set by defence sector organisations, and their relative levels of ambition, would also constitute a means by which to understand their level of 'engagement' with climate change challenges. The documents reviewed as part of this research regularly contain information about organisational targets, and therefore this data has been categorised and collated. This data allows Correlational Research to be conducted with the quantitative GHG dataset in the Results chapter (**4**) that follows.

BAE Systems, in a number of peer and customer review exercises undertaken with external consultant support, produced a summary of the targets and objectives that are in place across the defence sector. Table 56 in Appendix A provides a summary of these targets including some additional ones gathered in this investigation. Table 56 categorises the targets in the following ways:

- GHG Reduction Target: An absolute GHG reduction target associated with all or part of the organisation, and part or all of the organisations scope 1-3 inventory
- GHG Intensity Target: A GHG reduction target normalised against some other indicator (e.g. revenue)
- Facility Energy Reduction Target: An absolute energy reduction target associated with all or some of the organisations facilities
- Facility Energy Intensity Target: An energy reduction target normalised against some other indicator (e.g. revenue)
- Facility Energy Generation Target: A target to generate a certain percentage of organisational energy use from renewable energy sources
- Facility Energy Procurement Target: A target to procure a certain percentage of organisational energy use from renewable energy sources
- Operational Energy Reduction Target: An absolute energy reduction target associated with all or some of the organisation's operational energy use (applies to defence departments)
- Operational Energy Intensity Target: An operational energy reduction target normalised against some other indicator (e.g. per mile travelled) (applies to defence departments)
- Operational Energy Procurement Target: A target to procure a certain percentage of operational energy use from alternative sources (e.g. biofuel blends)

These targets form the 'Public Targets Qualitative Dataset' for analysis in the Results chapter (**4**) that follows. Performance against these targets tends to be communicated by the companies' CR Reports and the corresponding reports for the MoD and DoD.

3.4.2.3 External Accounts of Organisational Performance (CDP Scores)

Outside of the CDP academic dataset discussed in the previous section, CDP publish numerous narrative reports annually that describe trends in the various sectors, and identify the leading companies on energy and climate change performance (e.g. CDP, 2016c). They also publish scores for the companies based on the information submitted in the CDP Climate Change questionnaire (CDP, 2017 and Appendix B). These scores (or 'third party accounts of performance') are split between a 'disclosure score' (between 0 and 100), which describes how comprehensively the company has responded to the questions, and a 'performance score' (A-F), which describes how well it is performing.

CDP publish their scoring methodology (CDP, 2015), explaining how these scores are derived, but acknowledge that scoring methodologies for this topic are still in their infancy.

These 'external accounts' of the performance of defence sector organisations represent another means by which we might judge 'engagement with the challenges of climate change' in addition to the 'keyword count' and 'public targets' datasets explained above. Again, this data allows Correlational Research to be conducted with the quantitative GHG dataset in the Results chapter (**4**) that follows.

Tables 57 and 58 in Appendix A list the disclosure and performance scores published by CDP (CDP, 2016d) for the organisations included in the research sample.

3.5 Relevant Secondary Sources of Data

Whilst the previous section described how quantitative and qualitative datasets were established from the primary data sources (company documents), the exploratory archival research strategy applied here is also interested in secondary sources of data.

This fifth and final part of the Methodology briefly summarises the environment-focused grey literature in the defence sector, much of which is produced by the various organisations and foreign policy think tanks discussed in section **2.2** ('Defence Industrial Policy') that are included within the 'complex entity' that is the defence enterprise. This section summarises some of this contextual grey literature, identifying some key documents that will be used to support and contextualise some of the trends discussed throughout the Results chapter (**4**).

Merging the topics of defence and climate change can at first glance seem slightly incongruous, with the histories of environmental activism and defence respectively seeming at opposing ends of the political spectrum. However, the topic areas have gradually been recognised as meaningful ones to analyse together, and this position is becoming increasingly mainstream.

The foreign policy think tanks discussed in section **2.2** ('Defence Industrial Policy') have arguably led the way in driving the recognition of the topic. In the UK, the Royal United Services Institute (RUSI) has published a number of relevant articles (Tibbles, 2009; Behrend, 2009; Bui, 2010; Stein, 2009; Banfield, Courtaux & Golightly, 2009; Vettehen & Ross, 2010). However, due to the scale of the US Department of Defense and the extent of its military engagement through the first decade of the 21st century, the energy challenges are that much more critical in the US, and think tanks there have published the most relevant thought leadership pieces. The Brookings Institution have published some of the most significant early works in this area (Lengyel, 2007; Warner & Singer, 2009), but various other think tanks have also been active on the topic, for example: Pew (Pew, 2010); the Center for a New American Security (Partemore & Nagl, 2010); and the Center for Strategic & International Studies (Posner, 2010). The vast majority of this literature from the think tanks enthusiastically advocates for defence to place its energy challenges at the centre of its strategy, but it should be noted that there are some organisations such as the Heritage Foundation suggesting that these studies are going too far in the importance they give to the issue (Spencer, 2011).

With the think tanks having established the issue in the grey literature, more recently the major consulting firms have also been publishing thought-leadership pieces that suggest it makes good economic sense to discuss environment and defence in the same context (e.g. Deloitte, 2009; CNA, 2009; PWC, 2010; Crowley et al, 2007; Ash & Erdmann, 2013).

All of this activity inevitably influences activity within the defence departments themselves, and a US Defense Science Board (DSB) Task Force within the US DoD produced a comprehensive report on the topic that is often referred to in the grey literature above (Department of Defense, 2008b).

In the media, popular environmental news outlets such as Greenbiz have produced many articles discussing the potential for mutual benefit to security and the environment by considering the topics together (e.g. Lehner, 2011; Guevarra, 2012) and popular non-fiction books have also heavily included, or been dedicated to the topic (e.g. Friedman, 2008; Mykleby, Doherty & Makower, 2016).

Significantly, increasing numbers of mainstream news outlets have now also been producing reports relevant to the topic (BBC, 2012) that summarise the relevance of defence engaging with energy and climate change challenges.

At the most enthusiastic end of this spectrum, one commentator has developed the theme of the 'military-industrial complex' to coin the term the 'military-environment complex' (Light, 2014), in an effort to effectively communicate the significance of the idea, and more recently foreign policy think tanks specifically dedicated to the issue have arisen such as the Center for Climate and Security[27].

It is clear that the grey literature focused on defence-environmental challenges is rich and varied, and the documents referred to in this section will be used to contextualise the results presented in chapter **4**.

[27] https://climateandsecurity.org/

3.6 Methodology Summary

The introduction to this Methodology chapter briefly introduced the industrial context to the study, and described the relevance of an exploratory, inductive approach to the research. A flexible approach that allowed relevant patterns to emerge throughout the research made sense in a context where both the academic field and professional practice were still emerging.

Section **3.1** ('The Research Approach') provided a thorough overview of the research approach that has been applied with reference to the Research Onion (Saunders, Lewis & Thornhill, 2015), which is a method of breaking down the different stages of a research strategy. Section **3.1** summarises the broad research philosophy, approach and strategy, before subsequent sections focus on more detailed stages of the Research Onion. It justifies the inductive approach taken within an interpretivist research philosophy, and explains the relevance of a strongly archival strategy to this research. Section **3.2** ('Selecting an Appropriate Sample') describes how the sample was selected, and explains which defence sector organisations have been included in the research. It explains how this sample covered a significant proportion of the defence sector by spend, and allows the analysis to extend across different regions and types of defence company. Despite several complimentary strategies being used, the research is fundamentally underpinned by an archival strategy and section **3.3** ('Designing the Archival Research Strategy') describes how this was designed, with reference to the organisations included within the research sample. It explains a rationale for selecting relevant public documents for the organisations in the sample, and a systematic approach to identifying these. With a large selection of relevant documents selected, section **3.4** ('Establishing the Primary Datasets') then describes how quantitative datasets were established for GHG and energy data, as well relevant normalising data. Qualitative datasets were also established in relation to energy and climate change keywords used in the documents, and any public targets or ambitions being communicated by them. Section **3.5** ('Relevant Secondary Sources of Data') describes relevant secondary data sources that have been identified and used in the research. These sources of defence-energy grey literature provide some additional context to the data identified in the primary sources from the organisations in the sample.

The introduction to this chapter also provided a clear link to the Literature Review, explaining how the 'themes' of Carbon Accounting deemed most relevant to this research could all benefit from an archival strategy that analysed the increasing quantities of public information on the subject that are being made available by defence sector organisations across the world.

The first theme related to the difficulty allocating emissions between organisations in existing OCAs, which is likely to be particularly marked in the defence sector due to close working relationships, and may result in abstract OCA that does not engage relevant actors to the task of reducing GHGs. This theme clearly requires a detailed understanding of all relevant quantitative OCAs that exist in the sector at present, and related qualitative information.

The second theme discussed the potential for 'Project Level' Carbon Accounts, focused on large-scale collaborative programmes to better account for the emissions of the sector in a way that engages new/relevant actors to defence-energy debates, supporting low carbon innovation. This necessitates a review of all relevant Scope 3 Carbon Accounts that exist in the sector at present, as well as gaining some understanding of the maturity of 'Project Level' Carbon Accounts in defence organisations.

The third theme related to the potential for 'consequential carbon accounting' perspectives to align with concepts of 'defence capability', and inform wider strategic narratives that help construct a positive selection environment for low carbon technologies in the defence sector. This theme benefits significantly from a broad review of relevant grey literature across the defence enterprise (both primary and secondary sources) in order to identify and understand any relevant concepts or metrics that might link to consequential carbon accounting approaches.

This Methodology chapter has described how the public information on GHGs and climate change across the defence enterprise has been reviewed; how relevant primary and secondary sources have been identified; and how quantitative and qualitative datasets have been established.

The Results chapter (**4**) that follows presents correlational analysis of this data. It begins with quantitative analysis of the broad GHG trends across the sample of defence sector organisations included in this research. It explains Scope 1 & 2 comparisons, and how the inclusion of Scope 3 data can impact this analysis. It then integrates the qualitative data in order to demonstrate a correlational link between the volumes of emissions reported by defence sector organisations, and their level of engagement with climate change mitigation. Finally, it analyses the secondary sources of information described above for relevant concepts and metrics that have the potential to enhance the value of quantitative and qualitative data that the defence sector organisations are currently producing.

The Discussion chapter (**5**) then comprehensively evaluates OCA practices in the defence sector by integrating the themes from the Literature Review with the correlation analysis presented in the Results chapter.

4) Results

The Methodology chapter described how the public information on GHGs and climate change across the defence enterprise have been reviewed; how relevant primary and secondary sources have been identified; and how quantitative and qualitative datasets have been established. These form the basis of the analysis that is presented in this chapter.

The 'Aims and Objectives of the Thesis' section (**1.4**) established several objectives relevant to the Results chapter.

The first objective for the Results chapter (**4**) was to present relevant correlational analysis in relation to the quantitative and qualitative datasets established in the Methodology.

This chapter begins with quantitative analysis of the broad GHG trends across the sample of defence sector organisations included in this research (**4.1** 'Correlational Analysis of the Quantitative Data'). Comparisons of the Scope 1 & 2 data show that defence departments currently report the overwhelming majority of the overall emissions from the sector (**4.1.1**). However, where scope 3 data related to the value chain is available it has a significant impact on these quantitative trends, and is clearly acknowledged as important by the majority of organisations included in the sample (**4.1.2**). The research uses energy usage breakdowns in the defence department data to suggest that 'Project Level' Carbon Accounts – if more widely available – could potentially account for a large proportion of the sectors total emissions complicating the picture as to which organisations in the sample are the most quantitatively significant (**4.1.3**).

The second part of the Results chapter (**4.2** 'Integrating the Qualitative Data') integrates the qualitative data to the analysis above, and demonstrates a connection between the volume of emissions reported and the level of priority placed on the issue of climate change mitigation, suggesting that the technical accounting issues that drive reported volumes do potentially influence organisational responses to climate change, and therefore are significant.

The next objective for the Results chapter was to associate findings from the quantitative and qualitative analysis with information from relevant secondary sources to illustrate pertinent issues in defence sector Carbon Accounting. The third part of the Results chapter (**4.3** 'Integrating the Secondary Sources') describes the emergence of some new 'strategic vectors' of 'resilience' and 'endurance' in the military discourse. The Fully Burdened Cost of Energy (FBCE) is a metric that could be described as a 'consequential approach' to Carbon Accounting that is helping to drive these new strategic vectors into military doctrine and improve decision making in relation to defence energy use. These concepts and metrics have the potential to enhance the value of quantitative and qualitative data that the defence sector organisations are currently producing. However, the implementation of the FBCE relies on robust 'Project Level' Carbon Accounts and less attributional mind-sets that are discussed in other parts of the thesis.

The final objective for the Results chapter was to defend/justify the interdisciplinary approach taken to the academic literature, and the research strategy used. The final part of this Results chapter (**4.4** 'Results Summary') summarises the analysis and describes how the relevance of the correlational analysis presented validates the exploratory, inductive approach to the research and the strongly archival strategy. Despite the lack of relevant sector-level precedents in the Carbon Accounting literature, and the evolving nature of existing OCA practices, relevant patterns are identified in the quantitative and qualitative data. When aligned to the secondary sources of defence-energy grey literature, strong trends can be observed that could begin to define some relevant ways forward for OCA practices in the sector, validating the research approach taken.

The ‘Results Summary’ (**4.4**) also briefly describes the relevance of the analysis for the ‘themes’ of OCA in the defence sector that were established in the Literature Review. This provides a link to the Discussion chapter (**5**) that follows, which comprehensively evaluates OCA practices in the defence sector by integrating the themes from the Literature Review with the correlation analysis presented throughout the Results chapter.

4.1 Correlational Analysis of the Quantitative Data

This section is focused on the correlational analysis of the quantitative data, and is split into three sub-sections, with the first analysing the trends in the Scope 1 & 2 data, which show that the defence departments account for the vast majority of the defence sectors GHG impacts and are by extension deemed the most significant organisations in the sample (**4.1.1**). However, the second sub-section focuses on the trends within the available Scope 3 data published by the defence companies in the sample, and shows the clear focus on indirect Scope 3 emissions as opposed to those related to the value chain. Where these 'value chain-relevant' emissions (e.g. 'emissions associated with products in use') are available, the scale of magnitude of these Scope 3 categories is clearly highly significant (**4.1.2**). The third sub-section uses the data available to show the high proportion of emissions that could be connected between the organisations in the sample if relevant Scope 3 data was more widely published, and suggests that if Scope 3 emissions were properly accounted for, then the relative significance of different organisations within the sample could change (**4.1.3**).

4.1.1 Analysis of Scope 1 & 2 Data

This sub-section compares the volumes of Scope 1 & 2 GHGs emitted by different defence sector organisations. The results are discussed across two separate figures, with the first (Figure 6) providing simple organisational comparisons of Scope 1 & 2 GHGs emitted, and then the second (Figure 7) applying the normalisation metrics. Both show that a clear majority of emissions are reported by the defence departments.

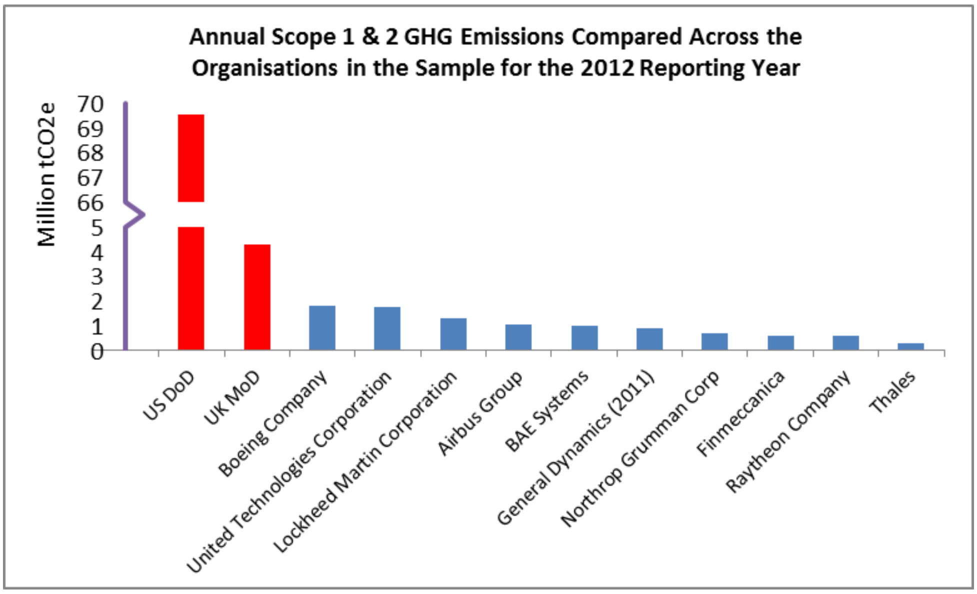

Figure 6: Showing Annual Scope 1 & 2 emissions (Million tCO_2e) compared across the organisations included in the research. It shows that the defence departments in the sample report the overwhelming majority of the sector's Scope 1 & 2 emissions (Source: Quantitative dataset (Source: Appendix A, Tables 21, 25, 29).

Figure 6 shows the total Scope 1 & 2 GHGs reported by the twelve organisations included in this research, in descending order.

As expected, the US DoD, which is by far the largest organisation in the research, emits far larger quantities of GHGs than any of the other organisations. Much of the 'defence-energy grey literature' (see section **3.5** 'Relevant Secondary Sources of Data') makes reference to the US DoD's 'exceptional appetite for energy' (Warner & Singer, 2009: p.3), contextualising how the organisation would rank 34th in the world in average daily oil use, just behind Iraq and just ahead of Sweden, and its electricity use would rank 58th in the world between Denmark and Sweden's national totals (Lengyel, 2007: p.11). The exceptional nature of its energy use is clearly reflected in the uniquely high volumes of GHGs emitted by the organisation as shown in the Figure 6 above.

However, it is also notable that amongst the other organisations, the UK MoD also emits a significantly larger volume of GHGs than the other any of the defence companies, suggesting that the defence departments are accounting for a much larger volume of the sector's GHG emissions than the supporting industrial base.

The defence companies can be seen to be fairly similar in the volume of GHGs reported.

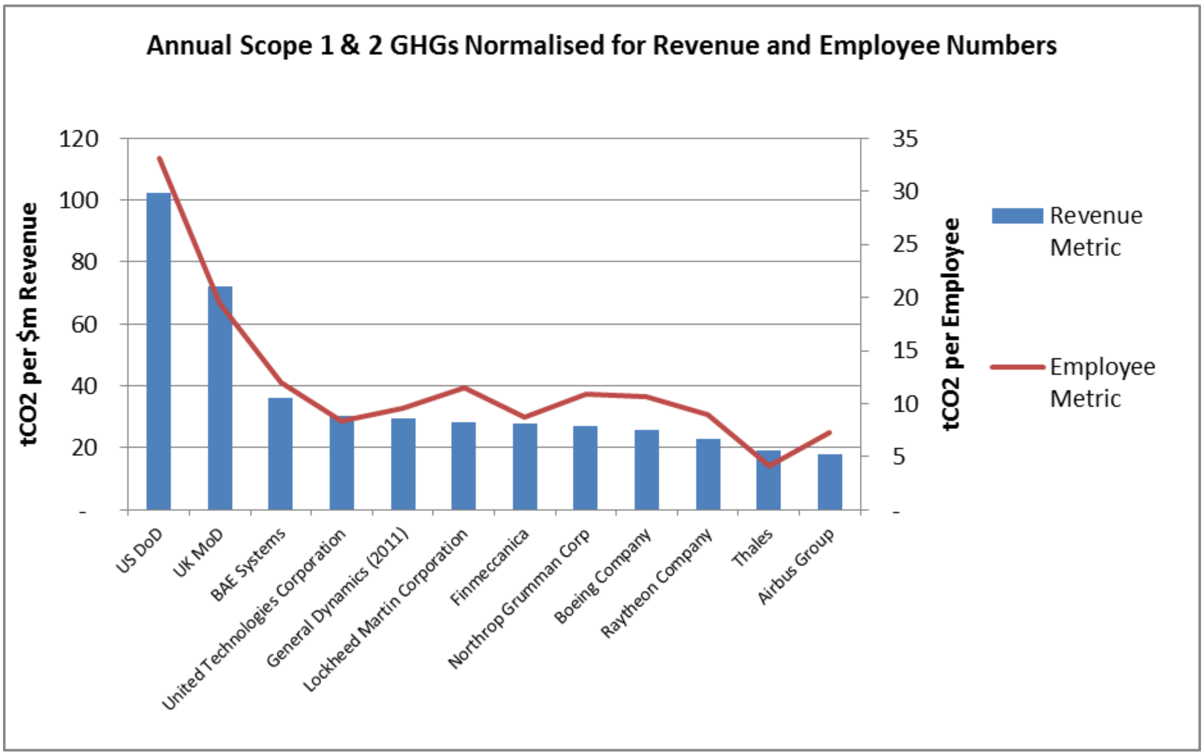

Figure 7: Showing Annual Scope 1 & 2 GHG emissions normalised for revenue and employee numbers. It shows how both metrics maintain the trend from Figure 6 that the defence departments are the most GHG-intensive organisations in the research sample. (Source: Appendix A, Tables 21, 25, 29, 44, 45, 46, 47)

When common normalisation metrics are applied (for revenue, or headcount) that ought to adjust to some extent for the difference in size between the organisations included in this research, it can be seen that the findings above still hold – namely, that the defence departments (rightly or wrongly) tend to account for a much larger 'share' of the sectors' emissions. Therefore, the Carbon Accounting practices currently used across the defence sector assign a larger volume of emissions to the defence departments.

Interestingly, although the defence departments and the defence companies sit broadly in two categories of 'emissions-intensity' in the Figure 7 above, there is variation between defence departments (the US DoD is clearly more 'GHG-intensive' then the UK MoD under current OCA practices).

4.1.2 Analysis of Scope 3 Data

This section describes the current (immature) state of Scope 3 Carbon Accounting in the public disclosures in the defence sector. It explains the inadequacy of current Scope 3 reporting as it applies to the value chain, with most accounts focused on less material Scope 3 categories such as business travel, with the exception of those published by Lockheed Martin. Where accounts more relevant to the value chain do exist, they demonstrate the scale of emissions associated with other parts of the lifecycle of defence products. It contrasts the lack of quantitative data available in this area with the qualitative emphasis placed on the importance of these more direct 'value chain' impacts of defence products in the public documents of many of the organisations included in this research.

To recap some of the introductory information from the Carbon Accounting Literature Review (**2.1.2** 'OCAs and their Limitations'), Scope 3 accounts are defined as follows by WRI (2004):

- 'Scope 3 allows for the treatment of all other indirect emissions. They are a consequence of the activities of the organisation, but occur from sources it does not own control. Some examples of scope 3 activities are extraction and production of purchased materials; and use of sold products and services.' (p.25)

This is a wide category, and the challenges that organisations have in reporting Scope 3 information were described in section **2.1.3** ('Scope 3 Emissions Inventories and the Relevance of 'Project Level' Carbon Accounts'). Section **2.1.3** also discussed some distinctions in the scope 3 categories between emissions that relate more directly to the value chain, and those that do not. Table 61 in Appendix A shows how the defence companies included in this research report their Scope 3 emissions for each of the 15 categories of emissions established in the GHG Protocol and reported in CDP's climate change questionnaire. Of these 15 categories of emissions, some are clearly more directly relevant to the value chain than others. This research would contend that the most directly relevant categories to the value chain for manufacturing organisations are the emissions associated with 'purchased goods and services', and those associated with 'the use of sold products' (highlighted in bold italics in Table 61 in Appendix A). Many of the other categories of emissions are not so directly relevant to the value chain (e.g. Business Travel), or in the case of some of the categories (e.g. franchises, investments) not relevant to the sector more generally.

Table 61 (see Appendix A) shows that Business Travel is by far the most well reported category with 8 of the 10 companies reporting against it. After this, no other category is reported by more than 4 of the 10 companies, and as with the 'business travel' category these are not so directly relevant to the value chain. Only one company, Lockheed Martin, reports against the most 'value chain' relevant categories of 'Purchased Goods and Services' and 'Use of Sold Products' (highlighted red). Beneath these highlighted categories in the table, there are a number of categories against which none of the companies report, and these generally appear to be categories that are not as relevant to defence as other sectors of the economy.

Reasons for the gap between the numbers of companies reporting against the most 'value chain relevant' categories and the least 'value chain relevant' categories could be as simple as the availability of relevant information. Business travel for example is likely to be the most reported category because of the ease with which large companies can access data. These 'indirect' categories also benefit more from top down measures for estimating emissions relevant to a category (e.g. one can estimate employee commuting relevant to organisation size and turnover etc.).

In contrast, value chain-relevant data, particularly in a sector like defence where particularly complex products are produced at low volume, can be far more difficult to derive.

In terms of reported scope 3 information, Figure 8 shows the volume of emissions reported by the defence companies across their 'less-value chain relevant' reported categories (i.e. Lockheed Martin's data on 'purchased goods and services' and 'use of sold products' is not included in Figure 8). The black line overlaying the stacked columns shows each organisations' Scope 1 & 2 emissions for reference. Figure 8 clearly shows that the reported Scope 3 emissions are generally lower, and often small, when compared in aggregate to the Scope 1 & 2 emissions of the reporting organisations. The Literature Review made clear in **2.1.3** ('Scope 3 Emissions Inventories and the Relevance of 'Project Level Carbon Accounts') that Scope 3 emissions tend to represent the vast majority of an organisation's overall GHG impact (~75%), and therefore it does appear that the less 'value chain relevant' categories of Scope 3 emissions reported by the defence companies included in this research do not represent where their biggest impacts are.

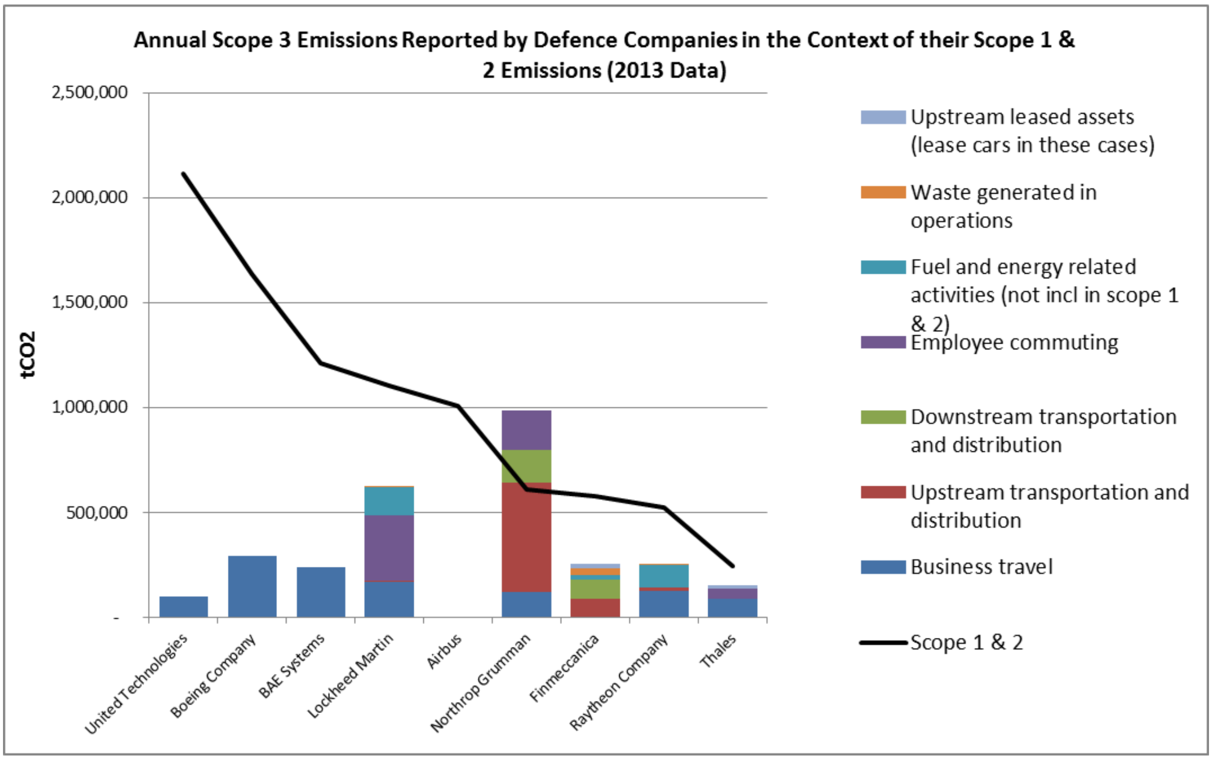

Figure 8: Annual Scope 3 emissions for all defence companies included in the sample, in the context of their Scope 1 & 2 disclosures. The figure excludes Scope 3 data related to the 'use of sold products' or 'purchased goods and services' from Lockheed Martin, which is analysed separately in Figure 9. It illustrates how the volumes of Scope 3 emissions currently reported by organisations in the sample are in a similar order of magnitude to their Scope 1 & 2 emissions, but this is likely to be because their Scope 3 emissions do not currently include emissions relevant to the value chain. (Source(s): Appendix A, Table 29, and Tables 32-40)

Figure 9 below confirms the hypothesis above. Lockheed Martin are the only organisation in the research who publish data for the most 'value-chain relevant' categories of Scope 3 emissions, and this data demonstrates that these categories clearly dwarf the Scope 1 & 2 emissions of defence companies.

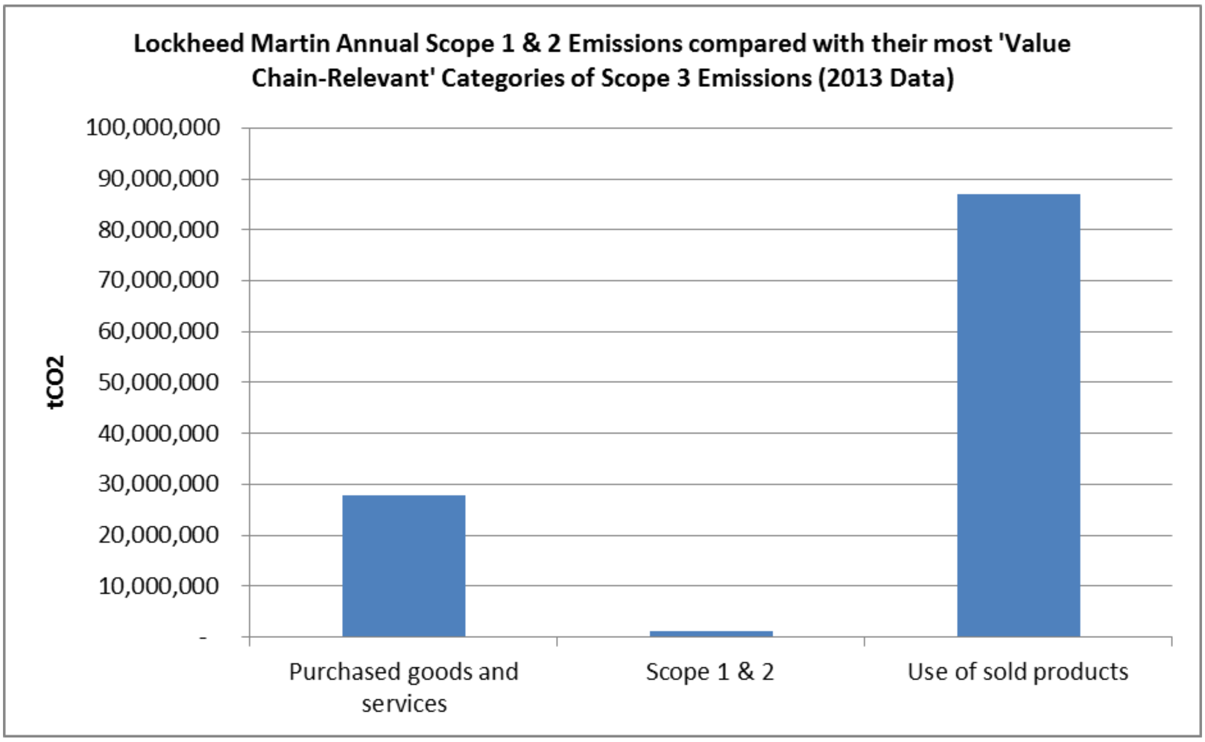

Figure 9: Summary of Lockheed Martin's Annual Scope 3 Emissions related to 'Purchased Goods and Services' and 'Use of Sold Products' in the Context of their Scope 1 & 2 Disclosures. It illustrates the significance of the Scope 3 emissions categories that relate to the value chain, which are currently only reported by Lockheed Martin. The emissions from these Scope 3 categories are far more quantitatively significant than the Scope 1 & 2 emissions reported by the organisation. (Source(s): Appendix A, Tables 29, 39 and 40)

Lockheed Martin's data confirms that the emissions associated with its most direct value chain impacts (the purchase of goods and services, and particularly the use of sold products) is where its biggest GHG impacts are. These two categories represent over 99% of its total reported Scope 3 emissions, and over 98% of its total Scope 1-3 emissions.

BAE Systems have produced some 'Project Level' Carbon Accounts that are not available publicly but demonstrate a similar scale of emissions in other parts of the product lifecycle. In one of these studies for a complex defence platform, emissions related to manufacturing represented just 3.4% of the total lifecycle emissions, whereas the 'use of sold products phase represented 94.3%.

Therefore, despite the difficulty in deriving the Scope 3 emissions values that are most relevant to the value chain, the submissions by Lockheed Martin in figure 9 above (and the private data from BAE Systems) would suggest that these are by far the most relevant ones to be reporting.

Whilst very little value-chain relevant GHG data exists in the public reporting in the defence sector, the emphasis on its importance is clear qualitatively in the documents.

Defence departments are quick to recognise the importance of their supply chains to their products and capability (Cabinet Office, 2010b; Department of Defense, 2010a), and there are many references in their specialist public documents to the importance of having energy efficient products and services and limiting the environmental impacts of these (Ministry of Defence, 2011b; Department of Defense, 2014b).

The 'Sustainable Procurement' guidance of the defence departments (much of which is publicly available) is also designed to ensure that suppliers limit the environmental impacts of their products in later phases of the product lifecycle. In the US DoD context, there is lots of guidance available on Sustainable Procurement of products and services (Defense Acquisition University, 2016), and Sustainable Procurement is actually mandated across the organisation with the Strategic Sustainability Performance Plan (Department of Defense, 2014b) publicising a target for 95% of procurement to be conducted sustainability, which means that contracts should:

> 'contain requirements for (as relevant and where such products and services meet DoD performance requirements): energy-efficient (ENERGY STAR or Federal Energy Management Program [FEMP] designated), water-efficient, biobased, environmentally preferable, non-ozone depleting, containing recycled content, and/or are non-toxic or less-toxic alternatives' (p.24)

The US DoD has also mandated that the Fully Burdened Cost of Energy (see section **4.3.2** 'Integrating the Secondary Sources' below) be used in the 'Analysis of Alternatives' at concept phase to ensure that whole life costing rewards more energy efficient equipment (BAE Systems CORDA, 2015).

Many of the most relevant UK MoD Sustainable Procurement guidance is available via registered access or the MoD internal network, but this documentation is also showing an increased emphasis on the environmental impacts of products in use, albeit without the same sort of pan-organisation requirements being mandated by the US DoD (BAE Systems CORDA, 2015).

Similarly, Corporate Responsibility and Sustainability Reports from all of the defence companies included in this research provide significant narrative sections on 'product stewardship' that summarise the activities they are undertaking to limit the environmental impacts of their products and services (see 'Specialist' public documents summarised in Appendix A, Table 20).

A review by Context for BAE Systems (Context, 2015) provides a useful summary of some of the key activities undertaken by the defence companies to engage with their suppliers. Most companies clearly demand that suppliers satisfactorily complete questionnaires relating to their environmental impacts, but some have additionally published targets in relation to this, with Raytheon having set a target to increase eco-friendly procurement by 20% by 2015, and Thales planning to assess environmental maturity of 80% of suppliers by 2015.

The same review (Context, 2015) also summarised some of the activities taken to ensure the environmental efficiency of their products, with most companies conducting Lifecycle

Assessments where appropriate and convening ‘Product Environmental Working Groups’ to share best practice across their organisations. However, there are very few quantitative metrics or targets in this area, and indeed only Boeing seem to communicate a quantitative goal for their products, declaring in their 2014 Environment Report their aim that biofuel will meet 1% of global jet demand by 2016.

Despite this clear qualitative emphasis on environmental performance across the value chain, and the recognition of it as fundamental to environmental strategy, examples of GHG data published by organisations that is relevant to the value chain are scarce.

Lockheed Martin are clearly beginning to publish relevant data in this area (see Figure 9 above), and BAE Systems are doing it internally for certain products and services. The numerous references to the use of lifecycle assessments in the public reporting of defence companies suggests that others are also generating this type of data, if not making it public or calculating it for the organisation as a whole.

On the defence department side, there are clearly some efforts to understand their own ‘supplier emissions’ in quantitative terms, with the US Navy notable for having joined CDPs Supply Chain scheme (CDP, 2016e) and asking its major suppliers to provide GHG data associated with the supply of their products and services to the organisation.

However, these efforts remain immature in the sector at present. The lack of good, public ‘Project Level’ Carbon Accounts is notable, and limits the relevance of OCA where Scope 3 emissions inventories generally do not contain information relevant to the most significant parts of the defence value chain, or those where the majority of emissions are located.

Recognising the lack of data available in this area, the next section analyses the published energy breakdowns of the different organisations across the defence sector, and suggests that the way that Lockheed Martin and BAE Systems have quantified the value chain relationships above appears to hold across the sector more broadly.

4.1.3 How the Significance of Different Organisations in the Sample Could Change if Scope 3 Emissions were more Widely Available

This sub-section compares the 'operational energy' demands of the defence departments with relevant portions of the defence company totals. It reinforces the scale of emissions likely to be linked to defence products, and contrasts the scale of these 'linked' accounts with the large differences in volumes reported by organisations in the existing organisational accounts. As the defence departments tend to wholly account for the GHGs emitted in the usage phase of defence products at present, their organisational totals will inevitably be far higher than those of the defence companies, despite the significant impact that defence companies have on the design, manufacture, operation and maintenance of these products. In the absence of a full set of Scope 3 emissions data, linking a portion of the departmental emissions to the supporting industrial base gives some indication of the scale of emissions that can be associated across the defence value chain.

The 'facility' and 'operational' split is common language in the defence department reporting, and is useful for understanding the volume of emissions that can be connected across the defence value chain. The 'facility' emissions refer to those related to a given defence department's (largely domestic) static estate, and the 'Operational' emissions represent the 'operational fuel' that the department is buying to power its equipment. Lengyel (2007) explains in the US context:

> 'In simple terms, DOD energy use can be divided into two main categories: petroleum based fuel for mobility platforms, and infrastructure energy based on electricity, natural gas. The vast majority of DOD energy consumption, some 74% of total energy cost, supports mobility platforms – aircraft, ships, and ground vehicles…Buildings/facilities account for 22% of DOD's energy cost.' (p.9)

In the UK the breakdown is fairly similar (see next sub-section), and these percentage-splits are obviously subject to change over time as deployed operations occupy a larger or smaller proportion of defence activity (Pew, 2010).

This division is partly founded on the organisational structures of defence departments, with facility energy and operational energy often located in separate areas of the organisation, as Partemore & Nagl (2010) describe:

> 'there is no single official who oversees DOD's entire energy portfolio; authority within DOD is currently divided' (p.4) …
>
> 'Within OSD and the services, responsibility is generally split between those managing energy for military installations and those managing operational energy. This is in part a legacy divide: Positions governing operational energy in OSD and the services have only been stood up as dedicated offices over the past few years, while offices governing energy use at military bases have long been part of the DOD organizational structure.' (p.19)

It is reinforced by the public reporting, which distinguishes fairly heavily between facility and operational energy, and in the case of the US they are reported on separately.

Figure 10 demonstrates the scale of difference between the defence departments and defence companies in the proportion of 'operational energy' that they report.

Note that the 'facility' and 'operational' split does not apply well to the companies included in this research because they don't have the same concept of 'deployed operations' described above. However, the companies do tend to publish details of the energy mix that underpins their reported GHG data (via CDP), and therefore we can make an imperfect, but interesting comparison with the defence departments by splitting out the liquid fuels that they use (assumed mostly relevant to testing and trialling equipment), from their solid fuels and purchased electricity (assumed relevant to their 'static estate').

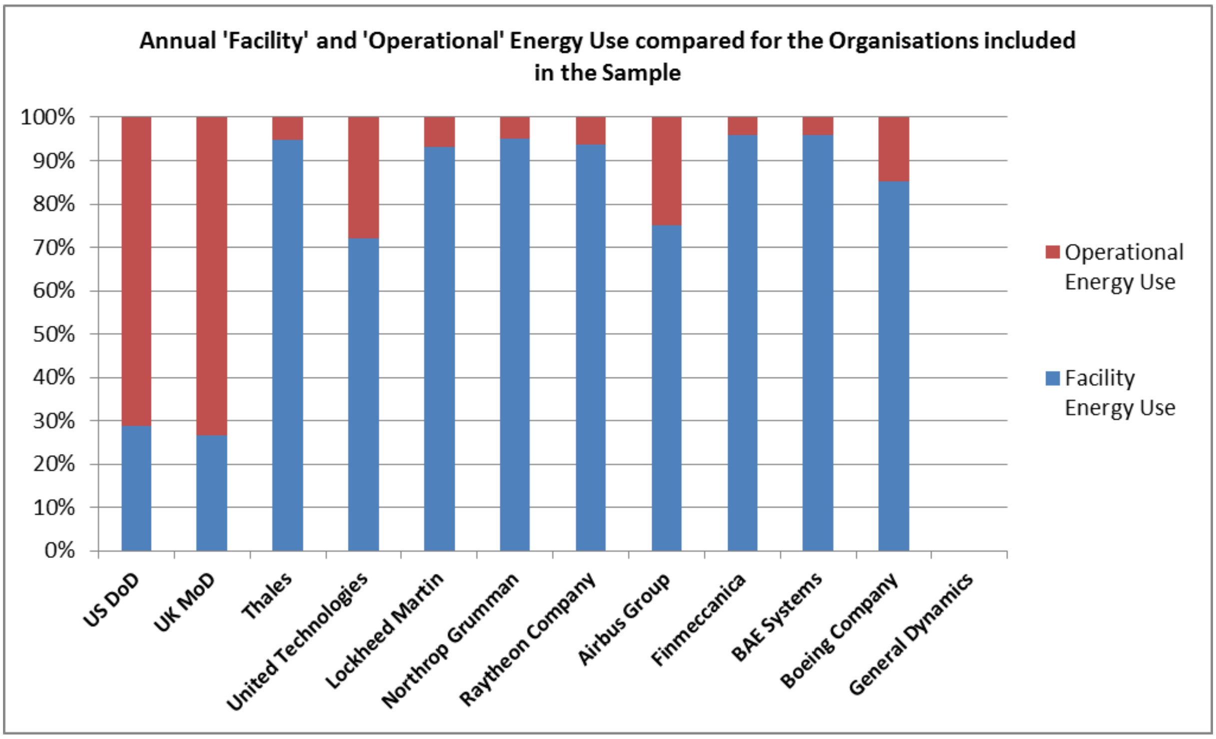

Figure 10: 'Facility-Operational Split' in energy consumption compared across defence sector organisations. It demonstrates a significant difference between the defence departments and defence companies in the proportion of 'operational energy' (or liquid fuels) that they report (Source: Appendix A, Tables 23-24, 26-27, 41-43)

One conclusion from Figure 10 above is that the facility-operational profile of the organisations in the research differs so markedly between defence departments and defence companies because they are doing significantly different tasks, with the defence departments using mobile platforms and the defence companies simply manufacturing and testing them. However, these are strongly linked activities given that the 'operational loads' of the defence departments are often based on the equipment and services provided to them by the defence companies.

Table 62 in Appendix A is reproduced from Page (2007) with some additions, and demonstrates the extent to which BAE Systems is the dominant supplier to the UK MoD in relation to the products that use a significant amount of the department's operational energy use. The table implies that it is reasonable to make a comparison of the operational energy use of the MoD and BAE Systems total ‘revenue adjusted’ emissions for their sales to that customer (see Figure 11).

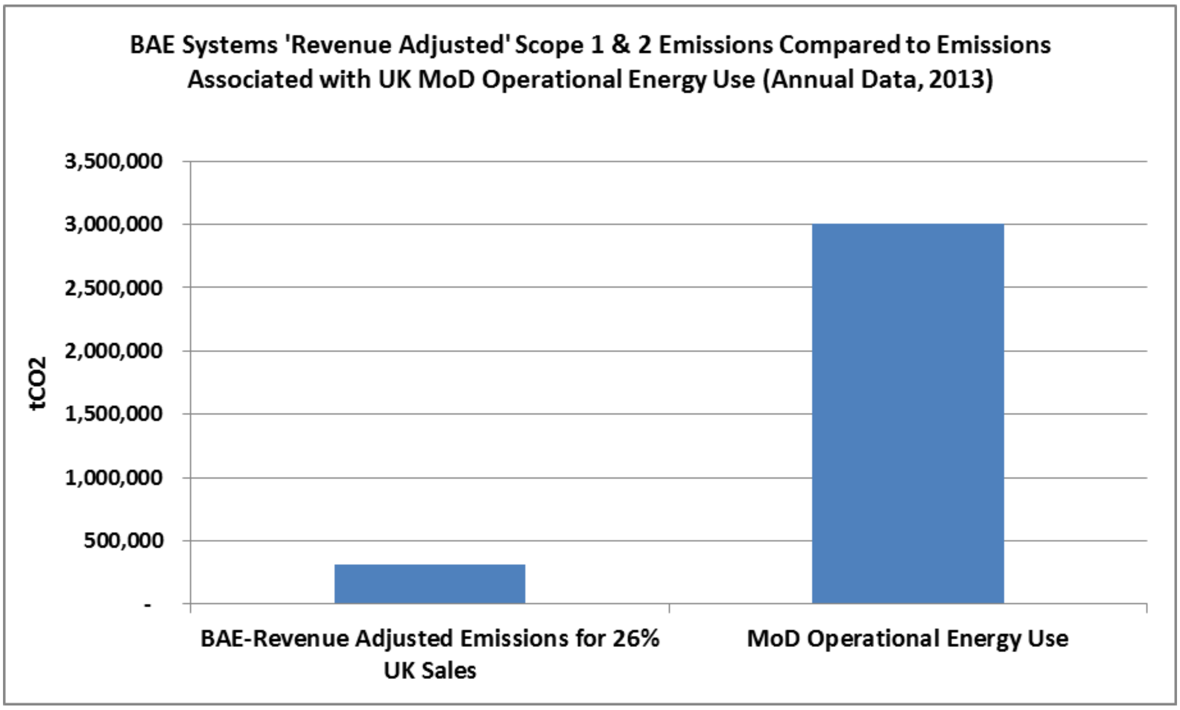

Figure 11: Comparison of ‘revenue-adjusted’ BAE Systems emissions with the operational energy use of the UK MoD. This represents an attempt to ‘link’ a relevant proportion of BAE Systems’ emissions with those of the UK MoD. The BAE Systems emissions have been normalised for the proportion of total company sales that went to the UK MoD (26%). All of the MoD’s emissions related to operational energy use are included as it can be demonstrated that the vast majority of their combat platforms are supplied by BAE Systems (see Table 62). The figure illustrates how these ‘linked emissions’ together represent a very significant volume of emissions, which are currently overwhelmingly reported by the defence department. (Source: Appendix A, Tables 21, 29, 50)

Similarly, one might hypothesise that the US DoD’s main combat platforms are supplied by one or other of the top US defence contractors. Figure 12 below shows the same comparison of US DoD operational energy use and revenue-adjusted emissions of the top US defence companies.

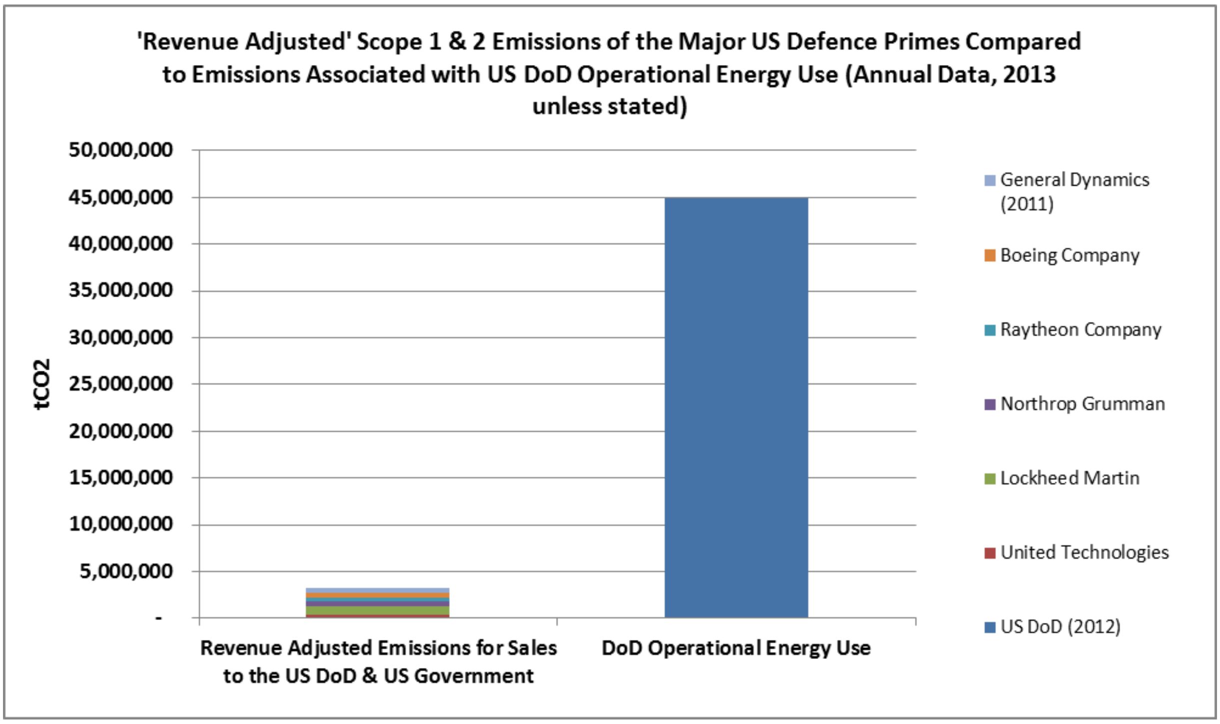

Figure 12: Comparison of 'revenue-adjusted' emissions for US defence companies in the sample with the operational energy use of the US DoD. This represents an attempt to 'link' a relevant proportion of relevant defence company emissions with those of the US DoD. The US defence company emissions have been normalised for the proportion of total company sales that went to the US DoD. All of the US DoD's emissions related to operational energy use are included as the vast majority of their combat platforms are supplied by these companies. The figure illustrates how these 'linked emissions' together represent a very significant volume of emissions, which are currently overwhelmingly reported by the defence department. (Source: Appendix A, Tables 25, 29, and 49)

These estimates of 'linked emissions' in the sector as a whole corroborate the scale of Scope 3 value chain emissions estimated by Lockheed Martin above and derived in the internal BAE Systems product-level footprint. Figure 13 below aggregates the organisational totals described in section **4.1.1** ('Analysis of Scope 1 & 2 Data') and highlights the elements of them that link together between defence departments and defence companies.

As can be seen, despite the huge difference in volumes of emissions reported by the defence departments and the defence companies, a very significant proportion of the defence department emissions can be linked in some way to the defence companies.

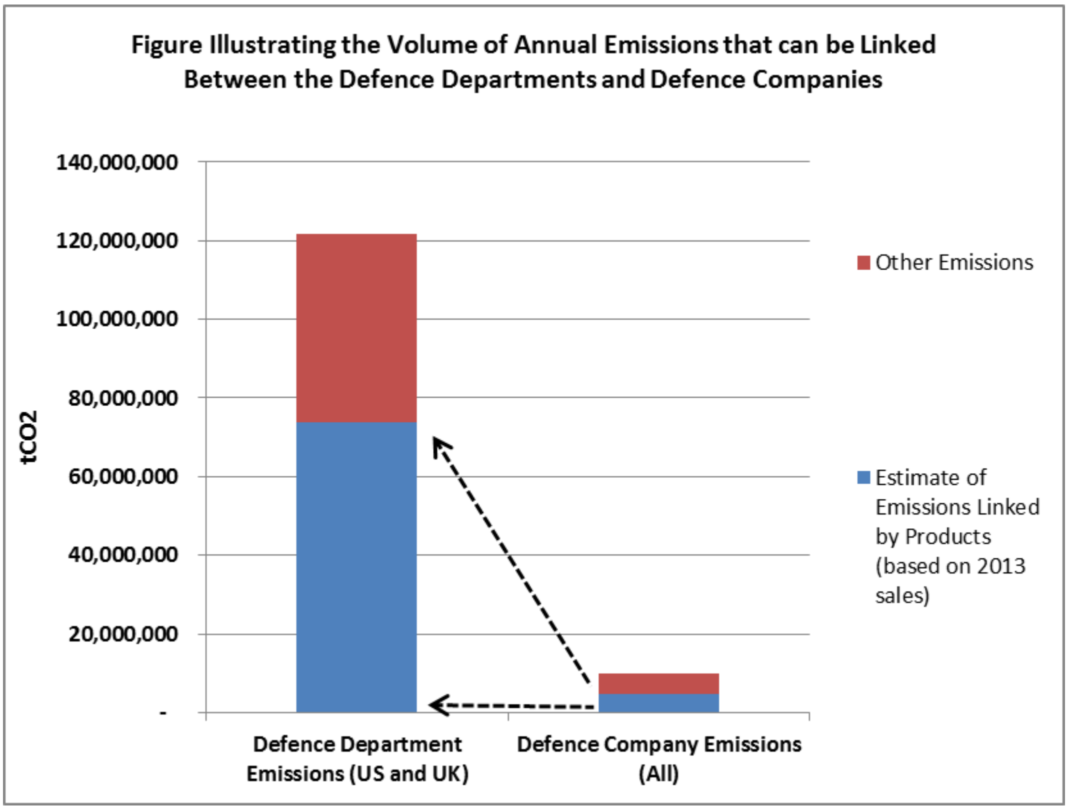

Figure 13: Comparison of 'revenue-adjusted' annual emissions of all defence companies in the sample with the operational energy use of the US DoD and UK MoD. This combines the data from figures 10 and 11 to show the same comparison for all organisations in the sample. This figure also shows these 'linked' emissions (in blue) in the context of the total reported Scope 1 & 2 emissions from all organisations in the sample ('other emissions' in red in the figure above). The figure illustrates how these 'linked emissions' together represent a very significant volume of the total emissions reported by the sample, which are currently overwhelmingly reported by the defence departments. (Source: Appendix A, Tables 21, 25, 29, 49, 50)

The scale of these 'linked emissions' emphasises the potential value that 'Project Level' Carbon Accounts can add in producing accounts for carbon that better acknowledge the extent to which the organisations are linked together by this equipment across the defence sector.

The scale of the emissions that can be linked across different organisations in the defence enterprise also gives some indication of how the significance of different organisations in the sample might change if certain categories of Scope 3 emissions were published. Section **4.1.1** analysing the scope 1 & 2 emissions showed a clear quantitative emphasis on the defence departments over the defence companies in the sample, however the analysis from the subsequent sections suggests that the some or all of the companies in the sample would become far more quantitatively significant if relevant categories of Scope 3 emissions are included.

The next section integrates the qualitative data to this analysis. It shows a correlational link between the quantity of emissions accounted for and the emphasis placed on the issue of climate change mitigation in the public documents that are produced by the defence organisations in the sample. This suggests that the OCA practices can potentially have a real impact on the level of importance placed on climate change mitigation, and the extent to which the innovative capacity of different organisations is being leveraged in the fight against climate change. Thus, OCA practices that assign the overwhelming majority of emissions to the defence departments may not encourage the whole of the defence enterprise to effectively engage on climate change mitigation.

4.2 Integrating the Qualitative Data

This section integrates the qualitative data discussed in the Methodology (section **3.4.2** 'Establishing the Qualitative Dataset') to analyse the significance of the higher volumes of emissions accounted for by the defence departments, highlighting a correlation between the volumes of emissions reported, and the level of importance placed on the issue by the organisation concerned. This is significant because it suggests that OCA practices can potentially have a real impact on the level of importance placed on climate change mitigation by the organisations in the sample, and the extent to which their innovative capacity is being leveraged to help mitigate dangerous climate change.

This section is split into two sub-sections that each compare total reported emissions with some relevant indicators taken from the qualitative dataset. Section **4.2.1** compares reported emissions with the use of certain climate change 'keywords' in the public reporting of the organisations in the sample, and section **4.2.2** compares reported emissions with the levels of ambition enshrined within their public targets for reducing GHGs.

4.2.1 Volumes of Emissions Reported vs Public Use of Energy and Climate Change Keywords

The public use of energy and climate change keywords can be used as one indicator of the level of importance placed on the issue of climate change mitigation by the organisations included in this research. By comparing this to the volumes of emissions reported by the organisations in the sample, the analysis below demonstrates that when higher volumes of emissions are reported by a particular organisation can increase the emphasis that they place on the topic in their public reporting.

Figure 14 below shows that there is no clear relationship between climate change and energy keywords used in the 'general' public documents produced by the organisations in this research and their relative GHG intensity. However, Figure 15 shows quite a clear relationship in relation to the 'specialist' public documents produced by the organisations included in the research.

Note that it is important to normalise for page numbers, as the documents reviewed can vary significantly in length, and differ in relation to how concise they are.

It is also interesting to see the split between 'climate change' keywords and 'energy' keywords in these documents. Certainly the US DoD appears to have a strong preference for discussing 'energy' in preference to 'carbon' or 'climate change', and this may reflect cultural issues within the regions and organisations analysed. These cultural influences on the language used is beyond the scope of this research, but the keyword-count datasets shown in section **3.4.2** ('Establishing the Qualitative Dataset') have potential to be used for a more in-depth analysis of this issue, particularly if the further categories within 'energy' and 'climate change' are explored.

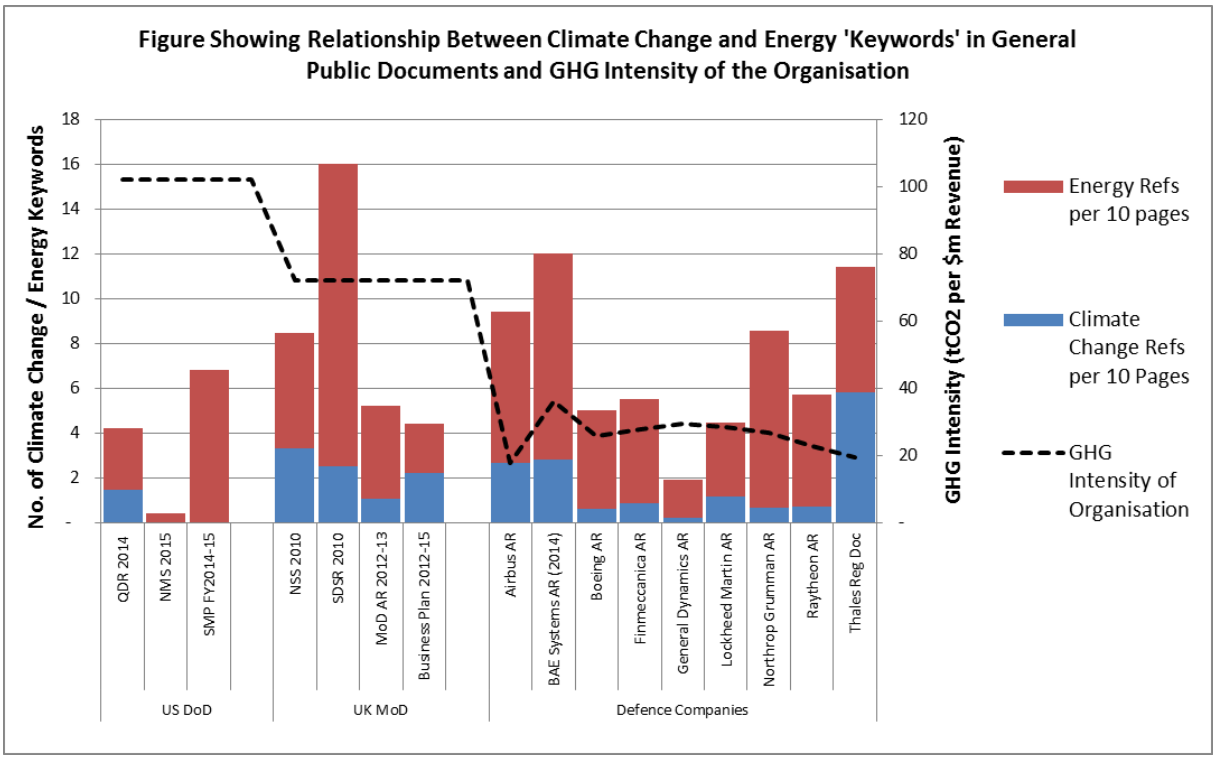

Figure 14: Showing the number of climate change and energy keywords in 'general' public documents produced by the organisations included in the sample (normalised for total number of pages in the document), compared to their GHG-intensity measured by their annual tCO_2 per $m revenue. It shows the lack of a clear correlation in relation to the 'general' public documents between the volume of emissions reported by organisations and the level of emphasis placed on energy and climate change in their public reporting. This is in contrast to the clear correlation in relation to the 'specialist' public documents described in Figure 15. (Source: All 'general' public documents described in Appendix A, Table 20**.** GHG Intensity derived from Appendix A, Tables 21, 25, 29, 44, 45, 46, and 47)

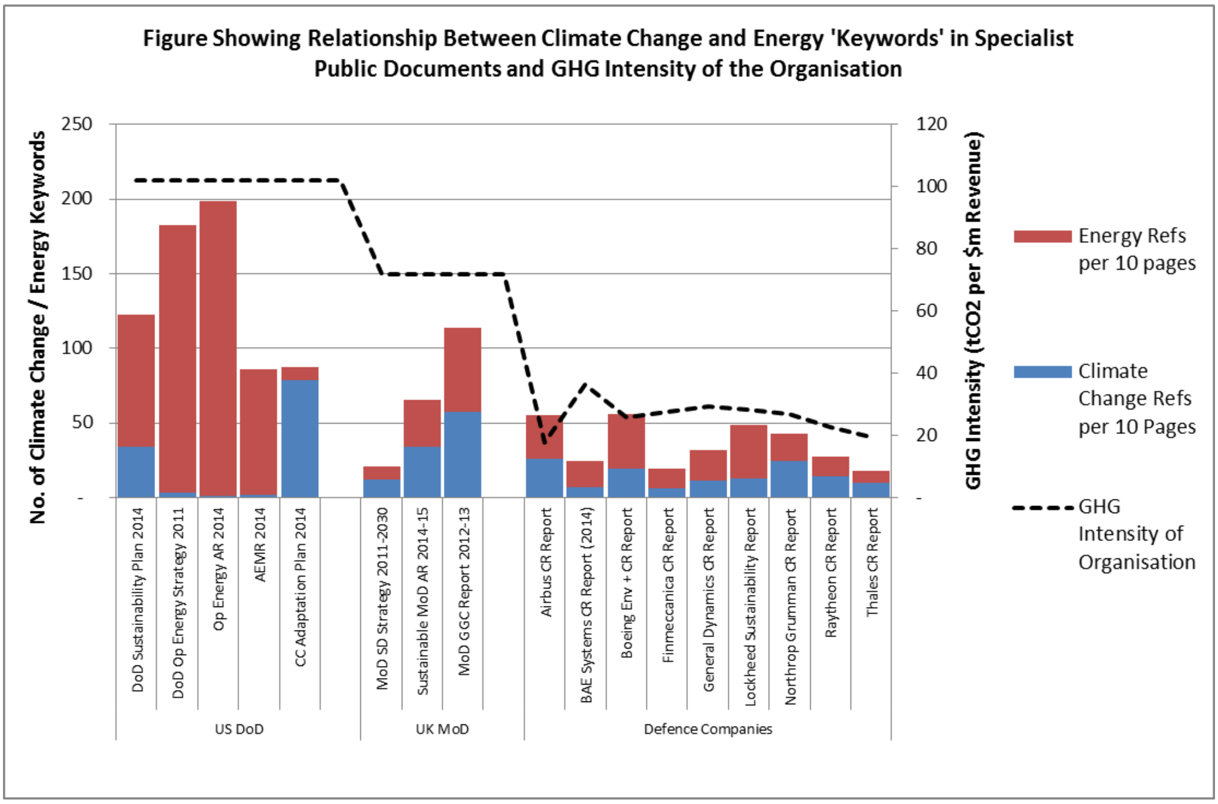

Figure 15: Showing the number of climate change and energy keywords in 'specialist' public documents produced by the organisations included in the sample (normalised for total number of pages in the document), compared to their GHG-intensity measured by their annual tCO_2 per $m revenue. It shows a correlation in relation to the 'specialist' public documents between the volume of emissions reported by organisations and the level of emphasis placed on energy and climate change in their public reporting. (Source: All 'specialist' public documents described in Appendix A, Table 20. GHG Intensity derived from Appendix A, Tables 21, 25, 29, 44, 45, 46, and 47)

The next section analyses whether the same correlations hold when considering the qualitative data related to GHG and Energy targets that are set by the organisations in the sample.

4.2.2 Volumes of Emissions Reported vs Energy and GHG Targets

Another indicator that helps describe the level of priority that organisations are placing on climate change mitigation is the type and scale of public targets that they are setting. This indicator can also be compared to the total volume of emissions that the organisations report to determine whether a correlation exists.

Figure 16 below shows where absolute GHG reduction targets exist across the organisations in this research, and how these compare to the GHG intensity of the organisations.

As can be seen, the two organisations clearly reporting the highest volumes of GHGs (US DoD and the UK MoD) are clearly setting public GHG reduction targets, and the reduction ambition of these targets neatly track each organisation's GHG Intensity measured by tCO_2 per $m Revenue. There will be other drivers pushing these organisations to set emissions reductions targets, for example the fact that they are public sector organisations subject to wider federal reduction targets. However, there is a notable correlation between the emissions intensity of the organisations and the scale of ambition demonstrated by their public targets, and the defence-energy grey literature (see **3.5** 'Relevant Secondary Sources of Data') demonstrates how defence departments (particularly the US DoD) come under some pressure to set energy and GHG targets of an appropriate ambition, partly as a result of the scale of emissions that they have declared. For example, Warner & Singer (2009) and Partemore & Nagl (2010) have both debated relevant energy targets for the US DoD in their thought-leadership pieces[28].

The picture is far more mixed for the defence companies included in this research. The presence of absolute GHG reduction targets for only 3 of the 10 companies included in the research does suggest that their lower reported volumes of emissions may be a driver in their decisions to publicly declare GHG reduction targets. This is clearly not the case for three of the organisations in the research (Lockheed Martin, Northrop Grumman, and Raytheon), who are setting emissions reduction targets that look particularly ambitious given their reported volumes of emissions. Interestingly, when referring to the qualitative dataset of 'external accounts of performance' (see Appendix A, Tables 57-58), the scores given to the defence companies by CDP for the period to which the data in Figure 16 relates would confirm these three organisations a 'good performers', as they were the only three organisations to receive the highest performance score of 'A' in that year. This implies some correlation between the different qualitative indicators used in this research, which suggests that any potential bias in the analysis is likely to have been reduced to an acceptable level.

[28] Warner & Singer (2009) recommended that 'based upon existing analysis and discussions with defense energy experts of what would be an ambitious but achievable goal, it is our contention that a target can be set for an overall reduction goal of 20 percent by 2025 and for the DoD to be a net-zero energy consumer at its bases and facilities by 2030' (p.5). Partemore & Nagl (2010) recommend that 'DOD should ensure that it can operate all of its systems on non-petroleum fuels by 2040…Ensuring that DOD can operate on non-petroleum fuels 30 years from today is a conservative hedge against prevailing economic, political and environmental trends, conditions and constraints.' (p.3)

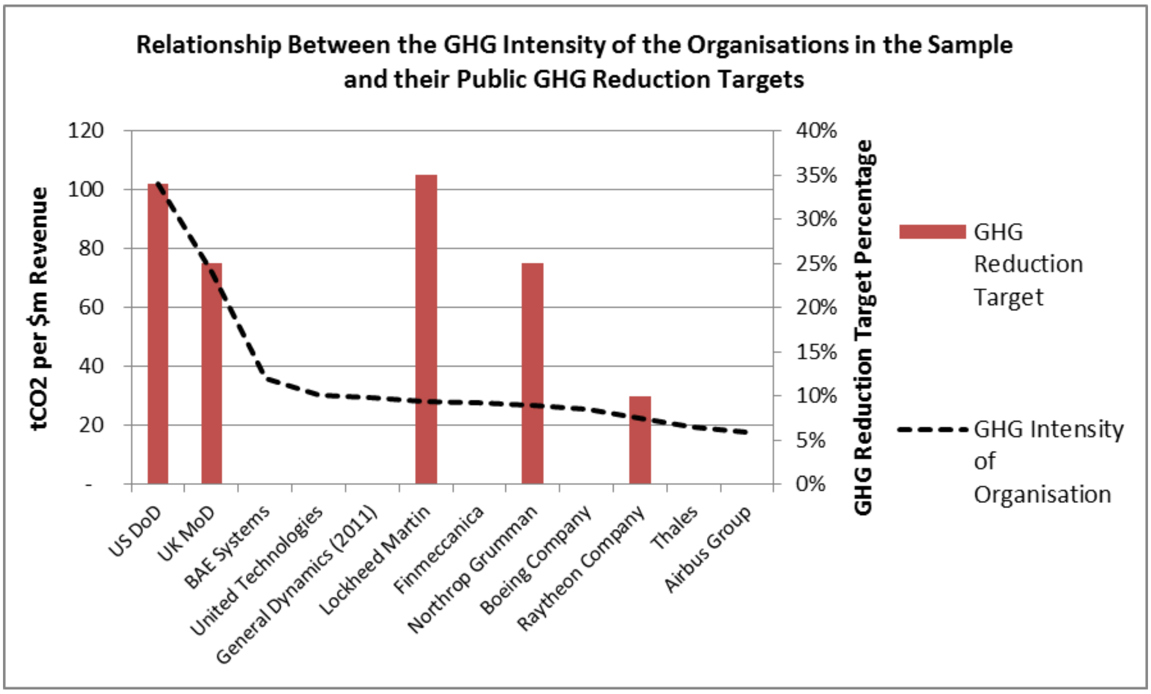

Figure 16: Showing the relationship between the GHG intensity of the organisations in the sample (measured by their annual tCO_2 per $m revenue) and their published GHG reduction targets. For the defence departments, it shows a correlation between the GHG intensity of the organisation and their level of ambition in relation to reducing their GHG emissions. For the defence companies, three companies are setting absolute reduction targets, which appear particularly ambitious in relation to their GHG intensity. Interestingly, these three companies appear to be scoring better than the others in the sample in relevant external accounts of environmental performance, such as those from CDP. (Source: Targets taken from Appendix A, Table 56. GHG Intensity derived from Appendix A, Tables 21, 25, 29, 44, 45, 46, and 47)

This section has illustrated a correlation between the volume of emissions reported by an organisation and the level of priority placed on the issue of climate change mitigation, by comparing total emissions with some qualitative analysis of public documents from the relevant defence sector organisations. It suggests that the technical accounting issues driving reported volumes may not only influence the absolute reported volumes of GHGs, but by extension the extent to which the organisation acts to mitigate climate change.

Some analysis from Kauffman, Tebar Less & Teichmann (2012) would reinforce this assessment, concluding that ‘in practice there seems to be a strong link between GHG emission reporting and the development of a corporate climate change strategy’ (p.24), and that discussing GHG reporting schemes (whether mandatory or voluntary) is a key lever for making organisations act to mitigate climate change.

4.3 Integrating the Secondary Sources

The exploratory approach and archival strategy applied in this research emphasised the relevance of using secondary sources from the defence sector (see Methodology section **3.5** 'Relevant Secondary Sources of Data'), where the topic of defence energy use and defence-climate issues has gathered significant momentum. These secondary sources highlight some relevant concepts and metrics related to defence energy use that are summarised in this part of the Results chapter, and returned to in the 'Results Summary' and Discussion chapter that follow.

In addition to the quantitative and qualitative analysis above, this analysis of the secondary sources provides some broader context to the way that defence-energy and defence-climate issues are being framed across the defence enterprise.

This section is split into three further sub-sections. The first (**4.3.1**) describes the emerging concepts of 'endurance' and 'resilience' in defence that help to contextualise defence-energy challenges at the system-level. The second sub-section (**4.3.2**) describes some relevant metrics that connect to these emerging concepts. It focuses on the 'Fully Burdened Cost of Energy' (FBCE) metric, which has illustrated the substantially increased cost of actually using energy in military operations, when a system-level perspective is applied that includes the logistics implications of delivering energy to remote and hostile locations. The third sub-section (**4.3.3**) explains the current state of the FBCE in practice, explaining how it has successfully established itself in the military lexicon, but there remain challenges in practically implementing it across defence decision making. The barriers to its practical application are of particular relevance to this research, and are summarised in relation to the lack of good 'project level' data (see section **4.1.2** 'Analysis of Scope 3 Data') that can support calculation of the FBCE in different scenarios, but also the emphasis on individual functions, departments or organisations that make it difficult to realise the potential benefits illustrated by the metric at the system level. This latter barrier can be seen as analogous to the emphasis on attributing emissions to individual organisations in traditional OCA practices.

4.3.1 Emerging System-Level Concepts in the Defence-Energy Grey Literature

Recent commentaries have emphasised the clear links between defence energy use and defence capability. When asked in 2003 what was the most important area of military research that was currently needed Lieutenant General James Mattis famously responded: 'unleash us from the tether of fuel' (Lengyel, 2007). This 'tether of fuel' places large restrictions on the military becoming the type of agile, flexible and 'light-footed' force required for the 'new wars' described in section **2.2** ('Defence Industrial Policy') that characterise the contemporary security environment. The previous Results sections have described the large volumes of energy required to support defence, but this is only part of the story – the logistics associated with delivering this fuel to point of use are very significant. Many recent studies from think tanks and military research organisations have focused on the logistical burden of having to supply fuel to deployed forces, highlighting the disparity between the force requirements for logistics and that used for actual operations. Warner & Singer (2009) elaborate on this issue, highlighting how the current US scenario harks back to civil war logistics:

> 'In a study of fuel use in Iraq, the Marines found that only 10 percent of their consumption was by armed vehicles. The remainder was consumed by logistics vehicles. For the Army, only two of its top ten fuel consumers are combat vehicles. Ironically, three of the four least fuel-efficient Army vehicles are trucks that haul fuel…the current situation echoes…Civil War logistics, when mule teams hauled wagons of supplies, half of whose tonnage was feed for the mules.' (p.2)

Lengyel (2007) summarises that 'the United States' unique ability to project military power anywhere on the globe requires incredible quantities of liquid hydrocarbon fuel' (p.52). The DSB Task Force on Energy Security discussed the issue of the logistical burden being carried by the US Armed Forces in their 2008 review (Department of Defense, 2008b) commenting on the poorly balanced ratio of 'operational effect' to 'logistics effort', or as they describe it 'tooth-to-tail'. The 'tail' of contemporary forces is huge, and this considerably restricts movement in the battlespace.

The 'logistics tail' has proved a vulnerable target to enemy attack in deployed environments. The following passage from a Deloitte study (2009) elaborates further on the fuel requirements of contemporary armed forces, the success that enemy forces have had in disrupting fuel supply, and how this 'logistics vulnerability' is very much a feature of contemporary conflict:

> 'High fuel requirements in forward deployed locations present the military with a significant logistical burden…More importantly, the transport of this fuel via truck convoy represents casualty risks, not only from IEDs and enemy attacks, but also rough weather, traffic accidents, and pilferage. DoD officials reported that in June 2008 alone, a combination of these factors caused the loss of some 44 trucks and 220,000 gallons of fuel' (p.15 Deloitte study)

Deloitte (2009) show a correlation between the fuel demands of US Forces and the increase in US casualties, and Warner & Singer (2009) describe how 'a mere 1 percent improvement in energy efficiency would mean that soldiers in Iraq would have to serve on 6,444 less convoy missions, a role considered one of the most dangerous in the operation' (p.3). The UK scenario is no different, with Stein (2009) commenting that 'fuel supplies are often targeted by enemy forces and 139 personnel and 89 tankers have been lost while delivering fuel since 2006 alone'.

Warner & Singer (2009) highlight the potential that reducing the logistics footprint has to 'enhance mobility and lighten footprint', emphasising that these are 'crucial goals in both conventional operations and a counterinsurgency campaign.' (p.3). Lovins (2010) notes the potential advantages:

> 'A lean or zero fuel logistics tail increases mobility, manoeuvre, tactical and operational flexibility, versatility, and reliability—all required to combat asymmetrical, adaptive, de-massed, elusive, faraway adversaries.' (p.4)

The fact that both authors tie this trend to the contemporary character of conflict is significant, with a mobile and agile force essential to the 'new wars' described in section **2.2** ('Defence Industrial Policy'). In this context energy efficiency is increasingly being seen as an enabler of defence capability, as opposed to a trade off with it. The DSB Task Force (Department of Defense, 2008b) confirm that the DoD need not choose between capability and energy efficiency:

> 'The payoff to DoD from reduced fuel demand in terms of mission effectiveness and human lives is probably greater than for any other energy user in the world. More efficient platforms would enhance range, persistence and endurance. They also would reduce the burden of owning, employing, operating and protecting the people and equipment needed to move and protect fuel from the point of commercial purchase to the point of use…In short, more efficient platforms increase warfighting capability.' (p.18)

Some new 'strategic vectors' have emerged to try and encapsulate this mind-set where energy efficiency is considered an enabler of defence capability, as opposed to a trade-off with it. Lovins (2010) describes these as 'endurance' and 'resilience', and these are discussed in more depth next.

Lovins (2010) describes how 'Strategic Vectors' can be summed up as 'succinct descriptions of capabilities that would make a big difference in military operations' (p. 3-4). The current vectors used are speed, stealth, persistence and networking (Department of Defense, 2008b: p.35). The DSB Task Force on Energy Security recommend two further vectors to appropriately consider energy within this process: endurance and resilience.

> 'Endurance exploits improved energy efficiency and autonomous energy supply to extend range and dwell—recognizing the need for affordable dominance, requiring little or no fuel logistics, in persistent, dispersed, and remote operations, while enhancing overmatch in more traditional operations. Resilience combines efficient energy use with more diverse, dispersed, renewable supply—turning the loss of critical missions from energy supply failures (by accident or malice) from inevitable to near-impossible.' (Department of Defense, 2008b: p.35)

Creating 'strategic vectors' that better relate to the energy challenges that defence faces provides a means of summarising the challenge at the 'system-level', and relating it strongly to the overarching issue of 'defence capability' discussed in section **2.2** ('Defence Industrial Policy').

To take 'resilience' first, this 'vector' might be seen to apply best to infrastructure energy use, with bases both in deployed or allied locations and at home needing a secure supply of energy to support operations. This vector is particularly important considering the contemporary character of conflict, where these operating bases are used extensively to support deployed forces through C4ISTAR operations (surveillance, reconnaissance, information analysis etc.).

The 'endurance' vector is perhaps most relevant to this research, with Lovins (2010) connecting this 'vector' strongly to platform energy use, and therefore it is directly relevant to the type of 'Project Level' Carbon Accounts discussed in section **4.1.2** ('Analysis of Scope 3 Data') above:

> ‘Endurance is needed in every “platform” using energy in the battlespace, from mobility platforms to expeditionary base power to battery-powered land-warrior electronics. Endurance is even more valuable in stability operations, which often need even more persistence, dispersion, and affordability than the combat operations with which they now enjoy comparable priority.’ (Lovins, 2010: p.4)

The same author uses this ‘vector’ to describe the system-level context and rationale for change (efficiency) at the project level:

> ‘radically boosting platforms’ energy efficiency and combat effectiveness at reasonable or reduced up-front cost can turn each of these energy risks into major warfighting gains. Requiring and exploiting Endurance can give DOD more effective forces and a more stable world, at reduced cost and risk. This better-than-free opportunity must become a cornerstone of military doctrine.’ (p.6)

This is particularly relevant in a context of increasing platform energy use at present. These increases can be partly justified by the increased capability of newer equipment, for example Lockheed Martin’s 2013 Sustainability Report (Lockheed Martin, 2014b) explains the relative ‘energy efficiency of their ‘force multiplier F-22 and F-35 aircraft [that] do the work of several prior-generation airplanes’ (p.22). However, the energy demands of new defence platforms are growing more intensive. Section **4.1.2** (‘Analysis of Scope 3 Data’) discussed the lack of ‘Project Level’ Carbon Accounts published in the defence sector, but some analysis by DoD and the Rocky Mountain Institute has suggested that:

> ‘oil intensity per warfighter rose 2.6%pa for the past 40 years, and is projected to rise another 1.5% pa through 2017, due to greater mechanization, remote expeditionary conflict, rugged terrain, and irregular operations’ (Lovins, 2010: p.1)

Therefore regardless of capability gains per platform, they are becoming more energy hungry. The same study suggests that compared with operations during the Cold War, ‘warfighting is [now] about 16 times more energy-intensive’ (Lovins, 2010: p.1). A Dutch Task Force on Energy Security (Vettehen & Ross, 2010) note a similar trend:

> ‘Since the end of the Cold War, the number of personnel within the Armed Forces has been substantially reduced, similar to the numbers of armoured vehicles, ships and aircraft. Declining numbers are partially compensated for by new technology. However, this new technology generally demands more energy – the energy consumption of a single soldier has risen by 175 per cent over the last three decades. It will continue to rise and increase the dependency on fossil fuels if policies to reduce energy consumption are not implemented.’ (p.94)

A Deloitte study (2009) notes similar issues and states that as a result defence has experienced ‘a steady increase in the dependence on fossil fuels since World War II’ (p.3).

Lovins (2010) summarises the importance of the ‘endurance’ vector within this context of increasing platform energy use:

> ‘An Endurance capability will create transformational strategies and tactics that both tell the requirements-writer to make a new platform fuel efficient and inspire the force planner to exploit its increased range and agility. Today’s DOD habits would instead

> tend to make it heavier with the same range—much as Detroit's engine improvements since the 1970s, rather than saving one-third of civilian cars' fuel, only made them more muscular.' (p3-4)

There is some suggestion in the defence-energy grey literature that the latter habits are occurring at present, with the DSB Task Force on Energy Security (Department of Defense, 2008b) suggesting that 'combat and combat related systems generally are inefficient in their use of fuel' (p.17) and summarising many potential broad technical improvements that would increase platform efficiency. Indeed, some authors suggest that fundamentally redesigning around energy efficiency might be the best way to enhance capability (Tibbles, 2009). Applying the wider concept of both the technical efficiency of platforms and the way in which they are used, Lengyel (2007) cites an internal Air Force study that:

> 'identified $750 million in potential fuel savings through: aircraft weight reduction;… increased use of simulators for flight training; reduced aircraft rotations to Iraq and Afghanistan; basing aircraft closer to operating areas; more direct aircraft routing through improved diplomatic over flight clearances; fuel efficient ground operations; eliminating unnecessary air refuelling.' (p.37)

Lovins (2010) heralds the identification of the need for these overarching strategic vectors as a real achievement of the DSB Task Force's report on Energy Security (Department of Defense, 2008b), but also discusses the need to 'drive them into doctrine':

> 'Endurance and Resilience are new capabilities that drive and apply new operational requirements…The need to change entrenched habits in force planning and operational requirements makes big new capabilities both vital and hard. Driving them deeply into doctrine, strategy, organizational structures, cultures, training, reward systems, and behaviours needs strong, consistent, persistent senior leadership. But once so embedded, new capabilities disruptively and profoundly improve military effectiveness and cost-effectiveness." (p.3-4)

It is in this context that new 'metrics' are relevant to enable decisions to reflect these new strategic requirements. The DSB suggest that at present:

> 'DoD lacks accepted tools to value their operational and economic benefits [of new technologies]. As a result, cost effective technologies are not adopted, science and technology programs significantly under-invest in efficiency relative to its potential value, and competitive prototyping to accelerate deployment of efficiency technologies is not done.' (Department of Defense, 2008b: p.4) …

> 'The same lack of analytical tools that prevent the requirements and acquisition processes from developing more efficient systems also prevent science and technology investments from identifying the most effective investments in energy efficiency technologies. Investments should be guided by a common understanding of their operational, force structure and cost value, but the tools and business processes needed to establish this understanding do not exist.' (Department of Defense, 2008b: p.6-7)

The DSB confirm that ‘Implementing new analytical products to better inform key decisions will be essential to enabling effective energy management’ (p.6). Likewise, Warner & Singer (2009) state that:

> ‘Part of achieving success is having the metrics on hand to implement measurable standards across the DoD and know what type of progress (or not) is being made in usage on an annual basis.’ (p.6)

The next section will focus on these types of ‘metric’, specifically discussing the Fully Burdened Cost of Energy (FBCE) metric within this context.

4.3.2 Relevant Metrics Connecting the System-Level Concepts and Decision Making (Fully Burdened Cost of Energy)

This sub-section describes some relevant metrics that connect to the emerging concepts above. It focuses on the 'Fully Burdened Cost of Energy' (FBCE) metric, which has illustrated the substantially increased cost of actually using energy in military operations, when a system-level perspective is applied that includes the logistics implications of delivering energy to remote and hostile locations. This sub-section explains the development of the metric, the range of cost projections associated with the FBCE, and the potential it has to substantially improve the business case for low carbon technology and behaviours in defence decision making. It has the potential to connect 'Project Level' Carbon Accounts to wider strategic vectors like 'resilience' and 'endurance' that enhance defence capability, and could be viewed as a 'consequential approach' to Carbon Accounting (as discussed in section **2.1.4**) given its focus on (reducing) future emission profiles in given scenarios, and its emphasis on helping to make good decisions that affect positive change at the system level.

The Fully Burdened Cost of Energy (FBCE) has rapidly gained credibility in the military lexicon as a method used to understand the true cost of the energy that defence departments are procuring at point of use. Friedman (2008) provides an engaging summary of the FBCE (often described as the Fully Burdened Cost of Fuel (FBCF) in the American context), discussing the background to its development and the implications of the finding for military investment decisions and the efficiency possibilities in deployed locations.

Lengyel (2007) describes how the DoD has traditionally valued energy in a very simple way:

> 'fuel costs for budgeting and resource planning have traditionally been based on the Defense Energy Support Center (DESC) standard price, which does not reflect the cost of the fuel logistics system required to deliver fuel to the war fighter. The standard price of fuel represents only a fraction of the true cost.' (p.11-12)

The DSB Task Force (Department of Defense, 2008b) confirms that:

> 'If the acquisition process does not understand the total ownership cost of buying, moving and protecting fuel to systems in combat (fully burdened cost of fuel), then its business case analyses will use only the commodity price for fuel. This distorts the results to make high return investments in efficiency look much worse than they really are.' (p.26)

The FBCE metric has been a response to this issue, and attempts to determine the full cost implications of energy used, at whichever point in the system it is being used. Lovins (2010) describes some of the ways that the FBCE can be determined:

> 'Just the dollar cost of protecting fuel convoys can be "upward of 15 times the actual purchase cost of fuel…[increasing] exponentially as the delivery cost increases or when force protection is provided from air." The ~8,000 gallons per troop-year consumed in Afghanistan at a typical delivered cost of $25–45/gal, reportedly accounts for ~20–36% of the ~$1 million/troop-year cost of deployment there…Yet

> most of the fuel delivered at such high cost could have been avoided by far more efficient use.' (p.2-3)

A Deloitte study (2009) provides a similar break down of how these FBCE estimates can be put together (building on work and previous reports by the Brookings Institute and Center for Naval Analysis (CNA). The study explains:

> 'Beyond the basic purchase cost of fuel are other 'hidden' costs, including maintaining fuel transport equipment, training personnel, and maintaining and protecting the oil supply chain. The military currently pays between $2 and $3 per gallon for fuel depending on market conditions. The process of getting the fuel to its intended destination, even assuming that no protection is provided to the convoys during transport, increases the cost to nearly $15 a gallon. Protection of fuel convoys in combat zones requires an enormous show of force in the form of armoured vehicles, helicopters, and fixed wing aircraft, forcing costs even higher. …Protecting fuel convoys from the ground and air costs the DoD upward of 15 times the actual purchase cost of fuel, depending on the level of protection required by the convoy and the current market prices of the fuel commodity. Fuel costs grow exponentially as the delivery distance increases or when force protection is provided from air" (p.19)

There are many 'multipliers' from standard domestic energy prices quoted in the context of the FBCE. The variety is understandable because the FBCE in a given scenario can be different depending on what the scenario is. Likewise, considering the FBCE in relation to a platform may differ depending on what that platform is doing. This strong link to scenarios and decision making connect it very closely to the ideas of 'consequential Carbon Accounting' discussed in section **2.1.4**, and particularly how these practices relate to 'defence capability'.

There have been many studies produced in relation to the FBCE, and as expected, a range of values appear. A Pew report (2010) summarises:

> 'Estimates of the fully burdened costs of fuel, depending on when and where it is needed, range from two to 20 times the pump price for aerial refuelling, to hundreds of dollars a gallon when delivered to a forward area. In that scenario, some estimates run as high as $400 a gallon.' (p.9)

In the US, Lengyel (2007: p.13) suggests that the average FBCE for the Army is around $5.62 per gallon; for the Navy was $3.08 per gallon; and for the Air Force was around $6.36 per gallon – although this rose to $42 per gallon if delivered via air-refuelling.

A team at BAE Systems in the UK produced a model for the UK MoD to better calculate the FBCE in different operational scenarios, and summarise in relation to Forward Operating Bases, that they:

> 'typically only account for 3% of the fuel usage in a deployed scenario, they can account for 20–30% of the fully burdened energy costs when all of the supporting infrastructure and elements of the supply chain are taken into account.' (Banfield, Courtaux & Golightly, 2009: p.90)

As an effect on overall departmental budgets, a RUSI article on the FBCE summarises in the US context that:

> 'although 3.3 % of the US DOD budget is spent on raw energy, when the cost of infrastructure and logistics support is included this increases to approximately 10–15%.' (Banfield, Courtaux & Golightly, 2009: p.89)

The same authors comment in the UK context that:

> 'although forward bases typically account for 3% of the fuel usage in a deployed scenario, they can account for 20-30% of the fully burdened energy costs' (p.90).

Therefore, energy – when valued properly – can have an enormous impact on defence budgeting, and this is before one considers that energy prices themselves can vary significantly. The Deloitte study (2009) considers the issue of price variability in depth, and Warner & Singer (2009) put the impact of energy price variation in the context of the impact on defence planning (note – this is before the energy is valued at FBCE):

> 'each and every $10 increase in the cost of a barrel of oil increases the price of DoD operations by $1.3 billion. To put this into context, each $10 price increase is equivalent to a loss of almost the entire U.S. Marine Corps procurement budget.' (p.3)

In terms of the implications of the FBCE for decision making, the BAE Systems team behind the UK model summarise:

> 'The assertion that the fully burdened spend on energy amounts to approximately 10–15% of the defence budget is a real and stark reminder that energy use will come under increasing levels of scrutiny as budgets are squeezed. Those procuring military platforms which have an in-service life extending into the middle of this century will need to consider options for reducing energy usage. Fully burdened cost savings may provide an opportunity to shorten the payback periods for investing in these energy saving options and enhance the sustainability of these platforms" (Banfield, Courtaux & Golightly, 2009: p.91)

The Deloitte (2009) study of FBCE in the US context agrees, commenting that the business case for alternative energy – so often founded on ecological grounds – are now being seen on cost grounds, with the FBCE clearly showing Defence departments the potential that these technologies have:

> 'The business case for alternative energy development has rested first on the concept of a sustainable planet…With the dramatic rise in the price of oil seen in 2008, and increased recognition that the oil supply may be limited, the business case has shifted emphasis to the economic benefit for developing and using renewable energy sources…This study demonstrates that the development and use of alternative energy can be a direct cause for reductions in wartime casualties and may rank on par with the business cases for development of ever more effective offensive weapons, sophisticated fuel transport tankers, mine resistant armoured vehicles, and net-centric sensing technologies…Aerospace and Defense firms, their government

> customers, and research labs around the world are well positioned to accelerate the development and deployment of such technologies.' (p.19)

Lovins (2010) emphatically agrees, suggesting that the metric could and should unlock substantial investment in energy efficiency:

> 'Even before these conservatisms are made realistic, initial FBCF estimates value saved fuel often one to two orders of magnitude higher than previously. If these new metrics gain momentum and top-level focus, they could drive strategic shifts and innovations that could revolutionize military capability and effectiveness.' (p.3)

With such clear benefits offered, the next sub-section discusses the barriers to implementation of the FBCE in practice.

4.3.3 Barriers to Implementation of the FBCE Metric and the Importance of System-Level Perspectives

In terms of the rate at which the FBCE has been incorporated into US defence decision making, the US DSB report provides a useful reference point (Department of Defense, 2008b), complaining that despite having advised it in 2001, by 2008 the metric had still not been incorporated into departmental decision making. However, more recent progress has been more promising with the 2009 National Defense Authorization Act (US Congress, 2008) recognising FBCE (FBCF in the US context) as a Key Performance Parameter (KPP) and due to receive similar weight to traditional KPPs like lethality, protection, and reliability. However, more needs to be done to implement the FBCE and other metrics operationally, as Lovins (2010) describes:

> ‘In principle, FBCF and energy KPPs will both guide requirements-writing, Analyses of Alternatives, choices in the acquisition tradespace, and the focus of DOD’s science and technology investments. In practice, energy KPPs have not yet been applied (their “selective use” is allowed but not yet launched), and much work must be organized and resourced to get the FBCF numbers right and apply them systematically.’ (p.3)

The FBCE is currently in a similar position in the UK context, with the MoD having stated the need to use the FBCE in departmental decision making as part of its climate change strategy, but with more work to be done to have the metric fully understood and implemented at the department.

With the rationale for the FBCE established and the potential benefits clearly significant, it is useful to reflect on the potential barriers to the application of the metric in practice. This sub-section discusses two barriers that are very relevant to this research.

The first (and perhaps most obvious) reason for its lack of use in practice would be the complexity of determining the FBCE for any given scenario.

Some of this complexity is evident in Lovins’ (2010) critique of the immature ways that the metric is applied at present even where it is used:

> ‘The FBCFs initially in use are incomplete. Current guidance still appears to omit support pyramids, multipliers to rotational force strength, actual (not book) depreciation lives, full headcounts including borrowed and perhaps contractor personnel, theft and attrition adjustments, and uncounted Air Force and Navy lift costs to and from theater. All should be included: FBCF should count all assets and activities—at their end-to-end, lifecycle, fully burdened total cost of ownership—that will no longer be needed, or can be realigned, if a given gallon need no longer be delivered’ (p.3)

Thus, the successful application of the FBCE inevitably relies on significant amounts of data, and indeed this was one of the areas that the DSB task force focused on in relation to improvements that would better enable metrics like the FBCE (Department of Defense, 2008b). The UK Defence Reform Unit made similar comments in the UK context about the lack of good management information maintained by the UK MoD (Ministry of Defence, 2011a). In the context of the wider discussion above, it is clear that the tangible nature of 'Project Level' Carbon Accounts make them far more relevant than traditional organisational accounts. Moreover, these 'Project Level' Carbon Accounts have the potential to far better support scenario based 'system-level' calculations of the FBCE.

The second barrier to implementation of the FBCE that this sub-section discusses is also of significant interest to this research, and is concerned with how the potential benefits of system-level concepts of Carbon Accounting are realised in a context where the dominant perspectives are strongly attributional. The FBCE clearly identifies system-level benefits, but the challenge of adequately realising these benefits across defence – both between functions within defence departments, and across the sector more broadly – should not be underestimated.

Put simply within the defence context, the issue is that often the acquisition department or even the single services buying the equipment don't see many of the logistics costs that the FBCE shows to be clearly relevant to their decisions

The DSB Task Force (Department of Defense, 2008b) summarise this as the 'split incentives' argument:

> '[It is] a well-known management issue and one DoD recognizes. It says the owner of one corporate account is not incentivized to make investments that only benefit the owners of other accounts, even if the investment is in the best interest of the corporation overall. For DoD, the issue is investing acquisition funds to reduce operating and support costs. If a more efficient combat system requires more acquisition investment, DoD could decide to increase the acquisition budget at the expense of the operating and support budget. The argument goes that the logistics community will not permit their budgets to be reduced, so the acquisition programs will not get the increased funding.' (p.36)

They continue, arguing that:

> 'this is no reason for choosing not to understand that the option exists…Understanding the full range of costs, benefits and risks of making deployed systems more efficient reveals options to decision makers that would not otherwise be visible. Having more options available is better than having fewer.' (p.36)

The point goes wider than the defence departments too. Defence companies are aware of the concept of the FBCE (in the UK context above, it is BAE Systems providing MoD with thought leadership on the subject), but without the right signals from their customers they are similarly slow to transform the products and services supplied.

Partemore & Nagl (2010) connect the conversation back to the strategic benefits that began this section, and suggest that the DoD can realise energy benefits for strategic gain, but must send the right signals to the private sector in this regard:

> 'DoD need not choose between accomplishing its mission and minimizing the strategic risks, price fluctuations and negative environmental effects of petroleum consumption. By providing the private sector with stable market signals and incentives to invest in scaling up the fuels that meet its unique energy needs, DoD

> will never need to sacrifice performance or national security for energy security. Rather, reducing reliance on petroleum will only help the armed services to accomplish their missions in the years and decades to come.' (p.5)

Warner & Singer (2009) are critical that at present 'without firm requirements, defense contractors that sell to the department don't yet know how seriously to program energy efficiency into their submissions' (p.4).

Thus, the FBCE relies on mind-sets that look beyond individual functions within the defence departments, and indeed mind-sets that go beyond the department itself and include the companies that support them.

4.4 Results Summary

The Methodology chapter described the exploratory nature of this research, which was emphasised in the introduction as appropriate to a subject area where little is currently known.

The Literature Review explored three distinct sets of literature relevant to Carbon Accounting in the defence sector, which was necessary given the lack of sector-level studies in the literature. It also emphasised the scale of activity in relation to Carbon Accounting, with many sites of enquiry, and a slowly emerging academic literature sometimes struggling to keep pace with.

As a result, the Methodology explained in detail how an archival research strategy focused on public information in the defence sector on Carbon Accounting and climate change mitigation was an appropriate response. This archival strategy established both quantitative and qualitative data in order to support an inductive research approach that would look for patterns within and across these datasets that were relevant to the themes established in the Literature Review.

This Results chapter has presented the correlational research, describing relevant patterns associated with the quantitative data (**4.1**) and qualitative data (**4.2**), and summarising relevant information from the secondary sources (**4.3**).

Section **4.1** presented the quantitative analysis, which showed that defence departments report the overwhelming majority of the overall emissions from the sector. It also described the current immature state of Scope 3 Carbon Accounting in the defence sector, where despite some narrative emphasis from many organisations about the importance of their impacts across the value chain, little GHG information exists publicly that connects to the product lifecycle. Some rare examples of 'Project Level' Carbon Accounts were described, and these clearly show the scale of impacts across the value chain that defence products can have, particularly in the usage phase. This section showed how these 'Project Level' Carbon Accounts potentially link very significant portions of the organisational accounts together between defence departments and defence companies, complicating the picture as to which organisations in the sample are the most quantitatively significant.

Section **4.2** integrated the qualitative data to the analysis and demonstrated a connection between the volume of emissions reported and the level of priority placed on the issue of climate change mitigation, suggesting that the technical accounting issues that drive reported volumes do potentially influence organisational responses to climate change, and therefore are significant. It showed that the organisations reporting the highest volumes of emissions appeared to emphasise the topic of climate change more in their public documents, and in some cases set more ambitious targets for reducing their environmental impacts.

This third part of the Results chapter (**4.3**) focused on relevant secondary sources of defence-energy grey literature, and described some emerging concepts and metrics that are helping to frame energy and climate change issues across the defence enterprise.

It introduced the concept of 'the tether of fuel' in contemporary conflict, and described the emergence of some related 'strategic vectors' of 'resilience' and 'endurance' that have been introduced to military discourse. The Fully Burdened Cost of Energy (FBCE) – a metric that could be described as a 'consequential approach' to Carbon Accounting – is helping to drive these new strategic vectors into military doctrine and decision making. The section explained the potential of the FBCE to radically alter the business case for low carbon technologies in defence contexts, but significant barriers to its implementation remain at present. These include the lack of 'Project Level' Carbon Accounts, but also the attributional mind-sets that characterise the current OCA practices, where a focus 'individual organisations' or 'individual functions' can undermine the clear system-level benefits of certain activities.

The analysis presented in this chapter has validated the exploratory, inductive approach taken to the research topic. Despite the lack of relevant precedents in the Carbon Accounting literature, and the evolving nature of existing OCA practices, relevant patterns can be found from the quantitative and qualitative data available. When aligned to the secondary sources of defence-energy grey literature, some strong trends emerge that begin to define some relevant ways forward for OCA practices in the sector.

The exploratory and interdisciplinary approach to the academic literature has also proved a valuable methodological choice. By reviewing three distinct but relevant sets of literature, the Literature Review was able to summarise the research topic into three key themes of Carbon Accounting that are grounded in the contemporary defence context, and relevant to the prospects for low carbon technology innovation in the sector. The results presented and summarised above confirm the relevance of these themes that were established in the Literature Review (see section **2.4** 'Summary of the Literature Review and Key Themes'). These three themes are re-iterated and elaborated on below.

The first theme related to the challenge of attributing emissions to individual organisations in the Carbon Accounting literature. This was likely to be particularly marked in the defence sector due to the very close working relationships between defence departments and their supporting industrial base, and the resultant accounts have the potential to be abstract in nature, limiting the extent to which they can engage the new/relevant actors to the task of mitigating climate change. This diminished potential for creating relevant coalitions that can challenge the established interests would significantly inhibit the potential for low carbon technology innovation in the sector. The Results chapter has confirmed the relevance of this theme, demonstrating how the quantitative data provided by existing OCA practices does not necessarily highlight the most significant organisations in the sample, due to the lack of available Scope 3 data for the emissions categories most relevant to the value chain. The qualitative analysis from section **4.2** ('Integrating the Qualitative Data') confirms the relevance of this, as the results suggest that technical accounting issues can have real impacts on organisational behaviours and their level of engagement with climate change mitigation.

The second theme emphasised the relevance of 'Project Level' Carbon Accounts to the defence sector, as multiple organisations often collaborate and 'team' around large scale industrial programmes. Where OCAs had the potential to be quite abstract as organisational boundaries could be difficult to define, 'Project Level' Carbon Accounts would likely be simpler and better connect to the underlying emissions-producing activities. They would therefore be more likely to recruit new/relevant actors to defence-energy debates and support the development of low carbon technologies in the sector. The results also confirm the relevance of this theme, with ‘Project Level’ Carbon Accounts and relevant Scope 3 reporting likely to connect relevant organisations together across a large proportion of the sector’s total emissions.

The third theme related to ‘consequential carbon accounting’ perspectives that have emerged in the field of LCA. These perspectives were more relevant to decision making than existing OCA practices, which are almost wholly ‘attributional’ in character. This is due to their focus on the potential that decisions have to generate system-level changes. The Literature Review noted the mutual focus of ‘defence capability’ concepts on system-level impacts and effective decision making. It suggested that relevant strategic narratives linked to defence capability, when aligned to OCA practices informed by ‘Project Level’ Carbon Accounts, could help construct a positive selection environment for low carbon technologies in the defence sector. The results also confirm the relevance of this theme, with section **4.3** (‘Integrating the Secondary Sources) describing the emerging strategic concepts of ‘resilience’ and ‘endurance’ that are responding to defence-energy challenges, and metrics such as the FBCE beginning to drive these concepts into military doctrine and decision making. It demonstrated the transformational impact that system-level perspectives with an emphasis on decision making and GHG reductions at the system level can have. However, it also highlighted the extent to which these rely on representative ‘Project Level’ Carbon Accounts that are currently immature in the defence sector, and the extent to which they can be undermined by strongly attributional mind-sets that characterise existing OCA practices.

With the Results chapter having clearly confirmed the relevance of the three themes established in the Literature Review, the Discussion chapter (**5**) that follows expands on these themes in order to develop some recommendations that can inform the ongoing development of OCA practices in the defence sector.

5) Discussion

The ‘Aims and Objectives of the Thesis’ that were set out in section **1.4** step through the different cognitive levels of Blooms Taxonomy, with successive chapters building on each other in order for more sophisticated concepts to be presented. This Discussion chapter relates to the higher levels of Blooms Taxonomy and aims to bring together the themes from the Literature Review, and the analysis from the Results chapter in order to comprehensively evaluate OCA practices in the defence sector, and create some recommendations for defence sector organisations as to how these might be improved to better support low carbon technology innovation.

The relevant objectives for this chapter are as follows:

- Relate the themes identified in the Literature Review to the analysis of OCA practices in the defence sector that was presented in the Results chapter
- Generate a set of recommendations for defence sector Carbon Accounting practices that will better support low carbon technology innovation

The three themes that were described across the Literature Review and summarised in section **2.4** (‘Summary of the Literature Review and Key Themes’) form the structure of this Discussion, with sections **5.1** to **5.3** focusing on each of these in turn.

The first theme related to the difficulty of allocating emissions between organisations in existing OCAs, which is likely to be particularly marked in the defence sector due to close working relationships, and may result in abstract OCAs that do not connect effectively to the underlying activities causing emissions to be produced. This is likely to inhibit the extent to which the accounts engage new/relevant actors and support low carbon technology innovation. Section **5.1** reiterates the context for this theme from the Literature Review and summarises the defence sector-specific attempts to standardise OCA practices and the implications of this. It concludes that existing OCA practices are likely to produce abstract accounts and are therefore unlikely to support low carbon technology innovation.

In contrast, the second theme running through the thesis relates to the potential for ‘Project Level’ Carbon Accounts focused on large-scale collaborative programmes to better account for the emissions of the defence sector in a way that engages new/relevant actors to defence-energy debates. These accounts are therefore more likely than existing OCAs to support low carbon technology innovation. Section **5.2** reiterates the context for this theme from the Literature Review, which described how Scope 3 reporting is immature at present – particularly where relevant to the product lifecycle and value chain. The section then summarises how the quantitative analysis from the Results chapter showed the lack of relevant Scope 3 reporting at present in the defence sector, despite a clear recognition of the importance of this data. There is a conflict between the recognised need to produce ‘Project Level’ Carbon Accounts, which are inevitably scenario specific, and the ongoing drive to standardise OCA practices. However, the defence sector is well placed to resolve this conflict, being characterised by several large scale industrial projects. It concludes that if this conflict in organisational reporting can be overcome, ‘Project Level’ Carbon Accounts have the potential to engage new and relevant actors to defence-climate change debates, and are therefore more likely to support low carbon technology innovation.

However, ‘Project Level’ Carbon Accounts cannot work effectively in isolation, which leads onto the third theme running through this thesis related to the potential for ‘consequential carbon accounting’ perspectives to align with concepts of ‘defence capability’, in order to inform wider strategic narratives that help construct a positive selection environment for low carbon technologies in the defence sector. Section **5.3** reiterates the context for this theme from the Literature Review, which described the relevance of ‘consequential accounting’ perspectives for connecting emissions inventories to positive change at the system level. This aligns them to ‘defence capability’ concepts that are likely to provide the strategic context through which ‘Project Level’ Carbon Accounts are understood and interpreted. It refers back to the Results chapter and the emergence of relevant strategic vectors of ‘resilience’ and ‘endurance’, and associated metrics such as the FBCE. It explains the FBCE as a type of consequential carbon account, but one which is underpinned by ‘Project Level’ Carbon Accounts in order to work in practice. The section then describes the relevance of the innovation studies literature in this context, and the need for ‘storylines’ at the niche and landscape level to be mutually reinforcing in order for a positive selection environment to be created in the defence sector. In other words, ‘Project Level’ Carbon Accounts and a wider strategic framework of relevant tools and metrics will both be required in order for OCA practices to effectively support technology innovation.

The final section (**5.4**) reiterates the themes above, and generates some recommendations for the development of OCA practices in the defence sector so that they can better support low carbon technology innovation.

5.1 Theme 1: OCA Practices and the Difficulty of Attributing Emissions to Organisations in the Defence Sector

This first theme relates to the difficulty of allocating emissions between organisations in existing OCAs, which is likely to be particularly marked in the defence sector due to close working relationships, and may result in abstract OCA that does not connect effectively to the underlying activities causing emissions to be produced. This is likely to inhibit the extent to which the accounts engage new/relevant actors and support low carbon technology innovation.

The Literature Review described the difficulty in attributing emissions to different organisations in a standardised way that retains relevance (**2.1.2** 'OCAs and their Limitations'). It introduced the GHG Protocol as the most commonly used standard for OCAs, which is open to wide interpretation in practice (WRI, 2004). The literature noted the significant potential for variance in the ways that existing OCAs are produced (Morel & Cochran, 2016). There is a drive to standardise approaches within specific sectors (e.g. IPIECA, 2003; IAEG, 2016) in ways that do not create significant barriers to entry for organisations wishing to produce OCAs. Bellassen et al. (2016) identified 'cost vs uncertainty' and 'comparability vs relevance' as two trade-offs that are common to all Carbon Accounting schemes, and suggested that as Carbon Accounts become more standardised or comparable (in a pragmatic and relatively low-cost way), they could also become less 'relevant' to the underlying organisational activities that produce the emissions.

Section **2.2.2** ('The Increasing Role of the Private Sector in All Defence Tasks') in the wider review of Defence Industrial Policy (**2.2**) described how these challenges of attributing emissions to organisations in a way that retains relevance is likely to be particularly marked in the defence sector. It described how defence budgets decreased in the post-cold war era, the Defence industry consolidated around a small number of large multinational companies, with an increasing focus on supplying services as well defence product. These trends as well as a preference for supporting national industries have resulted in close private sector involvement in all defence activity. Defence austerity and defence reform (as well as 'core competency' models) are encouraging further outsourcing of military activity to the private sector. The result is highly complex defence sites and programmes where multiple organisations are involved. Lines of responsibility for emissions are likely to be hard to discern, even if relevant measurement infrastructure is available. Therefore, as Bellassen et al. (2016) might predict, finding a pragmatic, low cost solution for the defence sector to account for its emissions at the organisational level is likely to simplify emissions accounting to the point where it begins to lose relevance.

Section **3.4.1** of the Methodology chapter ('Establishing the Quantitative Dataset') explained how the methodologies for producing OCAs in the defence sector are reasonably well aligned. Despite the ongoing challenges of standardisation, there is clearly some degree of consistency between defence sector OCAs focused around the GHG Protocol and the Operational Control method. The Literature Review summarised some of the challenges that organisations have had in determining organisational boundaries using the GHG Protocol's 'Operational Control' method (see **2.1.2** 'OCAs and their Limitations'), with the guidance in the standard open to wide interpretation:

> ‘A company has operational control over an operation if the former or one of its subsidiaries has the full authority to introduce and implement its operating policies at the operation … It is expected that except in very rare circumstances, if the company or one of its subsidiaries is the operator of a facility, it will have the full authority to introduce and implement its operating policies and thus has operational control…Under the operational control approach, a company accounts for 100% of emissions from operations over which it or one of its subsidiaries has operational control.’ (WRI, 2004, p.18)

Section **2.2.2** of the Literature Review (‘The Increasing Role of the Private Sector in All Defence Tasks’) explained how the statement above can be very difficult to apply to large defence sites, with many organisations involved in the various activities taking place on them. The example of Portsmouth Naval Base was used to illustrate some of these complexities in practice with a variety of stakeholders that cross organisational boundaries having some degree of influence on the emissions created by this large, complex defence site. A survey undertaken within BAE Systems was also described that confirmed the complexity of applying the ‘Operational Control’ criteria in the defence context, with just over half of the sites surveyed clearly able to say that they were 100% in control of the facility.

Even if it were simple to determine which party controlled relevant site activities, it is very unlikely that measurement infrastructure (whether utility meters, of various types and reliability across static infrastructure; or measurement devices associated with mobile vehicles) would neatly align to these distinctions, especially at large, often very old defence sites. Some of the environmentally focused grey literature from the defence enterprise that was described in section **3.5** (‘Relevant Secondary Sources of Data’) highlights the importance of this issue at US DoD sites, with the DSB Task Force on Energy Security (Department of Defense, 2008b) declaring that:

> ‘Effectively managing fuel demand requires an in depth understanding of the activities that are creating the demand. Unfortunately, data on energy usage are unevenly collected across the Department, making it difficult to form a comprehensive picture’ (p.15)

The GHG Protocol ‘Operational Control’ method clearly allows wide scope for interpretation as to what should be included in an emissions inventory, and we can see that this is particularly challenging at large, complex defence sites. In practice this means that even where defence organisations are referring to the same methodology, and the same approach for determining their emissions boundary, there is significant scope for interpretation (and therefore difference) in the way that this method is applied.

One effort to better standardise approaches to applying the GHG Protocol’s Operational Control method has been provided by the International Aerospace Environment Group (IAEG). Their working group focused on GHG Reporting has produced a document (IAEG, 2016) for the sector that supplements the GHG Protocol Corporate Standard (WRI, 2004) and is endorsed by the WRI. The guidance has received slow take up in practice, and Table 60 in Appendix A shows that it is currently only referenced by three of the organisations in this research. However, the table also shows that the clear majority of organisations in the sample are members of the IAEG and therefore it is not unreasonable to assume that take-up may well increase over time, depending on the extent to which it requires organisations to amend their established mechanisms for reporting GHGs.

The IAEG Guidance (IAEG, 2016) is explicit in relation to the emissions boundary 'rules' to use from the GHG Protocol, recommending that 'reporters shall utilize the operational control approach to define their organization boundary' (p.4), but does little to resolve some of the complexity of determining which parties have operational control of different activities. However, the guidance does pragmatically advise that reporting aligns with 'energy measurement' points for static infrastructure, focusing on the main utility meters from which a site is billed in order to determine the data that it is reported by an individual organisation[29]. More recent legislative initiatives in the UK have also focused on the points where utilities are billed in order to determine reported volumes, with the simplified version of the UK's Carbon Reduction Commitment (CRC) scheme (Environment Agency, 2015) requiring companies to report their billed volumes of electricity and gas that have been delivered to the site.

These pragmatic approaches allow for comparable approaches between organisations, but have the potential to simplify the broad definition of 'operational control' above to the extent that the emissions from a large and complex site can be allocated in a fairly binary way to one organisation or another. Thus, the relevance of the resulting OCAs may be reduced as the reported total does not reflect the different organisations active on the site and their related emissions producing activities.

These simplifications of the broad requirement to determine 'operational control' are relevant to the trade-off discussed in the Literature Review (**2.1.2** 'OCAs and their Limitations') between 'comparability' and 'relevance' of the carbon accounts (Bellassen et al, 2016), and in this case as in others that the authors note 'comparability often trumps relevance' (p.533).

This has implications for GHGs reported at the organisational level, where technical Carbon Accounting decisions made at site level that may not be entirely representative of the underlying activities involved, have the potential to become particularly abstract once aggregated to the organisational level of a large multinational.

The abstract nature of the accounts produced has implications for the extent to which existing OCA practices can support low carbon technology innovation. The Innovation Studies literature (see **2.3**) explained that contemporary 'network' perspectives on innovation have an emphasis on creating relevant coalitions that can 'negotiate for discursive hegemony' in order to change established socio-technical regimes. Carbon Accounting is relevant for the discursive role it can play in establishing 'storylines' that engage new/relevant actors in defence-climate change debates. The existing OCA methods described above – by seeking pragmatic approaches to standardisation – are becoming increasingly disconnected from the underlying activities that give rise to emissions in the defence sector. This disconnect means that the resultant accounts lose relevance, and are

[29] 'In short, companies shall report GHG emissions for all leased buildings for which the company directly pays the utility bills. In the event that the utility bills are a part of the rent and not independently available, an estimation of GHG emissions shall be derived consistent with the guidance identified in The Corporate Standard. Where utility data is directly available, the company shall report them.' (IAEG, 2016: p4)

therefore unlikely to support ‘storylines’ that engage new actors, or the most relevant organisations to the task of reducing GHGs.

The Results section showed some of the effects of this in practice, with Figures 15 and 16 in Section **4.2** (‘Integrating the Qualitative Data’) demonstrating how the higher volumes of emissions accounted for by the defence departments (due to the technical GHG Accounting decisions described above) correlated with an increased emphasis on climate change mitigation in their public reporting and organisational objectives and targets. The defence companies, despite having significant innovative capacity and being deeply involved in the process of creating defence equipment, were accounting for far fewer emissions and appeared to be less engaged with climate change mitigation in their public reporting and target setting.

In contrast to the traditional OCA practices described in this section, ‘Project Level’ Carbon Accounts have the potential to better represent the underlying emissions-producing activities in the sector and are the focus of the second theme that runs through this thesis.

5.2 Theme 2: 'Project Level' Carbon Accounts and their Relevance to the Defence Sector

The second theme running through the thesis relates to the potential for 'Project Level' Carbon Accounts focused on large-scale collaborative programmes to better account for the emissions of the defence sector in a way that engages new/relevant actors to defence-energy debates. These accounts are therefore more likely than existing OCAs to support low carbon technology innovation.

The Literature Review described the potential of 'Project Level' Carbon Accounts to make OCA more meaningful (see **2.1.3** 'Scope 3 Emissions Inventories and the Relevance of 'Project Level' Carbon Accounts'). Existing OCAs tend to be immature in terms of their reporting of scope 3 emissions and therefore the full carbon impact of an organisation across the value chain is rarely explained. Organisations tend to focus on certain categories of scope 3 reporting that are not the most relevant ones (CDP, 2013). Some authors suggest that the scope 3 category of emissions is too broadly defined at present, and that a 'scope 4' should be introduced to distinguish the aspects of scope 3 relevant to the product lifecycle (Matthews, Hendrickson & Weber (2008). This concept is currently rare in the academic literature and receives very little take-up in practice. Life Cycle Assessment (LCA) is very relevant to any 'scope 4' account, but the variability of LCA methodologies conflicts with the drive to standardisation in existing OCAs. There is lots of interest in applying LCA and project level assessments to corporate footprints (Harangozo, Szechy & Zilahy (2015), but no companies believed to have used product footprints to devise company-wide results as yet (Gibassier, 2015).

The Defence Industrial Policy literature described how these 'Project Level' Carbon Accounts are likely to be a good fit for the sector (see **2.2.3** 'International Collaborative Programmes and Industrial Teaming'). The section described how the need to standardise defence equipment across regions is a crucial and widely acknowledged challenge for defence departments due to the need for inter-operable equipment and economic efficiency amongst allies. Industrial activity has driven some of the most notable trends towards standardisation as the global defence industry has consolidated around a shrinking volume of orders overall. International collaborative projects supported by industrial 'teams' are now common, and allow partners to share the costs and risks of developing high-tech equipment, and achieve economies of scale in production runs. In contrast to the discussion in theme 1 above, where contemporary trends in the defence sector made OCA more challenging, this trend makes 'Project Level' Carbon Accounting particularly well suited to the sector.

The Literature Review described the relative lack of maturity in relation to Scope 3 emissions reporting by organisations. The Results chapter showed that this trend is certainly relevant to the defence sector, where limited scope 3 data is available. Section **4.1.2** ('Analysis of Scope 3 Data') explained the inadequacy of current Scope 3 reporting as it applies to the value chain, with most accounts focused on less material Scope 3 categories such as business travel, with the exception of those published by Lockheed Martin. Matthews, Hendrickson & Weber (2008) suggest these 'value chain-relevant' emissions could be called 'Scope 4' emissions, and it is these that would be particularly relevant to the defence sector.

Where these types of account do exist, they demonstrate the scale of emissions associated with other parts of the lifecycle of defence products.

These ‘value chain-relevant’ accounts also change the ways that the total emissions of the sector can be apportioned between organisations. Section **4.1.3** of the Results chapter (‘How the Significance of Different Organisations in the Sample Could Change if Scope 3 Emissions were more Widely Available’) described how comparisons of existing OCAs across the sector show defence departments as by far the most significant organisations in the sample, with the defence companies being ‘low impact’ organisations by comparison. This is driven by the fairly simplistic ‘operational-facility’ split in defence department energy use, with the former (‘operational energy use’) wholly accounted for by the defence departments, despite the products that consume this energy being designed and manufactured by the supporting industrial base. The Results chapter compared this ‘operational energy use’ of the defence departments, with the ‘revenue-apportioned’ part of the emissions associated with the defence companies in the sample. This comparison suggested that the defence companies in the sample were actually far more quantitatively significant than the existing Scope 1 & 2 OCAs had suggested.

An increase in ‘Project Level’ Carbon Accounting that showed the impact of defence products across the lifecycle, or a related increase in Scope 3 emissions reporting associated with the value chain (‘Scope 4’ for Matthews, Hendrickson & Weber (2008)) would be highly beneficial for better understanding the emissions of the sector and which organisations are most relevant or best placed to improve the energy efficiency of the sector as a whole. The organisations in the sample clearly recognise the relevance of these emissions. Section **4.1.2** (‘Analysis of Scope 3 Data’) contrasted the lack of quantitative data available in this area with the qualitative emphasis placed on the importance of these more direct ‘value chain’ impacts of defence products in the public documents of many of the organisations included in this research.

Despite the recognition of the importance of Scope 3 data in the defence sector, practical challenges do remain for organisations wanting to produce quantitative summaries of their scope 3 impacts. Section **5.1** above described some challenges of interpretation with traditional Scope 1 & 2 OCA and the literature on Scope 3 (see section **2.1.3**) acknowledges that methodologies used by organisations are highly variable. Even for the more commonly published indirect categories of Scope 3 emissions there are wide inconsistencies in how the data is reported and the methodologies used are bespoke in nearly all cases. Just as there are ongoing efforts to standardise methodologies for producing Scope 1 & 2 accounts as described in relation to the first theme above (**5.1**), there are also efforts in place to standardise approaches towards Scope 3 reporting. Morel & Cochran (2016) confirm that:

> ‘scope 3 emissions can represent the lion’s share of emissions and cannot be ignored…however, due to more complex calculations and data needs, standardization of scope 3 emissions quantification approaches is ongoing’ (p.310)

In relation to the defence sector, the latest iteration of the IAEG guidance for reporting GHGs (IAEG, 2016) includes some guidance for reporting Scope 3 emissions, but this only focuses on the more established indirect categories of Business Travel, Employee Commuting, and Transportation and Distribution.

However, the challenge of producing relevant Scope 3 accounts is far more significant in relation to the value-chain relevant categories of Scope 3, which are scenario-specific by nature and whose methodologies as a result are likely to be highly bespoke. The Literature Review (**2.1.3** 'Scope 3 Emissions Inventories and the Relevance of 'Project Level' Carbon Accounts) referred to the Clean Development Mechanism (CDM), which is the best known 'Project Level' Carbon Accounting scheme in use, as having to accept a great variety of project-specific methodologies relevant to the different types of scheme that it interacted with. The guidelines produced for the CDM (United Nations, 2016) have attempted to reduce the number of methodologies in use, but there are currently still over 200 methodologies allowed that are in active use.

Thus, whilst scope 3 reporting related to the value chain is clearly highly relevant to companies, it is very difficult to reconcile with the ongoing trends towards standardisation of OCA practices that were described in relation to theme 1 above (**5.1**). Despite this inevitable tension, the defence sector is well placed to reconcile these conflicting interests, as it is currently characterised by international collaboration and industrial teaming, around a relatively small number of large, high-profile programmes. As a result, relatively few 'Project-Level' Carbon Accounts could account for a significant proportion of the sectors emissions, and therefore meaningfully interact with organisational reports.

The prize for resolving this conflict and producing relevant 'Project Level' Carbon Accounts in the defence sector would be that OCA practices could begin to better support low carbon technology innovation, in a couple of meaningful ways.

The first is that, by making OCAs less abstract, and more understandable, new actors are more likely to be drawn into defence-climate change debates. The activities that underpin 'Project Level' Carbon Accounts are far easier to understand and conceptualise. For example, one can quite quickly and easily explain the relevance of emissions associated with a programme to build a new multi-role jet aircraft – it needs fuel for flying through-life, and emissions are likely to be produced in its manufacture, testing, and end of life disposal. In contrast, conceptualising the emissions associated with a large and complex multi-national organisation is far more difficult, with legal structures and other boundaries to organisational accountabilities rendering the resultant OCA opaque to all but the most institutionally embedded observers.

The Innovation Studies literature (see **2.3**) explained that contemporary 'network' perspectives on innovation have an emphasis on creating relevant coalitions that can 'negotiate for discursive hegemony' in order to change established socio-technical regimes. Carbon Accounting is relevant for the discursive role it can play in establishing 'storylines' that engage new actors in defence-climate change debates. Thus, the more new actors that can be attracted to these debates, the more likely it is that a coalition of interests can emerge that challenge the status quo, and lay the foundation for innovation. This research contends that it is 'Project Level' Carbon Accounts that are far more likely to engage these new actors than existing practices that are focused on attributing emissions to individual organisations.

However, it is worth noting that 'Project Level' Carbon Accounts would not just increase the number of actors engaged with defence-climate change debates due to their conceptual accessibility. They would also support low technology innovation in the sector by engaging the most relevant actors to these debates.

The Results chapter showed (see section **4.1** 'Correlational Analysis of the Quantitative Data') that where traditional Scope 1 & 2 OCAs simplistically highlighted the defence departments as the only organisations that were quantitatively significant, attempts to connect emissions across the organisations in the sample (via the defence departments' operational energy use) showed that a large proportion of the emissions of the sector are relevant to multiple organisations. Therefore, a description of the most 'quantitatively significant' organisations in the sample would likely be different, and certainly include some of the defence companies, if more Scope 3 information were available. The Results chapter also described (see section **4.2** 'Integrating the Qualitative Data') a correlation between the volume of emissions reported by organisations in the sample and their level of engagement with the topic of climate change mitigation. Therefore, as well as attracting new actors to defence climate change debates, 'Project Level' Carbon Accounts are also likely to motivate organisations that become more quantitatively significant in the reporting to engage. Therefore in addition to new actors, these accounts could engage the most relevant actors to engage with defence climate change debates.

The first part of the introduction to this thesis (**1.1** 'Background') described how technology innovation is widely seen as the most relevant contribution the defence sector can make to climate change mitigation. This discussion across themes 1 and 2 has made the argument that the more that OCA practices can engage with 'Project Level' narratives, the more effective they are likely to be engaging new and relevant actors, and supporting low carbon technology innovation.

However, the innovation literature (see section **2.3.4** 'Discourse Perspectives and the Link to OCA Practices in the Defence Sector') described how 'Project Level' Carbon Accounts alone, and the new actors that they 'recruit', are unlikely to be sufficient to change an established socio-technical regime. Hughes (1983) sums up how the micro-selection environment for an individual technology needs to be seen in the context of the wider socio-technical regime that also needs to be attended to in order to create a positive environment for technological change:

> 'As cultural artefacts, [technologies] reflect the past as well as the present. Attempting to reform technology without systematically taking into account the shaping context and the intricacies of internal dynamics may well be futile. If only the technical components of systems are changed, they may snap back into their earlier shape like charged particles in a strong electromagnetic field. The field must be attended to: values may need to be changed, institutions reformed, or legislation recast.' (p.465)

To use Hughes' words, the next part of this discussion 'attends to the field' – and looks to the ways that the wider context in which 'Project Level' Carbon Accounts are presented in the defence sector can help create a positive selection environment for low carbon technology.

5.3 Theme 3: Connecting 'Project Level' Carbon Accounts and Strategic Narratives in order to construct a Positive Selection Environment for Low Carbon Technologies in the Defence Sector

The third theme running through this thesis relates to the potential for 'consequential carbon accounting' perspectives to align with concepts of 'defence capability', and inform wider strategic narratives that help construct a positive selection environment for low carbon technologies in the defence sector.

The Literature Review (section **2.1.4** 'Attributional-Consequential Distinctions in Carbon Accounting and the Implications for OCAs') explained the usefulness of 'consequential accounting' perspectives for connecting OCAs to decision making and positive change at the system-level. Where 'attributional methods [of Carbon Accounting] provide static inventories of emissions allocated or attributed to a defined scope of responsibility … consequential methods attempt to measure the system-wide change in emissions that occurs as a result of a decision or action' (Brander & Ascui, 2015, p.100). The distinction has emerged in the field of LCA and is little known in the field of OCA due to the dominance of attributional mindsets (Brander & Ascui, 2015). The authors note its relevance for OCA however, given that organisational accounts can and do inform decision making.

The Defence Industrial Policy (see section **2.2.4** 'Concepts of Defence Capability') described how the sector is currently characterised by a complex threat environment and a period of diminished economic resources. In this context, many authors stress the need for defence debates to move from second order questions about specific items of equipment, to conversations about strategic outputs and 'defence capabilities'. The Literature Review summary (see section **2.4** 'Summary of the Literature Review and Key Themes') explained the relevance of these 'defence capability' concepts to the debates concerning consequential approaches to Carbon Accounting, due to their mutual focus on understanding system-level impacts in order to make effective decisions.

Whilst the discussion across themes 1 and 2 has emphasised the relevance of 'Project Level' Carbon Accounts for engaging new and relevant actors to defence-climate change debates, the previous section also highlighted how these need to align with wider strategies at the system level in order to create a positive selection environment for low carbon technology. Thus, consequential approaches to Carbon Accounting that engage with system-level debates linked to defence capability will be necessary to interact with these 'Project Level' Carbon Accounts.

The analysis of the secondary sources of data in the Results chapter (see **4.3** 'Integrating the Secondary Sources') summarised some relevant 'strategic vectors' of 'resilience' and 'endurance' that emphasise the strong link between defence energy use and defence capability.

In order to drive these strategic vectors into military doctrine and decision making, relevant tools and metrics are required, and the most notable of these is a metric termed the Fully Burdened Costs of Energy (FBCE). The FBCE is particularly relevant here as it can be viewed as a 'consequential approach' to Carbon Accounting. It is concerned with specific scenarios, and models the system-wide energy impacts associated with it. A Deloitte study (2009) explains the types of things the FBCE needs to cover, and the impact it can have:

> ‘Beyond the basic purchase cost of fuel are other ‘hidden’ costs, including maintaining fuel transport equipment, training personnel, and maintaining and protecting the oil supply chain. The military currently pays between $2 and $3 per gallon for fuel depending on market conditions. The process of getting the fuel to its intended destination, even assuming that no protection is provided to the convoys during transport, increases the cost to nearly $15 a gallon. Protection of fuel convoys in combat zones requires an enormous show of force in the form of armoured vehicles, helicopters, and fixed wing aircraft, forcing costs even higher. …Protecting fuel convoys from the ground and air costs the DoD upward of 15 times the actual purchase cost of fuel … [These] costs grow exponentially as the delivery distance increases or when force protection is provided from air” (p.19)

The FBCE supports decision making, by allowing users to understand the real energy costs associated with a given operation, and the knock-on effects it may have on other areas of military activity. It has proved powerful in demonstrating the true cost of military energy use, and therefore has significant potential to alter defence decision making

However, the Results chapter (**4.3.3** ‘Integrating the Secondary Sources’) also described the barriers to the widespread use of the FBCE in practice. One of these relates to the attributional mind-sets characterised for Carbon Accounting by theme 1 above, where the process of attributing emissions to one organisation or another entailed a significant loss of meaning in the data. This is in some ways analogous to the ‘split incentives’ argument that inhibits the use of the FBCE in practice, where the allocation of costs to different parts of the organisation (e.g. the function that buys the fuel, the function that transports the fuel; the function that maintains the oil supply chain etc.), entails significant loss of meaning as to the system wide impact of the activity.

The other barrier to the adoption of the FBCE is a more pragmatic but equally important one, and relates to the lack of ‘Project Level’ data that can inform FBCE modelling. This is particularly relevant to the discussion above, given the recommendation that ‘Project Level’ Carbon Accounts need to be integrated as much as possible with defence sector OCA practices.

Just as the discussion of theme 2 above concluded by suggesting that the ‘Project Level’ Carbon Accounts need wider strategic narratives available to connect to, likewise the strategic vectors and associated metrics described here are equally reliant on the ‘Project Level’ Carbon Accounts.

Lehtonen & Kern (2009) describe how socio-technical regimes can experience structural change as a result of interactions between different levels:

> ‘The ‘landscape level’ encompasses factors beyond the control of individual actors, such as demographic developments, culture or external events (e.g. oil shocks). ‘Niches’ are protected spaces where novel technologies, ideas or practices emerge, some of which can come to challenge the dominant regime… Structural change occurs over extended periods of time through interactions between these landscape- and regime-specific levels and niches’ (p.104)

Thus, the ways that defence sector Carbon Accounting is designed to support low carbon technology innovation should be aware of these ‘niche’ and ‘landscape’-level interactions. The ‘storylines’ created by ‘Project Level’ Carbon Accounts at the ‘niche’ level, and concepts of endurance and the FBCE metric at the ‘landscape’ level need to become mutually reinforcing. Only in their positive interaction can a supportive selection environment for low carbon technology be created in the defence sector.

5.4 Discussion Summary

This Discussion has brought together the themes from the Literature Review and the analysis from the Results chapter in order to comprehensively evaluate OCA practices in the defence sector.

The first theme related to the difficulty of allocating emissions between organisations in existing OCAs, which is likely to be particularly marked in the defence sector due to close working relationships, and may result in abstract OCAs that do not connect effectively to the underlying activities causing emissions to be produced. This is likely to inhibit the extent to which the accounts engage new/relevant actors and support low carbon technology innovation. Section **5.1** reiterated the context for this theme from the Literature Review, before summarising the detail of the methodologies used for producing OCAs in the defence sector as well as attempts to further standardise these. It concluded that existing OCA practices are likely to produce abstract accounts and are therefore unlikely to support low carbon technology innovation.

In contrast, the second theme running through the thesis related to the potential for 'Project Level' Carbon Accounts focused on large-scale collaborative programmes, to better account for the emissions of the defence sector in a way that engages new/relevant actors to defence-energy debates. These accounts are therefore more likely than existing OCAs to support low carbon technology innovation. Section **5.2** reiterated the context for this theme from the Literature Review, which described how Scope 3 reporting is immature at present – particularly where relevant to the product lifecycle and value chain. The section then summarised how the quantitative analysis from the Results chapter showed the lack of relevant Scope 3 reporting at present in the defence sector, despite a clear recognition of the importance of this data. There is a conflict between the recognised need to produce 'Project Level' Carbon Accounts, which are inevitably scenario specific, and the ongoing drive to standardise OCA practices. However, the defence sector is well placed to resolve this conflict, being characterised by several large scale industrial projects. It concluded that if this conflict in organisational reporting can be overcome, 'Project Level' Carbon Accounts have the potential to engage new and relevant actors to defence-climate change debates, and are therefore more likely to support low carbon technology innovation.

However, 'Project Level' Carbon Accounts cannot work effectively in isolation, which led onto the third theme running through this thesis related to the potential for 'consequential carbon accounting' perspectives to align with concepts of 'defence capability', in order to inform wider strategic narratives that help construct a positive selection environment for low carbon technologies in the defence sector. Section **5.3** reiterated the context for this theme from the Literature Review, which described the relevance of 'consequential accounting' perspectives for connecting emissions inventories to positive change at the system level. This aligns them to 'defence capability' concepts that are likely to provide the strategic context through which 'Project Level' Carbon Accounts are understood and interpreted. It referred back to the Results chapter and the emergence of relevant strategic vectors of 'resilience' and 'endurance', and associated metrics such as the FBCE. It explained the FBCE as a type of consequential carbon account, but one which is underpinned by 'Project Level' Carbon Accounts in order to work in practice. The section then described the relevance of the innovation studies literature in this context, and the need for 'storylines' at the niche and landscape level to be mutually reinforcing in order for a positive selection environment to be created in the defence sector. In other words, 'Project Level' Carbon Accounts and a wider strategic framework of relevant tools and metrics will both be required in order for OCA practices to effectively support technology innovation.

Together these themes suggest that if OCA practices in the defence sector are to effectively support low carbon technology innovation, then existing practices need to change; 'Project Level' Carbon Accounts need to be developed; and these need to be presented within an appropriate strategic framework. This implies a number of recommendations for existing OCA practices in the defence sector as follows.

To focus on existing OCA practices first, despite their limitations in supporting low carbon technology innovation, it is important to stress that they do have a legitimate role. There is a strong rationale for the existing 'attributional' approaches to Carbon Accounting that encourage organisations to take ownership of their climate change impacts and act to reduce their GHG emissions. Indeed, it is difficult to conceive of ways that policymakers can regulate for organisations to take action without 'attributional' Carbon Accounts that quantify their emissions – regardless of the method used to do this. Similarly, external stakeholders (investors, civil society) would struggle to put pressure on organisations to act to mitigate climate change without some way of understanding their individual impacts and comparing them to their peers. This latter point is particularly relevant, with financial market actors gaining increasing influence over how organisations account for their GHG impacts and responses to climate change (Bebbington & Larrinaga, 2014).

However, Schaltegger et al (2015) emphasise the different roles that Carbon Accounting can play:

> 'Corporate climate accounting can either be introduced as a means to create information for reporting to various public stakeholders or customers. Another purpose can be to initiate company internal processes of reducing the carbon footprint of the organisation and to support organizational learning processes' (p.8)

This research is concerned with the extent to which OCA practices support low carbon technology innovation, as this is seen as the best way that the defence sector can contribute to climate change mitigation. From this perspective, existing OCAs are unlikely to widen participation in defence-energy debates or establish compelling storylines that support low carbon technology innovation. The existing trends in both Organisational Carbon Accounting and Defence Industrial Policy are only likely to make these accounts less supportive of technology innovation, with increasing pressure to pragmatically standardise Carbon Accounting methodologies so that individual organisations can be compared (driving decreased 'relevance'), and defence sector organisations becoming increasingly integrated in relation to all aspects of defence activity (making the challenges of attributing emissions to individual organisations yet more difficult).

Therefore, in terms of recommendations for OCA practices in the defence sector, this research would suggest that defence sector organisations should support and effectively respond to the demands placed on them by regulators and external stakeholders to produce standardised and comparable Organisational Carbon Accounts. However, these methods should not dominate their agenda as at present in relation to climate change mitigation, and wherever possible (for example in their public reporting that does not respond to regulatory agendas) they should seek to provide more relevant ‘Project Level’ Carbon Accounts.

This research recommends that the Defence sector should collaboratively create these ‘Project Level’ Carbon Accounts as a means to establish their scope 3 inventories, and make these publicly available wherever possible so as to ‘recruit’ as many new or relevant actors into ‘discourse coalitions’ that are supportive of low carbon technology development in the sector.

In the context of the mounting pressure on organisations to develop and publish their scope 3 inventories, ‘Project Level’ Carbon Accounts jointly created by multiple organisations could be a very relevant way to build up relevant scope 3 accounts that communicate the value chain impacts of different organisations, as opposed to the existing scope 3 accounts that are focused on less relevant categories such as business travel or employee commuting. The concept of ‘Scope 4’ Carbon Accounting introduced by Matthews, Hendrickson & Weber (2008) is useful in this respect to focus organisations on the most relevant impacts to the product lifecycle, but is probably only practical for defence sector organisations to apply if it is recognised in a widely use methodology such as the GHG Protocol.

Given the potential that ‘Project Level’ Carbon Accounts have to establish relevant ‘storylines’ and create ‘coalitions’ relevant to the development or integration of low carbon technologies to the specific projects with which they are concerned, this research recommends that these ‘Project Level’ Carbon Accounts should be created whenever organisations have capacity to create their own carbon accounting and climate change narratives (outside of regulatory requirements). They should actively seek to include relevant Small and Medium-sized Enterprises (SMEs) in these activities, who are largely without GHG reporting drivers at present (Buhr, Gray & Milne, 2014) but can often be more agile and innovative than larger organisations.

Where existing OCA practices were likely to get less relevant given contemporary trends in the sector, the opposite seems true for ‘Project Level’ Carbon Accounts, supported as they are by the increasing trends towards international collaboration and industrial teaming, and the continuing standardisation and inter-operability of defence products.

As well as producing ‘Project Level’ Carbon Accounts wherever possible, this research also recommends that these are presented within a relevant framework of strategic concepts and tools.

This research recommends that OCA practices in the defence sector need to be very conscious of the interplay between ‘Project Level’ Carbon Accounts and relevant strategic narratives.

Alone, both the ‘Project Level’ Carbon Accounts discussed in the second theme of this thesis and ‘system-level’ perspectives discussed in the third theme, are limited in the change that they can achieve. However, together they can have a transformative impact on the way that the sector views energy use and GHG emissions, and begin to construct a strong selection environment for low carbon technologies that effect positive change at the system level.

There is significant potential to do this at present, given the growing acknowledgement of energy as ‘the key enabler of military power’ (Lengyel, 2007: p.8). Despite this acknowledgement, the overall approach to defence energy issues at present lacks strategic coherence (Warner & Singer, 2009), and the types of Carbon Accounting practices recommended in this research provide one means to start addressing this.

This chapter has comprehensively evaluated OCA practices in the defence sector, and generated some relevant recommendations for the organisations within it. The Conclusion that follows summarises the thesis as a whole before reflecting on the implications of this ‘sector-level’ research for the emerging field of Carbon Accounting more broadly, suggesting ways that it might become more effective in supporting the fight against climate change as it continues to develop.

6) Conclusion

This thesis is titled "An investigation of Organisational Carbon Accounting (OCA) practices in the Defence Sector to determine how these can best support Low Carbon Technology Innovation".

Section **1.4** of the introductory chapter described 'The Aims and Objectives of the Thesis', categorising these according to the different 'cognitive levels' of Blooms Taxonomy and the relevant chapters of the thesis that addresses them. This concluding chapter provides a chronological summary of the thesis by describing how these objectives have been met. The Conclusion then finishes by addressing the final objective listed in **1.4**, for the research to "Formulate some recommendations for the wider field of Carbon Accounting that can inform its ongoing development".

There were several objectives associated with the Literature Review (chapter **2**). The first simply aimed to provide the reader with a broad knowledge of the history and key theories associated with three academic fields: Carbon Accounting; Defence Industrial Policy; and Innovation Studies. Given the emerging nature of the field of Carbon Accounting, particularly as regards sector level research, the supporting literatures of Defence Industrial Policy and Innovation Studies were reviewed to provide essential context to the Carbon Accounting debates discussed.

For the 'themes' of Carbon Accounting identified as most relevant to this research, the thesis aimed to describe the gaps and areas of immaturity in the existing knowledge. The three 'themes' identified related to the difficulty of attributing Scope 1 & 2 emissions to individual organisations with methodologies still evolving; the lack of mature Scope 3 emissions accounting and 'Project Level' Carbon Accounts related to the value chain despite their acknowledged importance to organisational reporting; and the relevance of little-known 'consequential perspectives' for OCAs that are increasingly informing organisation decision making.

The third objective was to convey how the gaps in the Carbon Accounting literature are reinforced by contextual aspects of the Defence Industrial Policy supporting literature. The Literature Review described how the difficulty of attributing emissions to individual organisations was particularly challenging in the defence sector due to the increasing private sector involvement in nearly all defence tasks, to the extent that defence departments and their supporting industrial base can be highly integrated and difficult to separate for emissions accounting purposes. In contrast, 'Project Level' Carbon Accounting methods align well to a sector that is increasingly characterised by a small number of large, high profile international programmes supported by industrial 'teams' comprising multiple companies. Similarly, consequential perspectives on Carbon Accounting align well with concepts of 'defence capability' that are gaining traction in a period of defence reform in most western countries.

The Literature Review explained how Carbon Accounting can influence technology innovation, most notably in its discursive power to build coalitions of interests that can challenge established ways of working, and existing socio-technical regimes. It characterised the existing calls for defence to support low carbon technology innovation as based on outdated models of innovation (technology push, demand pull), and described how Carbon Accounting was particularly relevant to more contemporary ‘networked’ models of innovation.

The final objective for the Literature Review was to convey the relevance to the reader of an interdisciplinary approach, with the use of relevant supporting literatures necessary to effectively investigate Carbon Accounting at the sector level, given the way that strengths and weaknesses of existing Carbon Accounting methods can be amplified or reduced in the sector-specific context. Given that the defence sector is widely characterised as a ‘technology innovator’ in climate change debates, the innovation studies literature was also particularly relevant for reflecting on the purpose of OCA practices in the sector.

The first objective for the Methodology (chapter **3**) of the thesis was that the reader should understand the relevance of an exploratory archival research strategy for analysing Carbon Accounting and climate change information produced by defence sector organisations. The exploratory, inductive approach to the research made sense given that relatively little is currently known about the subject, but there are increasing quantities of public information being made available by organisations across the world.

The second (related) objective was that the reader should be able to apply the exploratory archival strategy used in this research, and the different parts of the Methodology chapter explained in detail how relevant primary and secondary sources of data were identified and reviewed for quantitative and qualitative data. A sample of defence organisations was selected for inclusion in the research that included the UK MoD, US DoD, and the ten largest multi-national defence companies globally. The Methodology explained how this sample covered a significant proportion of the defence sector by spend, and allowed the analysis to extend across different regions and types of defence company. The chapter described a rationale for selecting relevant public documents for the organisations in the sample, and a systematic approach to identifying these. With a large selection of relevant documents selected, the Methodology then described how quantitative datasets were established for GHG and energy data, as well relevant normalising data. Qualitative datasets were also established in relation to energy and climate change keywords used in the documents, and any public targets or ambitions being communicated by them. Secondary sources of defence-energy grey literature were also reviewed to provide some additional context to the data identified in the primary sources from the organisations in the sample.

The Results chapter (**4**) presented relevant correlational analysis from the quantitative and qualitative datasets established in the Methodology. Comparisons of the quantitative data showed that defence departments currently report the overwhelming majority of the overall emissions from the sector. Where scope 3 data related to the value chain was available it had a significant impact on these quantitative trends, and suggested that ‘Project Level’ Carbon Accounts could potentially account for a large proportion of the sectors total emissions, complicating the picture as to which organisations in the sample are the most quantitatively significant. By integrating the qualitative data, a connection could be demonstrated between the volume of emissions reported and the level of priority placed on the issue of climate change mitigation, suggesting that the technical accounting issues that drive reported volumes do potentially influence organisational responses to climate change, and therefore are significant.

The second objective for the Results chapter was to associate findings from the quantitative and qualitative analysis with information from relevant secondary sources to illustrate pertinent issues in defence sector Carbon Accounting. The Results chapter described the emergence of some new 'strategic vectors' of 'resilience' and 'endurance' in the military discourse. The Fully Burdened Cost of Energy (FBCE) is a metric that could be described as a 'consequential approach' to Carbon Accounting that is helping to drive these new strategic vectors into military doctrine and improve decision making in relation to defence energy use. However, the implementation of the FBCE relies on robust 'Project Level' Carbon Accounts and less attributional mind-sets that are discussed in earlier parts of the thesis.

The final objective for the Results chapter was to defend/justify the interdisciplinary approach taken to the academic literature, and exploratory archival research strategy employed. Despite the lack of relevant precedents in the Carbon Accounting literature, and the evolving nature of existing OCA practices, relevant patterns were identified in the quantitative and qualitative data. When aligned to the secondary sources of defence-energy grey literature, strong trends were observed that could begin to define some relevant ways forward for OCA practices in the sector, validating the research approach taken.

The Discussion (**5**) aimed to bring the preceding chapters of the thesis together in order to comprehensively evaluate OCA practices in the defence sector, and their potential to support low carbon technology innovation. The first objective set in **1.4** ('Aims and Objectives of the Thesis') was to relate the most relevant themes of defence sector Carbon Accounting that were identified in the Literature Review to the analysis of OCA practices presented in the Results chapter. The first of these themes related to the difficulty of allocating emissions between organisations in existing OCAs, which is likely to be particularly marked in the defence sector due to close working relationships, and may result in abstract OCAs that do not connect effectively to the underlying activities causing emissions to be produced. This is likely to inhibit the extent to which the accounts engage new/relevant actors and support low carbon technology innovation. In contrast, the second theme running through the thesis related to the potential for 'Project Level' Carbon Accounts focused on large-scale collaborative programmes, to better account for the emissions of the defence sector in a way that engages new/relevant actors to defence-energy debates. These accounts are therefore more likely than existing OCAs to support low carbon technology innovation. However, 'Project Level' Carbon Accounts cannot work effectively in isolation, which led onto the third theme running through this thesis related to the potential for 'consequential carbon accounting' perspectives to align with concepts of 'defence capability', in order to inform wider strategic narratives that help construct a positive selection environment for low carbon technologies in the defence sector.

The other objective for the Discussion was to generate a set of recommendations for OCA practices in the defence sector that will better support low carbon technology innovation. The research concludes that if OCA practices in the defence sector are to effectively support low carbon technology innovation, then existing practices need to change; 'Project Level' Carbon Accounts need to be developed; and these need to be presented within an appropriate strategic framework. Existing OCA practices focused on attributing Scope 1 & 2 to individual organisations do have a legitimate role in the Carbon Accounting landscape, given their usefulness for policymakers and civil society across all sectors. However, for defence sector organisations these accounts should be seen as a means to a regulatory end, and any spare capacity should be focused on producing collaborative ‘Project Level’ Carbon Accounts that are more likely to widen participation in energy and climate change debates in the defence sector. Given that technology innovation is seen as the most valuable contribution that the defence sector can make to climate change mitigation, these ‘Project Level’ Carbon Accounts – by widening participation – are more likely to support the building of relevant ‘discourse coalitions’ that can challenge incumbent interests in the sector and encourage technology innovation. Finally, this research recommends that OCA practices in the defence sector need to be very conscious of the interplay between ‘Project Level’ Carbon Accounts and relevant strategic narratives. Alone, both the ‘Project Level’ Carbon Accounts discussed in the second theme of this thesis and ‘system-level’ perspectives discussed in the third theme, are limited in the change that they can achieve. However, together they can have a transformative impact on the way that the sector views energy use and GHG emissions, and begin to construct a strong selection environment for low carbon technologies that effect positive change at the system level.

The ‘Aims and Objectives of the Thesis’ (section **1.4**) also set an objective relevant to this concluding chapter. This chapter will “Formulate some recommendations for the wider field of Carbon Accounting that can inform its ongoing development”.

In terms of the implications for the wider field of Carbon Accounting, it has been clear throughout this thesis that OCA can clearly benefit from incorporating methodologies and perspectives from wider parts of the Carbon Accounting field.

Ascui and Lovell’s (2011) definition of Carbon Accounting that was used to introduce the topic of Carbon Accounting (See section **1.2** ‘Academic Context and Novelty’, Figure 1) demonstrates the breadth of the field. Brander & Ascui (2015) explain how there is significant potential for learning across different parts of this field:

> ‘methods of carbon accounting…have developed in a number of semi-isolated fields of practice, such as national inventory accounting, corporate carbon accounting, project level accounting, and product life cycle assessment, and there appears to be considerable potential for learning across these different fields’ (p.100)

These existing ‘semi-isolated fields of practice’ are arguably not working, and Burritt, Schaltegger & Zvedov (2011) conclude that there is currently a lack of sophistication to Carbon Accounting that to an extent undermines its utility. Whilst climate change mitigation is a much broader challenge than Carbon Accounting alone, Bebbington & Larrinaga (2014) emphasise the technicalities of Carbon Accounting, and that we ‘should not forget [its] powerful shaping role’ (p.203).

Bulkeley and Newell (2010) comment on the limitations of existing activities:

> ‘despite the enormous proliferation of initiatives aimed at reporting, benchmarking, and measuring performance…it would be difficult to argue that the world is showing genuine progress in moving away from a model of development that is fuelling climate change.’ (p.110)

Bailey, Gouldson & Newell (2010) mention the concern that the plethora of complex regulatory regimes can reinforce existing Carbon Accounting practices, and act to stifle innovation or 'alternative framings' of the issue (in this case discussing the experience of regulated carbon markets):

> 'A final issue concerns the degree to which the recent formation of these market-based approaches has locked corporations, countries and the wider international community into a neoliberal experiment with climate governance…the opportunity for more radical voices to impact upon the dominant framings or governance processes seems very limited indeed.' (p.15)

Section **1.2** ('Academic Context and Novelty) introduced the rarity of sector-level analyses of OCA, but this perspective has proved particularly useful in this research for identifying relevant Carbon Accounting methods from other fields of practice that can improve 'Organisational' Carbon Accounting specifically. The sector-level perspective is particularly relevant, as the strengths and weakness of different methods can be amplified by the sector-specific context. This research has shown that existing OCA practices focused on attributing scope 1 & 2 emissions to individual organisations do not align well to contemporary trends in the defence sector, but 'Project Level' methodologies have considerable potential.

Thus, OCA practices can be significantly improved by borrowing from other areas of the wider Carbon Accounting field, and various techniques and methods will be appropriate depending on the specific sector in question. From this perspective, the wide range of activity across all 'scales' of Carbon Accounting is cause for optimism, as it offers a dynamic and growing set of activities from which to borrow, as Bulkeley & Newell (2010) confirm:

> 'While the tremendous diversity and dynamism of climate governance generates huge challenges of co-ordination, accountability and effectiveness … the plurality of sites of action could also be a positive thing as actors move between arenas trying to advance action in the fastest and most effective way they can, working with whom they need to, wherever that happens to be.' (p.114)

Bebbington & Larrinaga (2014) emphasise the scale of the challenge but would also welcome this diversity, arguing that 'the scientific and technical indeterminacy of the social and physical processes giving rise to global climate change precludes taking any measurement method for granted' (p.205), and suggesting that some of the core philosophical pillars of Carbon Accounting (such as the scope 1-3 distinctions) that have been dominant date do need to remain open to question:

> 'accounting research has not substantively engaged with those issues but they are the bedrock issues for approaching any reporting and are exactly the issues of detail that will have an impact on the relevance of carbon accounting data' (p.205)

Therefore, the sector-level perspective can clearly prove useful in challenging the dominant OCA practices, and identifying relevant areas of the wider Carbon Accounting field that can make them more relevant to the sector specific context. However, more fundamentally the sector-level perspective is useful for first understanding the contribution to climate change mitigation expected of a given sector, before critically analysing the role that OCA plays in inhibiting or supporting this contribution.

From the defence sector perspective, this thesis began by characterising the defence sector as a 'technology innovator' in climate change mitigation debates (see **1.1** 'Background'), and this research has demonstrated that the defence sector could potentially improve its capacity to develop low carbon technologies by adopting certain Carbon Accounting techniques that challenge the existing dominant OCA practices.

Thomson (2014) argues that this connection between the challenges of sustainable transformations and the accounting techniques employed by organisations and others is crucial to the development of the field:

> 'The radical nature of sustainable transformations…requires our research questions to be more radical and ambitious. As a community, we need to be challenging assumptions, engaging in actions and thinking that seeks to resist unsustainable practices, participating effectively in sustainability conflicts and focusing on solving problems.' (p.26)

This research would strongly endorse these perspectives on the future challenges for OCA, and argues that the sector-level perspective is particularly useful for critically analysing existing practices and future trajectories; and focusing on solutions to real world problems in a specific context.

Section **1.2** ('Academic Context and Novelty') described how despite the significant volume of grey literature focused around the many schemes and initiatives aiming to mitigate climate change, the academic literature is relatively immature, and significant edited volumes by Schaltegger et al (2015) and Bellassen & Stephan (2016) have only emerged in the last year. This research argues that 'sector-level' perspectives need to inform this literature as it develops, and will inevitably drive the field to become more interdisciplinary. Just as it has been necessary to engage with the Defence Industrial Policy and Innovation Studies in this research, other sector-level studies will require engagement with other literatures relevant to the sector in question. The choice of relevant supporting literatures needs to be based on an understanding of the most effective contribution the sector in question is likely to make to the challenge of mitigating climate change, and an exploratory, inductive approach to the research can help ground the investigation in its unique context.

Given the scale of the challenge of mitigating climate change, we must ensure that all sectors of the economy meaningfully contribute to the task, and we should be conscious of the powerful shaping role that Carbon Accounting can play in this regard.

7) Recommendations for Further Work

The ‘Aims and Objectives of the Thesis’ (section **1.4**) also described another objective for this thesis to “develop some suggestions of specific areas of further work that could effectively build on this exploratory research”.

This final chapter of the thesis describes some recommended areas of further work that would be beneficial to investigate but are beyond the scope of this research. It is often considered that exploratory research approaches in under-developed academic fields can be most valuable in the basis they create for further investigation, and this responds by describing two areas related to Carbon Accounting in the defence sector where further research could be particularly beneficial.

The first is a pragmatic area of further research, and relates to the practical feasibility of defence sector organisations making ‘Project Level’ Carbon Accounts widely available in a sector understandably known for its emphasis on secrecy.

This research clearly recommends that the Defence sector should collaboratively create ‘Project Level’ Carbon Accounts as a means to establish their scope 3 inventories, and make these publicly available wherever possible so as to ‘recruit’ as many new or relevant actors into ‘discourse coalitions’ that are supportive of low carbon technology development in the sector. They should actively seek to include relevant Small and Medium-sized Enterprises (SMEs) in these activities, who are largely without GHG reporting drivers at present (Buhr, Gray & Milne, 2014) but can often be more agile and innovative than larger organisations. As well as producing ‘Project Level’ Carbon Accounts wherever possible, this research also recommends that these are presented within a relevant framework of strategic concepts and tools.

Given the priorities for recruiting new actors into a ‘discourse coalition’ that challenges incumbents and the status quo, it is important that these accounts and frameworks are made public so as to communicate their impacts to as wide an audience as possible. It is acknowledged that this may be a challenge to defence sector practices, where product information is very rarely made public for the potential security threat it presents by providing information to potential adversaries. Indeed, this has been the rationale used by the IAEG for not determining any guidance for the sector as regards emissions related to ‘products in use’. However, significant high-level information is already widely communicated about significant defence products on platforms like Wikipedia, and high-level GHG information is unlikely to offer adversaries any more benefit than the type of information that already exists, but could serve to change the narrative around defence sector emissions. A balance needs to be struck between the potential threat that releasing this type of information poses, and the potential benefits it could offer.

This would be a valuable avenue of further research that explores some of the practical realities of implementing some of the recommendations from this research.

The second area of further research is a more theoretical line of enquiry, related to energy system debates. This thesis has been concerned with how Carbon Accounting methods in the defence sector have discursive power to influence technical change within the sector itself. However, the defence sector could also be analysed as an actor in its own right with significant discursive power to effect wider energy system debates.

The ‘energy security’ of western powers represents an increasing threat to national security, particularly in countries that are net importers of energy, such as the US and UK. The MoD Strategic Trends report predicts that global energy demand is likely to grow by more than half again by 2035, and that nations will be increasingly reluctant to trust the security of their energy supply to market forces and the integrity of the international trading system (Ministry of Defence, 2013e). Moreover, there is widespread acknowledgement of how the reliance of western industrialised countries on large volumes of imported energy can complicate foreign policy options, due to the need to maintain good business relations with oil exporting countries.

Therefore, with both a fundamental requirement to maintain secure supplies of energy, and a strategic benefit to reducing dependence on imports, the defence sector has a key interest in supporting the transition to a sustainable energy system. The question of how it could best support system-level change in the area of power generation is very relevant to this. There is a substantial volume of literature on sustainable energy systems (e.g. Hofman & Elzen, 2010; Sauter & Bauknecht, 2009; Schreuer, Rohracher & Spath, 2010), which is linked to the innovation studies literature described in section **2.3** and characterises existing centralised systems of power generation in industrialised countries as socio-technical regimes in ‘lock in’ (Unruh, 2000). Building on concepts of ‘selection environments’ for energy technologies as discussed in this thesis, centralised power generation systems and their associated institutional structures and political and industrial lobbies, can be hostile to new technologies. The literature applies discursive perspectives to socio-technical regimes characterised by ‘lock in’, and suggests that by widening the participation in energy debates to new institutions, individuals, and sectors (e.g. Defence), the legitimacy of powerful incumbent actors can be challenged at the energy system level.

Defence is a particularly relevant actor from this perspective as it aligns with one of several ‘core imperatives’ that constrain the influence that discourse can have in neo-liberal societies (Dryzek, 1997). Just as ‘economic growth’ is a core imperative that many advocates of sustainable energy systems align with in order to advance their argument, likewise security concerns could offer a similarly attractive framing to challenge energy system incumbents, if the defence sector was to effectively engage with the debate.

This research has been concerned with how OCA practices can better ‘frame’ debates within the defence sector. It emphasised the relevance of niche and landscape level interactions in order to creative a positive selection environment for low carbon technology (Lehtonen & kern, 2009), explaining in this case how ‘Project Level’ Carbon Accounts and strategic concepts and metrics are mutually reinforcing. However, there is an even wider ‘landscape-level’ to be considered, which is concerned with the energy system itself. In this sense, the defence sector itself and its activities could be seen as the ‘niche … protected space where novel technologies, ideas or practices emerge’ (Lehtonen & kern, 2009, p.104), and the landscape level debates and narratives relate to energy policy and the energy system as a whole.

Just as strategic narratives and ‘Project Level’ Carbon Accounts can become mutually reinforcing within the sector; defence sector activities and energy system debates can also become mutually reinforcing. The introduction to this thesis mentioned a relevant historical precedent in this context, with the military development of the jet engine crucial to the development of the combined cycle gas turbine that heralded a shift in how power was generated in all developed economies (Watson, 2004). Despite the defence sector and its role in the innovation process having changed significantly since the 1960s, it could still play a significant role in contemporary socio-technical models of change, if effective ‘storylines’ can be advanced at both the sector and energy system level.

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Appendix A: Datasets used in the Research

Emissions Boundary (CC8.1)	Number of Records	Percentage of Total
Operational Control	1,259	66%
Financial Control	504	26%
Equity Share	67	4%
Other	74	4%

Table 1: Emissions Boundary Methodologies Reported to CDP in 2014 (Original Analysis. Source Data: CDP Academic Dataset)

	Methodology Used	Global Warming Potentials Included	Emission Factors	Emissions Boundary
Thales	The Greenhouse Gas Protocol: A Corporate Accounting and Reporting Standard (Revised Edition)	CO_2; CH_4; N_20; HFCs; PFCs; SF_6 - IPCC Fourth Assessment Report (AR4 - 100 year)	No reference	Operational control
United Technologies	The Greenhouse Gas Protocol: A Corporate Accounting and Reporting Standard (Revised Edition)	CO_2; CH_4; N_20; HFCs; PFCs; SF_6 - IPCC Fourth Assessment Report (AR4 - 100 year)	US EPA	Operational control
Lockheed Martin Corporation	The Greenhouse Gas Protocol: A Corporate Accounting and Reporting Standard (Revised Edition)	CO_2; CH_4; N_20; HFCs - IPCC Second Assessment Report (SAR - 100 year)	No reference	Operational control
Northrop Grumman Corp	The Greenhouse Gas Protocol: A Corporate Accounting and Reporting Standard (Revised Edition)	CO_2; CH_4; N_20; HFCs; PFCs; SF_6; NF_3 - IPCC Fourth Assessment Report (AR4 - 100 year); IPCC Second Assessment Report (SAR - 100 year)	No reference	Operational control
Raytheon Company	US EPA Climate Leaders Guidance Documents; The GHG Protocol; Defra Voluntary Reporting Guidelines; Australia - National Greenhouse and Energy Reporting Act; Other	CO_2; CH_4; N_2O; HFCs; PFCs; SF_6 - IPCC Second Assessment Report (SAR - 100 year)	US EPA	Operational control
Airbus Group	The Greenhouse Gas Protocol: A Corporate Accounting and Reporting Standard (Revised Edition)	CO_2; CH_4; N_2O; Other: HCFC-22; Other: HFC-134a; Other: R404a; Other: R407a; Other: R407c; Other: R408a; Other: R410a; Other: R507; Other: R417a; Other: HFC-23	Commission Decision of 16 April 2009	Operational control
Finmeccanica	The Greenhouse Gas Protocol: A Corporate Accounting and Reporting Standard (Revised Edition); ISO 14064-1; Other	CO_2; CH_4; N_2O - GHG Protocol Tool 2011. HFCs; PFCs; SF_6 - IPCC Fourth Assessment Report (AR4 - 100 year)	No reference	Other: 149 sites are included in the CMS, in line with the Environmental Reporting perimeter
BAE Systems	The Greenhouse Gas Protocol: A Corporate Accounting and Reporting Standard (Revised Edition); Defra Voluntary Reporting Guidelines	CO_2; CH_4; N_2O - Linked to DEFRA guidance for conversions to CO_2e	Bespoke spreadsheet	Operational control
Boeing Company	The Greenhouse Gas Protocol: A Corporate Accounting and Reporting Standard (Revised Edition); Australia - National Greenhouse and Energy Reporting Act; Other	CO_2; CH_4; N_2O; HFCs; PFCs; SF_6; NF_3 - IPCC Fourth Assessment Report (AR4 - 100 year)	Bespoke spreadsheet	Other: GHGs represent 108 facilities located primarily in the U.S.; Operations of Boeing Australia and Boeing UK
General Dynamics	Not disclosed	Not disclosed	Not disclosed	US Based Business Units, Including their Foreign Operating Sites (2012 Sustainability Report)
MoD	None specified, but Scope 1-3 referenced	CO_2; CH_4; N_2O; HFCs; PFCs; SF_6	DEFRA factors	Described for 'goal-subject GHGs' - ~400 core facilities
DoD	None specified, but Scope 1-3 referenced	CO_2; CH_4; N_2O; HFCs; PFCs; SF_6	None mentioned	Data files simply list as 'Department of Defense'

Table 2: Carbon Accounting Methodologies used by Organisations in the Research Sample (Source(s): CDP Academic Dataset for company information, Sustainable MoD Annual Reports (Ministry of Defence, 2014m; 2015a; 2016b), Department of Energy Federal Greenhouse Gas Inventories (Department of Energy, 2016), Department of Energy Overview of Executive Order 13514 (Department of Energy, 2009))

Site No	Control % Estimate
1	100%
2	100%
3	90%
4	10%
5	NA
6	100%
7	75%
8	90%
9	90%
10	100%
11	90%
12	100%
13	90%
14	65%
15	100%
16	100%
17	100%
18	100%
19	100%
20	100%

Table 3: ‘Top 20 GHG-Producing Sites’ at BAE Systems and estimate of the companies’ percentage control based on some simple survey questions. Sites have been anonymised and included as a number.

Rank	Country	Spending ($ billion)	World Share (%)
1	USA	698	43%
2	China	[119]	[7.3%]
3	UK	59.6	3.7%
4	France	59.3	3.6%
5	Russia	[58.7]	[3.6%]
6	Japan	54.5	3.3%
7	Saudi Arabia	45.2	2.8%
8	Germany	[45.2]	[2.8%]
9	India	41.3	2.5%
10	Italy	[37]	[2.3%]

Table 4: Table (reproduced) showing Top 10 defence spending countries. Where figures are in square brackets they represent a SIPRI estimate. (Source: SIPRI, 2011: p. 9)

	1981	1986	1991	1996	2001	2005
United States	11,797	10,229	11,641	10,377	5,516	7,101
Russia	16,814	14,378	5,221	3,589	5,548	5,771
France	3,622	2,629	902	1,651	1,133	2,399
Germany	1,673	1,302	2,372	1,618	640	1,855
United Kingdom	1,919	1,733	1,394	1,526	1,070	791
Netherlands	697	342	423	381	190	840
Italy	1,549	334	506	414	185	827
Sweden	172	275	184	118	459	592
China	825	2,143	1,100	707	408	129
Ukraine	n/a	n/a	n/a	236	702	188
World Total	41,997	37,241	25,928	22,079	17,332	21,961
US percent of total	28.1%	27.5%	44.9%	47.0%	31.8%	32.3%

Table 5: Table (reproduced) showing Foreign Military Sales: Major Suppliers, 1981 to 2005 (millions of 1999 US dollars). (Source: Gansler, 2011: p.150)

Rank	Company	Arms Sales ($m)	Profit ($m)
1	Lockheed Martin (US)	35,490	2,981
2	Boeing (US)	30,700	4,585
3	BAE Systems (UK)	26,820	275
4	Raytheon (US)	21,950	2,013
5	Northrop Grumman (US)	20,200	1,952
6	General Dynamics (US)	18,660	2,357
7	EADS (trans-Europe) - now Airbus	15,740	1,959
8	United Technologies (US)	11,900	5,721
9	Finmeccanica (Italy)	10,560	98
10	Thales (France)	10,370	761

Table 6: Table (reproduced) showing the 10 largest arms-producing companies, 2013 (Source: SIPRI, 2015: p.17)

	Domestic Sales ($m)	Foreign Sales ($m)	Percentage Domestic	Source
Lockheed Martin	37,765	7,735	83%	2013 Annual Reports (some interpretation of data/narrative required)
Boeing	37,248	49,375	43%	
BAE Systems	7,386	21,020	26%	
Raytheon	17,305	6,401	73%	
Northrop Grumman	22,161	2,500	90%	
General Dynamics	24,255	6,963	78%	
Airbus	28,329	50,364	36%	
United Technologies	23,798	38,828	38%	
Finmeccanica	3,757	17,535	18%	
Thales	5,500	13,350	29%	

Table 7: The breakdown of the 'domestic' and 'foreign' sales for the companies included in this review (Source(s): Lockheed Martin, 2014a; Boeing, 2014a; BAE Systems, 2014a; Raytheon, 2014a; Northrop Grumman, 2014a; General Dynamics, 2014a; Airbus, 2014a; United Technologies, 2014a; Finmeccanica, 2014a; Thales, 2014a)

	Total 2013 Arms Sales ($m)	Total Sales ($m)	Percentage Arms Sales ('Defence Dependence')
Lockheed Martin	35,490	45,500	78%
Boeing	30,700	86,623	35%
BAE Systems	26,820	28,406	94%
Raytheon	21,950	23,706	93%
Northrop Grumman	20,200	24,661	82%
General Dynamics	18,660	31,218	60%
Airbus	15,740	78,693	20%
United Technologies	11,900	62,626	19%
Finmeccanica	10,560	21,292	50%
Thales	10,370	18,850	55%

Table 8: The revenue split between the ‘commercial sales’ and ‘defence sales’ for the companies included in this review (Source: SIPRI, 2014: p.3)

Search No	Source Website	Search Criteria / Browsing Section (of website)
1	www.gov.uk/government/publications	MoD; Corporate Reports
2	www.gov.uk/government/publications	MoD; Policy Papers
3	www.gov.uk/government/publications	MoD; Statistics
4	www.gov.uk/government/publications	MoD; Any other category of document
5	www.gov.uk/government/publications	Any Dept; Search Term "Defence"
6	National Archives (http://webarchive.nationalarchives.gov.uk)	
7	Google searches aimed at finding British Army Documents	"British Army Strategy"; "British Army Sustainability"; "British Army Environment"
8	Google searches aimed at finding Royal Navy Documents	"Royal Navy Strategy"; "Royal Navy Sustainability"; "Royal Navy Environment"
9	RAF Website	Downloads / Publications Section
10	Google searches aimed at finding RAF Documents	"Royal Air Force Strategy"; "Royal Air Force Sustainability"; "Royal Air Force Environment"
11	Specific google search for additional documents known to exist but not located via above searches	"UK SDSR 2010"; "MoD Strategic Trends"
12	Documents located from references in other documents found using search terms above	

Table 9: Summarising approach used to identify relevant MoD documents for use in this research

Document Type	Search No	Name & Example References	Summary	Publication Date															
				2000	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
Vision / Strategic	6; 11; 12	Strategic Defence & Security Review (Cabinet Office, 2010b; 2015)	The UK SDR and UK NSS provide the policy framework for defence. The Strategy for Defence and Defence Plan sit beneath these public documents but are not public and therefore not included here.			X (6)								X (11)					X (12)
Vision / Strategic	12	National Security Strategy (Cabinet Office, 2010a)												X (12)					
Regular Business Report	1	MoD Business Plan (Ministry of Defence, 2012a)	Describes how MoD is managing its commitments in the Defence Plan					X (1)	X (1)	X (1)	X (1)	X (1)	X (1)	X (1)	X (1)	X (1)	X (1)	X (1)	
Regular Business Report	1	MoD Annual Report and Accounts (Ministry of Defence, 2014k; 2015e; 2016a)	The MoD Business Plan and the Annual Report and Accounts are published annually together					X (1)	X (1)	X (1)	X (1)	X (1)	X (1)	X (1)	X (1)	X (1)	X (1)	X (1)	X (1)
Energy / Environment/ Sustainability	1	Sustainable Development Strategy: A Sub Strategy of the Strategy for Defence 2011-2030 (Ministry of Defence, 2011b)	This is a sub-strategy of the 'Strategy for Defence'. It provides a 20-year strategy and a 4-year plan (to align with the wider defence plan)												X (1)				
Energy/ Environment/ Sustainability	1	Sustainable MoD Annual Report (Ministry of Defence, 2014m; 2015a; 2016b)	Report refers to (1) the targets from the SD Strategy 2011-2030 above and (2) the greening government commitments (GGCs) of the coalition government												X (1)		X (12)	X (1)	X (1)
Energy/ Environment/ Sustainability	1	MoD Greening Government Commitments Annual Report (Ministry of Defence, 2012e; 2013a)	Standalone report published annually communicating performance against the GGCs													X (12)	X (1)		

Table 10: Shortlisted MoD documents included in this research. Their year of publication is mapped alongside a number that identifies the search method used to identify the document (these numbers cross reference to Table 9)

Type	Sub-Topic	Name & Example Reference	Publication Date															
			2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Strategy / Vision	Defence Reform	Defence Reform Implementation Outline (Ministry of Defence, 2009)										X (2)						
Strategy / Vision	Defence Reform	Defence Reform: An Independent Report into the Structure & Management of the Ministry of Defence (Ministry of Defence, 2011a)															X (1)	
Strategy / Vision	Defence Reform	Ministry of Defence Improvement Plan (Ministry of Defence, 2014a)															X (1)	
Strategy / Vision	Defence Reform	2010-2015 Government Policy: Armed Forces and Ministry of Defence Reform (Ministry of Defence, 2012)																X (2)
Strategy / Vision	Single Services	Transforming the British Army (British Army, 2013)														X (12)		
Strategy / Vision	Single Services	Future Navy Vision (Royal Navy, 2011)												X (12)				
Strategy / Vision	Single Services	RAF Strategy (Royal Air Force, 2006)					X (12)		X (12)			X (12)				X (12)		
Regular Business Report	Statistics	UK Defence Statistics Compendium (Ministry of Defence, 2014b)								X (12)	X (12)	X (12)	X (3)	X (3)	X (3)	X (3)	X (3)	
Regular Business Report	Statistics	MoD Annual factsheet 2013 (Ministry of Defence, 2013b)								X (12)	X (12)	X (12)	X (3)	X (3)	X (3)	X (3)	X (3)	
Regular Business Report	Statistics	Formations, Vessels and Aircraft Report: 2014 (Ministry of Defence, 2015b)															X (3)	X (3)
Regular Business Report	Statistics	UK Armed Forces and UK Civilian Operational Casualty and Fatality Statistics 2014-15 (Ministry of Defence, 2015c)											X (3)	X (3)	X (3)	X (3)	X (3)	X (3)
Regular Business Report	Statistics	Defence Departmental Resources (Ministry of Defence, 2014c)														X (3)	X (3)	X (3)
Regular Business Report	Statistics	UK Armed Forces Annual Personnel Report: 2013 (Ministry of Defence, 2014d)														X (3)	X (3)	
Regular Business Report	Statistics	Conventional Armed Forces in Europe Equipment Holding Statistics 2014 (Ministry of Defence, 2014e)														X (3)	X (3)	
Regular Business Report	Statistics	International Defence Expenditure (Ministry of Defence, 2014f)														X (3)	X (3)	
Regular Business Report	Statistics	UK Manufacturers' Sales by Product (PRODCOM): Defence-Related Activities in the UK (Office for National Statistics, 2014)															X (5)	

Regular Business Report	Acquisition	MoD Capability Action Plan 2011-12 (Ministry of Defence, 2012c)												X (2)			
Regular Business Report	Acquisition	Defence Growth Partnership: Strategic Vision for the UK Defence Sector (Ministry of Defence, 2014g)														X (2)	
Regular Business Report	Acquisition	Defence, Equipment & Support: Corporate Plan 2014-2017 (Ministry of Defence, 2014h)											X (1)			X (1)	X (1)
Regular Business Report	Acquisition	Defence Equipment Plan (Ministry of Defence, 2015d)													X (1)	X (1)	X (1)
Regular Business Report	Acquisition	Review of Acquisition for the Secretary of State for Defence (Gray, 2009)									X (6)						
Regular Business Report	Acquisition	The Defence Strategy for Acquisition Reform (Ministry of Defence, 2010b)										X (2)					
Regular Business Report	Acquisition	Better Defence Acquisition: Improving how we Procure and Support Defence Equipment (Ministry of Defence, 2013c)													X (1)		
Regular Business Report	Acquisition	Defence, Equipment & Support: Framework Document (Ministry of Defence, 2014i)														X (1)	
Energy/Env/ Sustainability	Estates	Defence Estates Development Plan 2009 (Ministry of Defence, 2009b)									X (1)						
Energy/Env/ Sustainability	Estates	Defence Infrastructure Organisation Business Plan 2012-2016 (Ministry of Defence, 2012d)												X (1)			
Energy/Env/ Sustainability	Estates	Defence Infrastructure Interim Land and Property Disposal Strategy (Ministry of Defence, 2011c)												X (1)			
Energy/Env/ Sustainability	Estates	MoD Estate Information (Ministry of Defence, 2013d)														X (1)	
Energy/Env/ Sustainability	Estates	MoD Land Holdings 2008-2014 (Ministry of Defence, 2014j)													X (3)	X (3)	
Energy/Env/ Sustainability	Estates	Defence Accommodation Management Strategy (Ministry of Defence, 2011d)											X (1)				
Climate Change/ Megatrends	General	Global Strategic Trends out to 2040 (Ministry of Defence, 2013e)														X (12)	

Table 11: Longlisted MoD documents included in this research as contextual grey literature. Their year of publication is mapped alongside a number that identifies the search method used to identify the document (these numbers cross reference to Table 9)

Search No	Source Website	Search Criteria / Section of website
1	defense.gov	Current Releases
2	Google Search (specific)	"Quadrennial Defense Review"
3	Google Search (specific)	"National Defense Strategy"
4	Google Search (specific)	“National Military Strategy”
5	Google search	"Department of Defense Energy"
5.1	energy.defense.gov (Assistant Secretary of Defense for Operational Energy Plans and Programs)	Home Page
5.2	www.nrel.gov/defense (National Renewable Energy Lab)	Publications section
5.3	http://www.acq.osd.mil/ie/ (Office of the Deputy Under Secretary of Defense - Installations and Environment)	Home Page; Reports sections
6	Google search	"Department of Defense Sustainability"
6.1	DoD Sustainability' Web page (http://archive.defense.gov/home/features/2010/1010_energy/)	
6.2	Center for Climate and Security website (https://climateandsecurity.org/2014/11/05/release-pentagons-strategic-sustainability-performance-plan/)	
6.3	Whitehouse.gov	
7	Google search	"Department of Defense Environment"
7.1	DENIX (DoD Environment, Safety, and Occupational Health Network and Information Exchange) http://www.denix.osd.mil/	
7.2	EPA website (https://www.epa.gov/p2/defending-environment-department-defense-using-environmentally-preferable-purchasing-procedures)	
7.3	REPI Programme (Readiness and Environmental Protection Integration) http://www.repi.mil/	
7.4	SERDP/ESTCP website (https://www.serdp-estcp.org/) - DoD's environmental research programs	
8	Google search	"Department of Defense Climate Change"
9	US Army Publishing Website (http://www.apd.army.mil/)	
10	Google search	"US Army Energy"
10.1	Army Office of Energy Initiatives (http://www.asaie.army.mil/Public/ES/oei/index.html) - previously 'army energy initiatives task force'	
10.1.1	AEPI (http://www.aepi.army.mil/) Army Environmental Policy Institute	
10.2	Army energy and water management program (http://army-energy.hqda.pentagon.mil/)	
11	Google search	"US Army Sustainability"
11.1	US Army Corps of Engineers (http://www.usace.army.mil/Missions/Sustainability.aspx)	Publications section
12	Google search	"US Army Environment"
12.1	US Army Environmental Command (http://www.aec.army.mil/)	References section
13	Google search	"US Army Climate Change"
14	US Navy Personnel Command (http://www.npc.navy.mil/bupers-npc/reference/publications/Pages/default.aspx)	
15	Google search	"US Navy Energy"
15.1	US Navy Greenfleet (http://greenfleet.dodlive.mil/energy/)	Various
15.2	Assistant Secretary of the Navy - Energy, Installations & Environment (http://www.secnav.navy.mil/eie/Pages/Energy.aspx)	
16	Google search	"US Navy Sustainability"

16.1	NESDI (Navy Environmental Sustainability Development to Integration (NESDI) Program - http://www.nesdi.navy.mil/)	
17	Google search	"US Navy Environment"
18	Google search	"US Navy Climate Change"
19	US Air Force e-publishing Website (http://www.e-publishing.af.mil/)	
20	Google search	"US Air Force Energy"
20.1	USAF Installations and Environment site (http://www.safie.hq.af.mil/energy/)	
20.2	Air Force Energy Initiatives site (http://www.af.mil/EnergyInitiatives.aspx)	
20.2.1	Civil engineer's Center for Renewables - (http://www.afcec.af.mil/energy/ratesandrenewables/index.asp)	
21	Google search	"US Air Force Sustainability"
22	Google search	"US Air Force Environment"
23	Google search	"US Air Force Climate Change"

Table 12: Summarising approach used to identify relevant DoD documents for use in this research

DoD or Services?	Document Type	Name & Example References	Summary	Publication Date															
				2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
DoD	Vision / Strategic	Quadrennial Defense Review (Department of Defense, 2010a; 2014a)	The main vision / strategy documents for DoD							X (2)				X (2)				X (1)	
DoD	Vision / Strategic	National Military Strategy (Department of Defense, 2015a)						X (3)							X (1)				X (3)
DoD	Regular Business Report	Strategic Management Plan (Department of Defense, 2011b; 2013a)	Main business planning doc for DoD									X (1)	X (1)		X (1)	X (1)	X (1)	X (1)	
DoD	Energy/ Environment/ Sustainability	DoD Strategic Sustainability Performance Plan (Department of Defense, 2014b)	Unites the 'operational' and 'facility' energy reporting below												X (5.3)	X (5.3)	X (6.2)	X (6.2)	
DoD	Energy/ Environment/ Sustainability	DoD's Operational Energy Strategy (Department of Defense, 2011a)	Key strategy doc re DoD Operational Energy Use												X (5.1)				
DoD	Energy/ Environment/ Sustainability	Operational Energy Annual Report (Department of Defense, 2012b; 2013d; 2014e; 2015b; 2016b)	Annual report on DoD Operational Energy Use												X (5.1)	X (5.1)	X (5.1)	X (5.1)	X (5.1)
DoD	Energy/ Environment/ Sustainability	Annual Energy Management Report (Department of Defense, 2009b; 2010c; 2011c; 2012a; 2013c; 2014d; 2015c)	Annual report on DoD Facility Energy Use										X (5.3)	X (5.3)	X (5.3)	X (5.3)	X (5.3)	X (5.3)	X (5.3)
DoD	Climate Change / Megatrends	DoD Climate Change Adaptation Roadmap (Department of Defense, 2014c)	'Adaptation focused' but discusses wider climate change themes															X (5.3)	

Table 13: Shortlisted US DoD documents included in this research. Their year of publication is mapped alongside a number that identifies the search method used to identify the document (these numbers cross reference to Table 12)

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DoD or Services?	Document Type	Name	Publication Date															
			2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
DoD	Vision / Strategic	National Defense Strategy (Department of Defense, 2008a)						X (3)			X (1)							
DoD	Financial	DoD Budget Fact Sheet FY2016 (Department of Defense, 2015d)																X (1)
DoD	Financial	DoD Fiscal Year 2015 Budget Request (Department of Defense, 2014f)															X (1)	X (1)
DoD	Financial	Defense Budget Priorities and Choices_FY2014 (Department of Defense, 2013b)														X (1)		
DoD	Financial	FY2009 Summary Performance and Financial Information (Department of Defense, 2010b)										X (1)						
DoD	Acquisition	Performance of the Defense Acquisition System Annual Report (Department of Defense, 2016a)														X (1)	X (1)	
DoD	Estates	DoD Base Structure Report: A Summary of DoD's Real Property Inventory (Department of Defense, 2009a)										X (1)						
DoD	Estates	Defense Installations Strategic Plan (Department of Defense, 2007)								X (5.3)								
DoD	Energy / Env	Microgrid Study: Energy Security for DoD Installations (Van Broekhoven et al, 2012)													X (7.4)			
DoD	Energy / Env	Solar Energy on DoD Installations in the Mojave and Colorado Deserts (Kwartin et al, 2012)													X (7.4)			
US Army	Energy / Env	Army Net Zero Energy Roadmap and Program Summary (National Renewable Energy Laboratory, 2013)														X (5.2)		
US Army	Energy / Env	US Army Energy Security and Sustainability Strategy (US Army, 2015)																X (10.1)
US Army	Energy / Env	US Army Sustainability Report (US Army, 2014)											X		X	X	X (11.2)	
US Army	Energy / Env	How The Army Can Be An Environmental Paragon on Energy (Army Environmental Policy Institute, 2005)						X (10.1. 1)										

US Army	Energy / Env	The Army Strategy for the Environment (Army Environmental Policy Institute, 2004)					X (10.1.1)											
US Army	Energy / Env	Future International Environmental Security Issues & Potential Military Requirements over the period 2010-2025 (Army Environmental Policy Institute, 2001)		X (10.1.1)														
US Army	Energy / Env	Maintaining a Trained and Ready Army from an Environmental Perspective (Army Environmental Policy Institute, 2002)			X (10.1.1)													
US Army	Energy / Env	Understanding International Environmental Security: A Strategic Military Perspective (Army Environmental Policy Institute, 2000)	X (10.1.1)															
US Navy	Energy / Env	A Navy Energy Vision for the 21st Century (Department of the Navy, 2010a)											X (15.1)					
US Navy	Energy / Env	Department of the Navy's Energy Program for Security and Independence (Department of the Navy, 2010b)											X (15.1)					
US Navy	Energy / Env	Strategy for Renewable Energy (Department of the Navy, 2012)													X (15.1)			
US Navy	Energy / Env	US Navy Climate Change Roadmap (Department of the Navy, 2010c)											X (18)					
US Air Force	Energy / Env	US Air Force Energy Strategic Plan (US Air Force, 2013)														X (20.1)		
US Air Force	Energy / Env	US Air Force Energy Plan (US Air Force, 2010a)											X (20)					
US Air Force	Energy / Env	US Air Force Infrastructure Energy Plan (US Air Force, 2010b)											X (20)					

Table 14: Longlisted US DoD documents included in this research as contextual grey literature. Their year of publication is mapped alongside a number that identifies the search method used to identify the document (these numbers cross reference to Table 12)

Generic Contents	1 Financial Highlights / Operational Summary	2 Chairman's Message	3 Message(s) from Executive Council	4 Board of Directors / Executive Committee	5 Detailed Financial Statements	6 Summary of Business Structure / Model	7 Summary of Selected Programmes	8 Risk Management Processes / Key Risks	9 Summary of Corporate Governance Processes	10 Specific Objectives / KPIs	11 Notes re Future Market Conditions	12 Executive Compensation	13 Corporate Responsibility Summary	14 Third Party Verification
Lockheed Martin 2013 Annual Report (Lockheed Martin, 2014a)	Y	Y		Y	Y	Y	Y	Y			Y	Y		Y
Lockheed Martin 2014 Annual Report (Lockheed Martin, 2015a)	Y	Y		Y	Y	Y	Y	Y			Y	Y		Y
Lockheed Martin 2015 Annual Report (Lockheed Martin, 2016a)	Y	Y		Y	Y	Y	Y	Y			Y	Y		Y
Boeing 2013 Annual Report (Boeing Company, 2014a)	Y	Y		Y	Y	Y	Y	Y			Y	Y		Y
Boeing 2014 Annual Report (Boeing Company, 2015a)	Y	Y		Y	Y	Y	Y	Y			Y	Y		Y
Boeing 2015 Annual Report (Boeing Company, 2016a)	Y	Y		Y	Y	Y	Y	Y			Y	Y		Y
Raytheon 2013 Annual Report (Raytheon, 2014a)	Y	Y		Y	Y	Y	Y	Y			Y	Y		Y
Raytheon 2014 Annual Report (Raytheon, 2015a)	Y	Y		Y	Y	Y	Y	Y			Y	Y		Y
Raytheon 2015 Annual Report (Raytheon, 2016a)	Y	Y		Y	Y	Y	Y	Y			Y	Y		Y
General Dynamics 2013 Annual Report (General Dynamics, 2014)	Y	Y		Y	Y	Y	Y	Y			Y	Y		Y
General Dynamics 2014 Annual Report (General Dynamics, 2015a)	Y	Y		Y	Y	Y	Y	Y			Y	Y		Y
General Dynamics 2015 Annual Report (General Dynamics, 2016)	Y	Y		Y	Y	Y	Y	Y			Y	Y		Y
Northrop Grumman 2013 Annual Report (Northrop Grumman, 2014a)	Y	Y		Y	Y	Y	Y	Y			Y	Y		Y
Northrop Grumman 2014 Annual Report (Northrop Grumman, 2015a)	Y	Y		Y	Y	Y	Y	Y			Y	Y		Y
Northrop Grumman 2015 Annual Report (Northrop Grumman, 2016a)	Y	Y		Y	Y	Y	Y	Y			Y	Y		Y
United Technologies 2013 Annual Report and Form 10k (United Technologies, 2014a; 2014b)	Y	Y		Y	Y	Y	Y	Y			Y	Y	Y	Y

United Technologies 2014 Annual Report and Form 10k (United Technologies, 2015a; 2015b)	Y	Y		Y	Y	Y	Y	Y			Y	Y	Y	Y
United Technologies 2015 Annual Report and Form 10k (United Technologies, 2016a; 2016b)	Y	Y		Y	Y	Y	Y	Y			Y	Y	Y	Y
BAE Systems 2013 Annual Report (BAE Systems, 2014)	Y	Y	Y	Y	Y	Y		Y	Y	Y		Y	Y	Y
BAE Systems 2014 Annual Report (BAE Systems, 2015a)	Y	Y	Y	Y	Y	Y		Y	Y	Y		Y	Y	Y
BAE Systems 2015 Annual Report (BAE Systems, 2016a)	Y	Y	Y	Y	Y	Y		Y	Y	Y		Y	Y	Y
Airbus 2013 Annual Report (Airbus Group, 2014a)	Y	Y	Y	Y	Y	Y	Y		Y			Y	Y	Y
Airbus 2014 Annual Report (Airbus Group, 2015a)	Y	Y	Y	Y	Y	Y	Y		Y			Y	Y	Y
Airbus 2015 Annual Report (Airbus Group, 2016)	Y	Y	Y	Y	Y	Y	Y		Y			Y	Y	Y
Finmeccanica 2013 Annual Report (Finmeccanica, 2014a)	Y	Y		Y	Y	Y			Y					Y
Finmeccanica 2014 Annual Report (Finmeccanica, 2015a)	Y	Y		Y	Y	Y			Y					Y
Finmeccanica 2015 Annual Report (Finmeccanica, 2016a)	Y	Y		Y	Y	Y			Y					Y
Thales 2013 Registration Document (Thales, 2014a)	Y	Y	Y	Y	Y	Y			Y			Y	Y	Y
Thales 2014 Registration Document (Thales, 2015a)	Y	Y	Y	Y	Y	Y			Y			Y	Y	Y
Thales 2015 Registration Document (Thales, 2016a)	Y	Y	Y	Y	Y	Y			Y			Y	Y	Y

Table 15: Defence company annual reports compared against a generic contents list, demonstrating their comparability

Generic Contents	1 Organisation Summary	2 Approach to CR / Sustainability	3 Future Trends	4 People / Employees	5 Ethics / Business Conduct	6 Safety and Health	7 Resource Efficiency	8 Products / Innovation	9 Collaboration and Suppliers	10 Communities	11 Information Security
Lockheed Martin Sustainability Report 2013 (Lockheed Martin, 2014b)	Y	Y		Y	Y	Y	Y	Y	Y	Y	Y
Lockheed Martin Sustainability Report 2014 (Lockheed Martin, 2015b)	Y	Y		Y	Y	Y	Y	Y	Y	Y	Y
Lockheed Martin Sustainability Report 2015 (Lockheed Martin, 2016b)	Y	Y		Y	Y	Y	Y	Y	Y	Y	Y
Boeing Environment Report 2013 & Corporate Citizenship Report 2012 (Boeing Company, 2013a; 2013b)	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	
Boeing Environment Report 2014 & Corporate Citizenship Report 2013 (Boeing Company, 2014b; 2014c)	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	
Boeing Environment Report 2015 & Corporate Citizenship Report 2014 (Boeing Company, 2015b; 2015c)	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	
Boeing Environment Report 2016 & Corporate Citizenship Report 2015 (Boeing Company, 2016b; 2016c)	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	
Raytheon CR Report 2013 (Raytheon, 2014b)	Y	Y		Y	Y	Y	Y	Y	Y	Y	
Raytheon CR Report 2014 (Raytheon, 2015b)	Y	Y		Y	Y	Y	Y	Y	Y	Y	
Raytheon CR Report 2015 (Raytheon, 2016b)	Y	Y		Y	Y	Y	Y	Y	Y	Y	
General Dynamics CSR Report 2011 (General Dynamics, 2012)	Y	Y		Y	Y	Y	Y	Y	Y	Y	
General Dynamics CSR Report 2015 (General Dynamics, 2016b)	Y	Y		Y	Y	Y	Y	Y	Y	Y	
Northrop CR Report 2013 (Northrop Grumman, 2014b)	Y	Y		Y	Y	Y	Y	Y	Y	Y	
Northrop CR Report 2014 (Northrop Grumman, 2015b)	Y	Y		Y	Y	Y	Y	Y	Y	Y	
Northrop CR Report 2015 (Northrop Grumman, 2016b)	Y	Y		Y	Y	Y	Y	Y	Y	Y	
BAE Systems CR Performance Summary 2014 (BAE Systems, 2015b)	Y	Y		Y	Y	Y	Y	Y	Y	Y	
BAE Systems CR Summary 2015 (BAE Systems, 2016b)	Y	Y		Y	Y	Y	Y	Y	Y	Y	
Airbus CR & S Report 2013 (Airbus Group, 2014b)	Y	Y		Y				Y	Y	Y	
Airbus CR & S Report 2014 (Airbus Group, 2015b)	Y	Y		Y				Y	Y	Y	
Finmeccanica Sustainability Report 2013 (Finmeccanica, 2014b)	Y	Y		Y	Y		Y	Y		Y	
Finmeccanica Sustainability Report 2014 (Finmeccanica, 2015b)	Y	Y		Y	Y		Y	Y		Y	
Finmeccanica Sustainability & Innovation Report 2015 (Finmeccanica, 2016b)	Y	Y		Y	Y		Y	Y		Y	
Thales CR Report 2013 (Thales, 2014b)	Y	Y		Y	Y		Y		Y	Y	
Thales CR Report 2014 (Thales, 2015b)	Y	Y		Y	Y		Y		Y	Y	
Thales 2015 Integrated Report - Corporate Responsibility (Thales, 2016b)	Y	Y		Y	Y		Y		Y	Y	

Table 16: Defence company Corporate Responsibility / Sustainability Reports compared against a generic contents list, demonstrating their comparability

Scheme	Carbon Accounting 'Scale'	Regional Application	Mandatory / Voluntary	Private / Public Disclosure of Data	Summary Notes
EU ETS	Site/Facility	Europe	Mandatory	Private	EU-wide, applies to facilities with significant combustion; allowances need to be acquired for tCO_2e emitted
Climate Change Agreements	Site/Facility	UK	Voluntary	Private	Reporting method (performance vs target) linked to discounts on Climate Change Levy
EPA GHG Reporting Programme	Site/Facility (Public Sector)	US	Mandatory	Public (unless confidentiality agreement)	Applies at facility level for public sector sites emitting >25,000 tCO_2e (rules for suppliers and emitters). Data must be submitted via EPA online reporting platform
California ETS	Site/Facility	US	Mandatory	Private	As EU ETS, but for certain facilities in California
Carbon Reduction Commitment (CRC)	Regional Legal Entity	UK	Mandatory	Private	Originally a reporting approach with league table, now a tax. Covers ~10% of UK emissions, and applies to organisations using >6,000MWh pa.
Energy Savings Opportunity Schemes (ESOS)	Regional Legal Entity	UK	Mandatory	Private (status-only reported)	Consumption reporting required for relevant legal entities, and efficiency surveys conducted for >95% of the measured consumption. Applies in the UK, implementing Article 8 of the EU Energy Efficiency Directive (2012/27/EU)
Grenelle II - Article 75	Regional Legal Entity	France	Mandatory	Private	French scheme, similar to CRC above
UK Greening Government Commitments	Public Sector Organisation	UK	Mandatory	Public	Mandatory targets and reporting requirements imposed on UK Government Departments (previously Sustainable Operations on the Government Estate (SOGE) Targets)
US Executive Order 13514 on Federal Sustainability	Public Sector Organisation	US	Mandatory	Public	Each Federal Agency was required in 2010 to submit a 2020 GHG pollution reduction target from its estimated 2008 baseline. An overall federal target is the aggregate of 35 Federal Agency self-reported targets
Companies Act - Mandatory Carbon Reporting Regs	Corporate Group	UK	Mandatory	Public	Applies to UK-listed companies, requiring mandatory GHG reporting in the 'Directors Report' section of the annual report
Grenelle II - Article 225	Corporate Group	France	Mandatory	Public	French scheme, similar to Companies Act - Mandatory Carbon Reporting Regs above
Climate Registry	Corporate Group	US	Voluntary	Public	NGO platform that many US businesses use to record and track their GHG emissions
Dow Jones Sustainability Index	Corporate Group	US	Voluntary	Private	Index measuring the sustainability performance of the largest 2,500 companies listed on the Dow Jones Global Total Stock Market Index (questionnaire to relevant companies)
CDP Climate Change Questionnaire	Corporate Group	US	Voluntary	Public	NGO questionnaire aiming to drive increased disclosure of organisational GHG emissions

Table 17: Summary of mandatory and voluntary schemes affecting the defence sector for which Carbon Accounting is required

Questionnaire Section	Summary of Topics Covered
1) Governance	1.1) Board Interaction
	1.2) Performance Incentives
2) Strategy	2.1) Processes to manage risks and opportunities
	2.2) Integration of Climate Change to Business Strategy
	2.3) Influencing Climate Change Policy
3) Targets & Initiatives	3.1) Do you have an emissions reduction target
	3.2) Does the use of your goods/services enable emissions to be avoided by 3rd parties
	3.3) Emission reduction initiatives active in the year
4) Communication (of climate change info)	4.1) Published information on Climate Change / GHG emissions
5) Climate Change Risks	5.1) Risks Driven by Changes in Regulation
	5.2) Risks driven by changes in physical climate parameters
	5.3) Risks driven by changes in other climate-related developments
6) Climate Change Opportunities	6.1) Opportunities Driven by Changes in Regulation
	6.2) Opportunities driven by changes in physical climate parameters
	6.3) Opportunities driven by changes in other climate-related developments
7) Emissions Methodology	7.1) Emissions Base Year
	7.2 / 7.3 / 7.4) Emissions Methodology
8) Emissions Data	8.1) Emissions Boundary used
	8.2) Scope 1 Emissions
	8.3) Scope 2 Emissions
	8.4) Sources of scope 1 and 2 not included above
	8.5) Estimated of Uncertainty Level
	8.6 / 8.7 / 8.8) Assurance & Verification
	8.9) Biologically Sequestered Carbon
9 / 10) Scope 1 / Scope 2 Emissions Breakdown	9.1 / 10.1) By Country / Region
	9.2 / 10.2) By Business Division; Facility; Activity
11) Energy	11.1) Percentage of Operational Spend on Energy
	11.2) Quantities of fuel, steam, heat, cooling
	11.3) Breakdown of 'fuels'
	11.4) Low carbon electricity
12) Emissions Performance	12.1) Comparison to Previous Year
	12.2) Revenue metric and change to previous year
	12.3) Employee metric (or other relevant metric) and change to previous year
13) Emissions Trading	13.1) Participation in Emissions Trading
	13.2) Originating Carbon Credits
14) Scope 3 Emissions	14.1) Accounting for scope 3 emissions
	14.2) Verification of Scope 3 emissions
	14.3) Trends in scope 3 emissions
	14.4) Supplier engagement on emissions
15) Sign Off	Sign Off

Table 18: Summarised Contents of the CDP Climate Change Questionnaire (Interpreted from: CDP, 2017)

Company (Organised by Earliest to Latest Participation)	**Participation in CDP**
Raytheon	CDP Response 2007-08; 2009-2014
Boeing	CDP Response 2008-2014
Finmeccanica	CDP Response 2008-2014
Thales	CDP Response 2008-2014
United Technologies	CDP Response 2009-2014
Lockheed Martin	CDP Response 2010-2014
Northrop Grumman	CDP Response 2010-2014
BAE Systems	CDP Response 2012-2014
Airbus	CDP Response 2012-2014
General Dynamics	Do not participate

Table 19: Participation in CDP’s Climate Change Questionnaire by the Companies Included in this research

Organisation	General Reports	Specialist Reports
UK MoD	National Security Strategy (Cabinet Office, 2010a); Strategic Defence & Security Review (Cabinet Office, 2010b; 2015); MoD Business Plan (Ministry of Defence, 2012a); MoD Annual Report and Accounts 2013-2015 (Ministry of Defence, 2014k; 2015e; 2016a)	Sustainable Development Strategy: A Sub Strategy of the Strategy for Defence 2011-2030 (Ministry of Defence, 2011b); Sustainable MoD Annual Reports 2013-2016 (Ministry of Defence, 2014m; 2015a; 2016b); MoD Greening Government Commitments Annual Report 2011-2013 (Ministry of Defence, 2012e; 2013a)
US DoD	Quadrennial Defense Review (Department of Defense, 2010; 2014a); National Military Strategy (Department of Defense, 2015a); Strategic Management Plan 2012-2015 (Department of Defense, 2011b; 2013a);	DoD Strategic Sustainability Performance Plan (Department of Defense, 2014b); DoD's Operational Energy Strategy (Department of Defense, 2011); Operational Energy Annual Report 2011-2015 (Department of Defense, 2012b; 2013d; 2014e; 2015b; 2016b); Annual Energy Management Report 2008-2015 (Department of Defense, 2009b; 2010c; 2011c; 2012a; 2013c; 2014d; 2015c); DoD Climate Change Adaptation Roadmap (Department of Defense, 2014c)
Lockheed Martin	Annual Report 2013-2015 (Lockheed Martin, 2014a; 2015a; 2016a)	Sustainability Reports 2013-2015 (Lockheed Martin, 2014b; 2015b; 2016b); CDP Response 2010-2014 (CDP Academic Dataset)
Boeing	Annual Report 2013-2015 (Boeing Company, 2014a; 2015a; 2016a)	Environment Reports 2013-2016 (Boeing Company, 2013a; 2014b; 2015b; 2016b); Corporate Citizenship Reports 2012-2015 (Boeing Company, 2013b; 2014c; 2015c; 2016c); CDP Response 2008-2014 (CDP Academic Dataset)
Raytheon	Annual Report 2013-2015 (Raytheon, 2014a; 2015a; 2016a)	Corporate Responsibility Reports 2013-2015 (Raytheon, 2014b; 2015b; 2016b); CDP Response 2007-08; 2009-2014 (CDP Academic Dataset)
General Dynamics	Annual Report 2013-2015 (General Dynamics, 2014; 2015a; 2016)	Corporate Sustainability Reports 2012 & 2015 (General Dynamics, 2012; 2015b); No CDP responses available
Northrop Grumman	Annual Report 2013-2015 (Northrop Grumman, 2014a; 2015a; 2016a)	Corporate Responsibility Reports 2013-2015 (Northrop Grumman, 2014b; 2015b; 2016b); CDP Response 2010-2014 (CDP Academic Dataset
United Technologies	Annual Report & Form 10K 2013-2015 (United Technologies 2014a; 2014b; 2015a; 2015b; 2016a; 2016b)	CDP Response 2009-2014 (CDP Academic Dataset)
BAE Systems	Annual Report 2013-2015 (BAE Systems, 2014; 2015a; 2016a)	Corporate Responsibility Summary 2014-2015 (BAE Systems, 2015b; 2016b); CDP Response 2012-2014 (CDP Academic Dataset)
Airbus Group	Annual Report 2013-2015 (Airbus Group, 2014a; 2015a; 2016)	Corporate Responsibility & Sustainability Report 2013-14 (Airbus Group, 2014b; 2015b); CDP Response 2012-2014 (CDP Academic Dataset)
Finmeccanica	Annual Report 2013-2015 (Finmeccanica, 2014a; 2015a; 2016a)	Sustainability Reports 2013-2015 (Finmeccanica, 2014b; 2015b; 2016b); CDP Response 2008-2014 (CDP Academic Dataset)
Thales	Registration Documents 2013-2015 (Thales, 2014a; 2015a; 2016a)	Corporate Responsibility Reports 2013-2015 (Thales, 2014b; 2015b; 2016b); CDP Response 2008-2014 (CDP Academic Dataset)

Table 20: Summary of Documents used to create the Quantitative and Qualitative Datasets

Source	**Description**	**Year (UK financial year April-March)**						
		2009-10	**2010-11**	**2011-12**	**2012-13**	**2013-14**	**2014-15**	**2015-16**
Aggregated Totals (processed for comparison with other organisations in the sample)	Scope 1 & 2 Emissions (Sum of Facility GHGs and Assumed Equipment GHGs) (tCO_2e)	***1,359,043***	***4,580,632***	***4,280,124***	***3,984,215***	***4,149,309***	***2,873,633***	N/A
	Scope 1 & 2 GHGs Associated with Facility Energy Use (Assumed all facility GHGs for GCC Targets) (tCO_2e)	1,359,043	1,364,055	1,210,328	1,168,036	1,141,033	1,090,872	N/A
	Scope 1 & 2 GHGs Associated with Equipment Energy Use (Assumed total scope 1-3 emissions less facility GHGs and all business travel) (tCO_2e)	-	***3,216,577***	***3,069,796***	***2,816,179***	***3,008,276***	***1,782,761***	N/A
	Scope 3 GHGs related to business travel (tCO_2e)	135,971	115,368	125,876	124,785	125,691	123,367	N/A
Original Published Totals (MoD, 2014m, p.26; MoD, 2015a, p.27; MoD, 2016b, p.53)	GHG Total Scopes 1,2,3 (tCO_2e)	***1,495,000***	***4,696,000***	***4,406,000***	***4,109,000***	***4,275,000***	***2,997,000***	N/A
	GHG Total Scope 1 (million tCO_2e)	578	3,796	3,557	3,238	3,558	2,236	N/A
	GHG Total Scope 2,3 (million tCO_2e)	917	900	849	871	717	761	N/A
Published Totals associated with GGC Targets (MoD, 2014m, p.7; MoD 2015a, p.12; MoD 2016b, p.23)	Total GHGs for targets (tCO_2e)	1,448,791	1,442,393	1,285,675	1,244,483	1,217,989	1,165,988	1,113,909
	GHGs associated with Estate Energy (tCO_2e)	1,359,043	1,364,055	1,210,328	1,168,036	1,141,033	1,090,872	1,050,751
	GHGs associated with Domestic Business Travel (tCO_2e)	89,748	78,338	75,347	76,447	76,956	75,116	63,158
Published GHGs for Business Travel (MoD, 2014m, p.17; MoD, 2015a p.19; MoD 2016b, p.35)	GHGs associated with all Business Travel (tCO_2e)	135,971	115,368	125,876	124,785	125,691	***123,367***	118,616

Table 21: UK MoD Greenhouse Gas Emissions 2009-10 to 2015-16.

No external methodology specified by UK MoD, but Scopes 1-3 used throughout. DEFRA conversion factors referenced, as are the 6 Kyoto Protocol gases. Does not include Non-Department Public Bodies and other MoD-funded bodies. Estimated that 75-90% of Defence estate included. Data is assured by Carbon Smart on behalf of DEFRA to validate reported information relevant to the GCCs but noted that the data are not presented as National Statistics (Ministry of Defence, 2014m). Note where values appear in bold italics they are subject to some form of aggregation or conversion from the original published data. No significant conversions, but some assumptions required to aggregate the data (Noted in the table where relevant. Not possible for 2015-16 due to missing data)

Description	Year (UK financial year April-March)						
	2009-10	2010-11	2011-12	2012-13	2013-14	2014-15	2015-16
Aggregated Total Facility Energy Use (MWh)	***4,333,898***	***4,330,224***	***3,773,828***	***3,638,953***	***3,772,989***	***3,405,114***	NA
Electricity: Non-Renewable (MWh)	1,460,770	1,464,106	1,282,421	-	-	-	1,212,917
Electricity: Renewable (MWh)	20,440	20,486	142,491	1,481,564	1,384,227	1,223,272	-
Gas (MWh)	2,482,020	2,475,352	1,952,488	1,740,426	1,971,184	1,804,037	1,931,147
LPG (MWh)	80,070	80,403	82,000	79,391	79,425	53,247	38,375
Other (MWh)	290,598	289,877	314,428	337,572	338,153	324,558	NA

Table 22: UK MoD – Facility Energy Use 2009-10 to 2015-16.

Data taken from the following sources: MoD, 2014m, p.26; MoD, 2015a, p.27; MoD, 2016b, p.53. Assumed 'consumed energy' as opposed to 'bought energy'. 'Other' energy data not broken down or explained; 'Renewable energy' relates to low carbon tariffs as opposed to actual generation. Data is assured by Carbon Smart on behalf of DEFRA to validate reported information relevant to the GCCs but noted that the data are not presented as National Statistics (Ministry of Defence, 2014m). Note where values appear in bold italics they are subject to some form of aggregation or conversion from the original published data. In this case this only applies to the aggregated total, which is a simple aggregation of the other fields.

Source	Description	Year (UK financial year April-March)						
		2009-10	**2010-11**	**2011-12**	**2012-13**	**2013-14**	**2014-15**	**2015-16**
Original Published Data in Litres (MoD, 2014m, p.9/p.26; MoD, 2015a, p.10/p.27; MoD, 2016b, p.20/p.53)	Total Energy Use (Litres)	1,250,000,000	1,231,000,000	1,187,000,000	1,071,000,000	1,068,000,000	928,000,000	NA
	Aviation Fuel (Litres)	827,800,000	792,400,000	767,400,000	693,097,000	627,420,000	584,022,000	NA
	Diesel (retail & mineral blend) (Litres)	340,500,000	354,300,000	339,300,000				NA
	Diesel (retail blend) (Litres)	-	-	-	118,394,000	105,318,000	85,125,000	NA
	Diesel (100% mineral blend) (Litres)	-	-	-	214,154,000	215,965,000	157,390,000	NA
	Gas Oil (Litres)	74,300,000	79,700,000	74,900,000	40,602,000	34,329,000	33,976,000	NA
	Petrol (Litres)	7,000,000	4,600,000	5,800,000	4,462,000	8,882,000	3,975,000	NA
Converted data in MWh for comparison with other organisations in the sample	Total Energy Use (MWh)	***13,005,097***	***12,825,312***	***12,368,000***	***11,152,898***	***10,333,701***	***8,992,620***	
	Aviation Fuel (MWh)	***8,485,919***	***8,123,027***	***7,866,748***	***7,105,055***	***6,431,789***	***5,986,909***	
	Diesel (retail & mineral blend) (MWh)	***3,654,689***	***3,802,808***	***3,641,809***	-	-	-	
	Diesel (retail blend) (MWh)	-	-	-	***1,270,758***	***1,130,410***	***913,672***	
	Diesel (100% mineral blend) (MWh)	-	-	-	***2,298,579***	***2,318,017***	***1,689,314***	
	Gas Oil (MWh)	***797,484***	***855,444***	***803,924***	***435,793***	***368,463***	***364,675***	
	Petrol (MWh)	***67,006***	***44,033***	***55,519***	***42,712***	***85,021***	***38,050***	

Table 23: UK MoD – Operational Energy Use 2009-10 to 2015-16.

Assumed 'consumed energy' as opposed to 'bought energy'. Data variously referred to as 'Equipment Energy', 'Equipment and Operations', and 'Operational Energy' throughout document set. Data is assured by Carbon Smart on behalf of DEFRA to validate reported information relevant to the GCCs but noted that the data are not presented as National Statistics (Ministry of Defence, 2014m). Note where values appear in bold italics they are subject to some form of aggregation or conversion from the original published data, as follows: Aviation Fuel: The conversion from litres to kWh is based first converting to kg using DEFRA's current assumed density of Aviation Fuel (DEFRA "AVIATION TURBINE FUEL": 1,253 litres per tonne), and then multiplying by 12.84471 (DEFRA's current assumed kWh per kg (Gross CV)). All types of Diesel and Gas Oil treated as Light Fuel Oil for Conversion: The conversion from litres to kWh is based first converting to kg using DEFRA's current assumed density of Light Fuel Oil (DEFRA "GAS OIL": 1,172 litres per tonne), and then multiplying by 12.57943 (DEFRA's current assumed kWh per kg (Gross CV)). Petrol: The conversion from litres to kWh is based first converting to kg using DEFRA's current assumed density of Petrol (1,368 litres per tonne), and then multiplying by 13.09491 (DEFRA's current assumed kWh per kg (Gross CV)). NOTE - Defra mid-2015 published factors used for all years; all data subsequently converted from kWh to MWh (divide by 1,000)

Description	Year (UK financial year April-March)						
	2009-10	**2010-11**	**2011-12**	**2012-13**	**2013-14**	**2014-15**	**2015-16**
Total Energy Spend (GBP)	***677,649,000***	***908,413,000***	***930,030,000***	***1,002,075,000***	***992,169,000***	***891,755,000***	***600,481,000***
Facility Energy Cost (GBP)	195,715,000	280,563,000	294,676,000	243,266,000	261,124,000	317,074,000	267,979,000
Equipment Energy Cost (Fuel) (GBP)	481,934,000	627,850,000	635,354,000	758,809,000	731,045,000	574,681,000	332,502,000
Total MoD Spend (GBP)	37,994,285,000	38,116,370,000	37,176,648,000	35,210,412,000	37,383,571,000	34,567,604,000	35,252,526,000

Table 24: UK MoD – Energy Spend Data 2009-10 to 2015-16. (MoD, 2014m, p.26). Data is assured by Carbon Smart on behalf of DEFRA to validate reported information relevant to the GCCs but noted that the data are not presented as National Statistics (Ministry of Defence, 2014m). Note where values appear in bold italics they are subject to some form of aggregation or conversion from the original published data. In this case this only applies to the aggregated total, which is a simple aggregation of the other rows.

Source	Description	Year (US FY October-September)								
		2007-08	2008-09	2009-10	2010-11	2011-12	2012-13	2013-14	2014-15	2015-16
Aggregated Totals (processed for comparison with other organisations in the sample)	Scope 1 & 2 Emissions (Sum of Facility GHGs and Assumed Equipment GHGs) (tCO_2e)	***77,225,335***	-	***76,935,742***	***74,648,147***	***69,558,567***	-	-	-	-
	Scope 1 & 2 GHGs Associated with Facility Energy Use (Assumed as 'goal-subject scope 1 and 2 emissions') (tCO_2e)	***26,855,109***	-	***27,427,436***	***25,894,940***	***24,613,290***	-	-	-	-
	Scope 1 & 2 GHGs Associated with Equipment Energy Use (Assumed as 'non-goal-subject scope 1 and 2 emissions') (tCO_2e)	***50,370,226***	-	***49,508,306***	***48,753,207***	***44,945,277***	-	-	-	-
	Scope 3 GHGs (total published scope 3 emissions - broader than business travel) (tCO_2e)	***7,707,646***	-	***7,436,554***	***8,159,246***	***7,653,704***	-	-	-	-
Published Totals converted to simple scope 1, 2, 3	GHG Total Scopes 1,2,3 (tCO_2e)	***84,932,980***	-	***84,372,296***	***82,807,393***	***77,212,271***	-	-	-	-
	GHG Total Scope 1 (tCO_2e)	***59,105,170***	-	***57,969,886***	***56,643,014***	***52,715,085***	-	-	-	-
	GHG Total Scope 2 (tCO_2e)	***18,120,165***	-	***18,965,856***	***18,005,133***	***16,843,482***	-	-	-	-
	GHG Total Scope 3 (tCO_2e)	***7,707,646***	-	***7,436,554***	***8,159,246***	***7,653,704***	-	-	-	-
Published Totals associated with Federal Targets (source website below)	Total GHGs for targets - Scopes 1-3 (tCO_2e)	***34,489,256***	-	***34,782,258***	***33,976,975***	***32,217,802***	-	-	-	-
	Total GHGs not subject to targets - Scopes 1-3 (tCO_2e)	***50,443,725***	-	***49,590,038***	***48,830,418***	***44,994,469***	-	-	-	-
	Total GHGs for targets - Scope 1 (tCO_2e)	9,647,351	NA	9,744,947	9,103,558	8,603,918	NA	NA	NA	NA
	Total GHGs not subject to targets - Scope 1 (tCO_2e)	49,457,819	NA	48,224,939	47,539,455	44,111,167	NA	NA	NA	NA
	Total GHGs for targets - Scope 2 (tCO_2e)	17,207,758	NA	17,682,489	16,791,381	16,009,372	NA	NA	NA	NA
	Total GHGs not subject to targets - Scope 2 (tCO_2e)	912,407	NA	1,283,367	1,213,751	834,110	NA	NA	NA	NA
	Total GHGs for targets - Scope 3 (tCO_2e)	7,634,147	NA	7,354,822	8,082,035	7,604,512	NA	NA	NA	NA
	Total GHGs not subject to targets - Scope 3 (tCO_2e)	73,499	NA	81,732	77,211	49,192	NA	NA	NA	NA

Table 25: US DoD Greenhouse Gas Emissions 2006-07 to 2015-16

Federal GHG Inventory data available at https://catalog.data.gov/dataset/federal-greenhouse-gas-inventories-and-performance'. Executive Order 13514 required federal departments to submit this data, in Scopes 1-3, and with reference to the 6 Kyoto Protocol gases (Department of Energy, 2009). Unclear whether the data is assured. Note where values appear in bold italics they are subject to some form of aggregation or conversion from the original published data (only simple aggregations in this case)

Source	Description	Year (US FY October-September)									
		2006-07	**2007-08**	**2008-09**	**2009-10**	**2010-11**	**2011-12**	**2012-13**	**2013-14**	**2014-15**	**2015-16**
DoD Annual Energy Management Reports (Department of Defense, 2009b; 2010c; 2011c; 2012a; 2013c; 2014d; 2015c)	Energy Use (MWh)	***60,161,081***	***60,712,186***	***61,530,484***	***61,795,038***	***62,358,462***	***59,833,761***	***60,785,217***	***60,076,025***	***59,256,553***	
	Energy Use (Billion btu) - Total	205,120	206,999	209,789	210,691	***212,612***	***204,004***	***207,248***	***204,830***	***202,036***	
	Energy Use (Billion btu) - Subject to Energy Reduction Targets					197,212	187,404	189,448	187,530	184,836	NA
	Energy Use (Billion btu) - Not Subject to Energy Reduction Targets					15,400	16,600	17,800	17,300	17,200	NA

Table 26: US DoD Facility Energy Use 2006-07 to 2015-16.

Data covers facility energy activities of the Army, Navy, Air Force, and Marine Corps, and the following Defense Agencies: Defense Contract Management Agency; Defense Commissary Agency; Defense Finance and Accounting Service; Defense Intelligence Agency; Defense Logistics Agency; Missile Defense Agency; National Geospatial-Intelligence Agency; National Reconnaissance Office; National Security Agency; and Washington Headquarters Services (Department of Defense, 2013c, p.6). Note where values appear in bold italics they are subject to some form of aggregation or conversion from the original published data. In this case some data has been converted from British Thermal Units (btu) to MWh (assuming that 1btu = 0.000293297 kWh), in addition to simply aggregating totals.

Source	Description	Year (US FY October-September)									
		2006-07	**2007-08**	**2008-09**	**2009-10**	**2010-11**	**2011-12**	**2012-13**	**2013-14**	**2014-15**	**2015-16 (forecast)**
DoD Operational Energy Annual Reports (Department of Defense, 2012b; 2013d; 2014e; 2015b; 2016b)	DoD Total (BOE)	117,300,000	114,300,000	110,600,000	112,600,000	113,400,000	103,900,000	89,800,000	87,400,000	88,500,000	87,800,000
	Army (BOE)	17,900,000	19,900,000	18,700,000	19,000,000	20,200,000	16,100,000	12,700,000	10,100,000	7,300,000	11,700,000
	Navy (BOE)	35,800,000	32,900,000	29,200,000	29,700,000	31,100,000	31,500,000	28,400,000	28,200,000	28,500,000	33,800,000
	Air Force (BOE)	62,300,000	60,800,000	61,600,000	63,000,000	61,300,000	55,700,000	47,800,000	48,600,000	52,000,000	38,800,000
	Marine Corps (BOE)	600,000	500,000	600,000	400,000	300,000	200,000	200,000	200,000	200,000	800,000
	Other DoD (BOE)	700,000	200,000	500,000	500,000	500,000	400,000	700,000	300,000	500,000	2,700,000
Converted Totals (MWh) for comparison with other organisations in the sample	DoD Total (MWh)	***199,410,000***	***194,310,000***	***188,020,000***	***191,420,000***	***192,780,000***	***176,630,000***	***152,660,000***	***148,580,000***	***150,450,000***	***149,260,000***
	Army (MWh)	***30,430,000***	***33,830,000***	***31,790,000***	***32,300,000***	***34,340,000***	***27,370,000***	***21,590,000***	***17,170,000***	***12,410,000***	***19,890,000***
	Navy (MWh)	***60,860,000***	***55,930,000***	***49,640,000***	***50,490,000***	***52,870,000***	***53,550,000***	***48,280,000***	***47,940,000***	***48,450,000***	***57,460,000***
	Air Force (MWh)	***105,910,000***	***103,360,000***	***104,720,000***	***107,100,000***	***104,210,000***	***94,690,000***	***81,260,000***	***82,620,000***	***88,400,000***	***65,960,000***
	Marine Corps (MWh)	***1,020,000***	***850,000***	***1,020,000***	***680,000***	***510,000***	***340,000***	***340,000***	***340,000***	***340,000***	***1,360,000***
	Other DoD (MWh)	***1,190,000***	***340,000***	***850,000***	***850,000***	***850,000***	***680,000***	***1,190,000***	***510,000***	***850,000***	***4,590,000***

Table 27: US DoD Operational Energy Use 2006-07 to 2015-16

Data is based on ‘purchased fuel’ as opposed to ‘consumed fuel’. Note where values appear in bold italics they are subject to some form of aggregation or conversion from the original published data. In this case some data has been converted from Barrels of Oil Equivalent (BOE) to MWh (assuming approximately 1,700 kWh per BoE).

Source	Description	Year (US FY October-September)									
		2006-07	**2007-08**	**2008-09**	**2009-10**	**2010-11**	**2011-12**	**2012-13**	**2013-14**	**2014-15**	**2015-16 (forecast)**
Energy Spend Data ($ bn) from DoD Operational Energy Annual Reports (Department of Defense, 2012b; 2013d; 2014e; 2015b; 2016b)	Total Energy Spend ($ bn)					***20.9***	***20.3***	***18.9***	***18.2***	***16.8***	
	Facility Energy Cost ($ bn)					4.1	4.0	4.1	4.2	3.9	
	Operational Energy Spend ($ bn)	11.0	15.3	10.2	13.3	16.8	16.3	14.8	14.0	12.9	10.0

Table 28: US DoD Energy Spend 2006-07 to 2015-16. Note where values appear in bold italics they are subject to some form of aggregation or conversion from the original published data. In this case this only applies to the aggregated total, which is a simple aggregation of the other rows.

	2007	2008	2009	2010	2011	2012	2013	2014
Thales		***377,340***	***291,002***	***267,075***	***253,101***	***275,457***	***264,405***	***248,295***
United Technologies Corporation			***2,081,907***	***1,886,208***	***1,914,377***	***1,772,220***	***1,682,590***	***2,115,982***
Lockheed Martin Corporation				***1,511,909***	***1,374,988***	***1,320,633***	***1,234,497***	***1,107,832***
Northrop Grumman Corp				***1,466,838***	***1,261,650***	***708,973***	***858,595***	***609,047***
Raytheon Company	***708,473***	***661,930***		***613,363***	***602,876***	***566,205***	***537,587***	***527,107***
Airbus Group (EADS NV pre-2014)						***1,048,900***	***1,013,207***	***1,009,188***
Finmeccanica		***481,531***	***363,669***	***514,953***	***591,562***	***575,534***	***572,140***	***577,315***
BAE Systems						***1,017,000***	***868,680***	***1,215,120***
Boeing Company		***1,692,000***	***1,679,000***	***1,720,000***	***1,717,000***	***1,793,000***	***1,574,000***	***1,636,000***
General Dynamics*		***966,900***	***956,232***	***918,788***	***914,956***			

Table 29: Scope 1 & 2 GHG Data in tCO_2e for All Companies Included in the Research 2007-2014 (Source: CDP Academic Dataset).

Data displayed in bold italics as it has been aggregated from Scope 1 and 2 data in tables 30 and 31 below, or otherwise manipulated as explained with the General Dynamics note below.

* General Dynamics data from their 2012 Sustainability Report (Assumed Scope 1 & 2 combined (not made clear in source document)), and had to multiply by $m of revenue as normalised values were published as opposed to actual data)

	2007	2008	2009	2010	2011	2012	2013	2014
Thales		377,340	121,703	105,900	95,130	94,330	97,707	87,824
United Technologies Corporation			968,080	905,586	946,075	856,354	801,694	955,785
Lockheed Martin Corporation				341,082	313,866	309,529	249,491	241,148
Northrop Grumman Corp				354,885	323,050	170,019	216,213	148,470
Raytheon Company	140,568	125,455		109,449	98,909	95,700	101,715	102,999
Airbus Group (EADS NV pre-2014)						593,530	581,115	585,374
Finmeccanica		145,793	148,060	199,107	247,293	204,467	232,302	232,911
BAE Systems						353,000	277,920	535,370
Boeing Company		550,000	575,000	579,000	595,000	718,000	576,000	610,000
General Dynamics	NA	NA	NA	NA	NA	NA	NA	NA

Table 30: Scope 1 GHG Data in tCO_2e for All Companies Included in the Research 2007-2014 (Source: CDP Academic Dataset: Section 8 (2011-14); Section 12.1 (2010); Various Sections (2007-2009)

	2007	2008	2009	2010	2011	2012	2013	2014
Thales			169,299	161,175	157,971	181,127	166,698	160,471
United Technologies Corporation			1,113,827	980,622	968,302	915,866	880,896	1,160,197
Lockheed Martin Corporation				1,170,827	1,061,122	1,011,104	985,006	866,684
Northrop Grumman Corp				1,111,953	938,600	538,954	642,382	460,577
Raytheon Company	567,905	536,475		503,914	503,967	470,505	435,872	424,108
Airbus Group (EADS NV pre-2014)						455,371	432,092	423,814
Finmeccanica		335,738	215,609	315,846	344,269	371,067	339,838	344,404
BAE Systems						664,000	590,760	679,750
Boeing Company		1,142,000	1,104,000	1,141,000	1,122,000	1,075,000	998,000	1,026,000
General Dynamics	NA	NA	NA	NA	NA	NA	NA	NA

Table 31: Scope 2 GHG Data in tCO_2e for All Companies Included in the Research 2007-2014 (Source: CDP Academic Dataset: Section 8 (2011-14); Section 12.1 (2010); Various Sections (2007-2009))

	2007	2008	2009	2010	2011	2012	2013	2014
Thales				94,085	87,453	105,979	89,527	91,349
United Technologies Corporation				59,477	66,336	85,054	90,066	99,673
Lockheed Martin Corporation				***219,518***	***212,431***	***188,319***	191,295	172,300
Northrop Grumman Corp				185,884	186,981	156,211	153,498	124,749
Raytheon Company						102,239	134,360	128,582
Airbus Group (EADS NV from 2013 back)								
Finmeccanica				52,165		68,043	39,677	
BAE Systems						125,000	137,820	243,710
Boeing Company				***229,000***	255,000	322,000	384,000	296,000
General Dynamics								

Table 32: Scope 3 GHG Data in tCO_2e Related to Business Travel for all Companies Included in the Research 2007-2014 (Source: CDP Academic Dataset: Section 14.1 (2014, 2013); Section 15.1 (2012, 2011, and 2010))

Note data in bold italics subject to some form of processing for comparability (all simple aggregations from the original data in this case).

	2007	2008	2009	2010	2011	2012	2013	2014
Thales							17,868	15,727
United Technologies Corporation								
Lockheed Martin Corporation								
Northrop Grumman Corp								
Raytheon Company								
Airbus Group (EADS NV from 2013 back)								
Finmeccanica							21,605	21,120
BAE Systems								
Boeing Company								
General Dynamics								

Table 33: Scope 3 GHG Data in tCO_2e Related to Upstream Leased Assets (lease cars in both these cases) for all Companies Included in the Research 2007-2014 (Source: CDP Academic Dataset: Section 14.1 (2014, 2013); Section 15.1 (2012, 2011, 2010))

	2007	2008	2009	2010	2011	2012	2013	2014
Thales								46,899
United Technologies Corporation								
Lockheed Martin Corporation								313,300
Northrop Grumman Corp				439,099	394,673	231,849	196,179	188,569
Raytheon Company								
Airbus Group (EADS NV from 2013 back)								
Finmeccanica								
BAE Systems								
Boeing Company								
General Dynamics								

Table 34: Scope 3 GHG Data in tCO_2e Related to Employee Commuting for all Companies Included in the Research 2007-2014 (Source: CDP Academic Dataset: Section 14.1 (2014, 2013); Section 15.1 (2012, 2011, and 2010))

	2007	2008	2009	2010	2011	2012	2013	2014
Thales								
United Technologies Corporation								
Lockheed Martin Corporation							24,442	2,300
Northrop Grumman Corp							487,835	518,469
Raytheon Company								17,707
Airbus Group (EADS NV from 2013 back)								
Finmeccanica							227,840	91,551
BAE Systems								
Boeing Company								
General Dynamics								

Table 35: Scope 3 GHG Data in tCO_2e Related to Upstream Transportation and Distribution for all Companies Included in the Research 2007-2014 (Source: CDP Academic Dataset: Section 14.1 (2014, 2013); Section 15.1 (2012, 2011, and 2010))

	2007	2008	2009	2010	2011	2012	2013	2014
Thales								
United Technologies Corporation								
Lockheed Martin Corporation								2,300
Northrop Grumman Corp				630,850	638,497	733,959	135,106	154,933
Raytheon Company								
Airbus Group (EADS NV from 2013 back)								
Finmeccanica							227,840	91,551
BAE Systems								
Boeing Company								
General Dynamics								

Table 36: Scope 3 GHG Data in tCO_2e Related to Downstream Transportation and Distribution for all Companies Included in the Research 2007-2014 (Source: CDP Academic Dataset: Section 14.1 (2014, 2013); Section 15.1 (2012, 2011, and 2010))

	2007	2008	2009	2010	2011	2012	2013	2014
Thales								
United Technologies Corporation								
Lockheed Martin Corporation								***129,700***
Northrop Grumman Corp								
Raytheon Company							118,840	106,903
Airbus Group (EADS NV from 2013 back)								
Finmeccanica				19,211	21,020		16,964	17,995
BAE Systems								
Boeing Company								
General Dynamics								

Table 37: Scope 3 GHG Data in tCO_2e Related to Fuel and Energy Related Activities Not Included in Scopes 1 & 2 for all Companies Included in the Research 2007-2014 (Source: CDP Academic Dataset: Section 14.1 (2014, 2013); Section 15.1 (2012, 2011, 2010))

Note data in bold italics subject to some form of processing for comparability (all simple aggregations from the original data in this case).

	2007	2008	2009	2010	2011	2012	2013	2014
Thales								
United Technologies Corporation								
Lockheed Martin Corporation								1,900
Northrop Grumman Corp								
Raytheon Company							3,260	3,100
Airbus Group (EADS NV from 2013 back)								
Finmeccanica				47,037		28,067	29,045	34,937
BAE Systems								
Boeing Company								
General Dynamics								

Table 38: Scope 3 GHG Data in tCO_2e Related to Landfill Emissions of Waste Generated in Operations for all Companies Included in the Research 2007-2014 (Source: CDP Academic Dataset: Section 14.1 (2014, 2013); Section 15.1 (2012, 2011, and 2010))

	2007	2008	2009	2010	2011	2012	2013	2014
Thales								
United Technologies Corporation								
Lockheed Martin Corporation								27,800,000
Northrop Grumman Corp								
Raytheon Company								
Airbus Group (EADS NV from 2013 back)								
Finmeccanica				138,669	131,440	198,389	168,274	129,700
BAE Systems								
Boeing Company								
General Dynamics								

Table 39: Scope 3 GHG Data in tCO_2e Related to Purchased Goods and Services for all Companies Included in the Research 2007-2014 (Source: CDP Academic Dataset: Section 14.1 (2014, 2013); Section 15.1 (2012, 2011, and 2010))

Note that data published by Finmeccanica in this category follows a very limited interpretation of this Scope 3 category, listing several raw materials for which purchasing records are used to make an estimate (ammonia, nitric acid, urea, petrochemicals, iron and steel, aluminium, magnesium, paper and cardboard packaging). This would not include any components, articles, or manufactured products purchased and therefore the published total is misleading for being so small.

	2007	2008	2009	2010	2011	2012	2013	2014
Thales								
United Technologies Corporation								
Lockheed Martin Corporation								87,000,000
Northrop Grumman Corp								
Raytheon Company								
Airbus Group (EADS NV from 2013 back)								
Finmeccanica								
BAE Systems								
Boeing Company								
General Dynamics								

Table 40: Scope 3 GHG Data in tCO_2e Related to Use of Sold Products for all Companies Included in the Research 2007-2014 (Source: CDP Academic Dataset: Section 14.1 (2014, 2013); Section 15.1 (2012, 2011, and 2010))

	Natural Gas	Distillate Fuel Oils (No 2; No 4; No 6)	Propane	Motor Gasoline	Diesel / Gas Oil	Gas Works Gas	Jet Kerosene	Jet Gasoline	Liquefied Petroleum Gas (LPG)	Butane	Residual Fuel Oil	Bituminous Coal	Wood Pellet	Lignite	Methane	Other
Thales	215,065	47,507												439		
United Technologies Corporation	2,696,209	38,250	26,875	1,132,290	28,979		823,384			2,779	6,660	91,966				149
Lockheed Martin Corporation	997,334	5,247	19,712	20,556	12,266	163,061										
Northrop Grumman Corp	548,039			9,831	17,395			60,973	345							
Raytheon Company	293,855	2,479		40,769				41,358								
Airbus Group (EADS NV from 2013 back)	1,488,584		14,158	2,506	38,673		989,142	4,205					19,298			
Finmeccanica		7,788		1,594	13,014			50,281	7,541						794,992	
BAE Systems	957,278			27,150	27,681			88,815	3,084		2,275	1,030,539				1,015
Boeing Company	1,861,000	68,000	17,000	33,000			627,000		2,000							
General Dynamics	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Table 41: Breakdown of Combustion Fuels used by the Companies Included in the Research for 2014 (MWh) (Source: CDP Academic Dataset: Sections 11.2 and 11.3 (2014))

	Electricity	Heat	Steam	Cooling
Thales	613,952	26,518		
United Technologies Corporation	2,361,579		53,618	
Lockheed Martin Corporation	1,709,064	-	-	22,990
Northrop Grumman Corp	1,149,101			
Raytheon Company	912,981		8,057	61,726
Airbus Group (EADS NV from 2013 back)	1,463,417	116,448		
Finmeccanica	872,336	55,456		
BAE Systems	1,239,368		227,248	
Boeing Company	2,325,000			
General Dynamics	NA	NA	NA	NA

Table 42: Breakdown of Delivered Energy used by the Companies Included in the Research for 2014 (MWh) (Source: CDP Academic Dataset: Sections 11.2 and 11.3 (2014))

	Facility Energy Use	Operational Energy Use
Thales	855,975	47,507
United Technologies Corporation	5,233,175	2,029,563
Lockheed Martin Corporation	2,749,100	201,130
Northrop Grumman Corp	1,697,485	88,199
Raytheon Company	1,276,619	84,606
Airbus Group (EADS NV from 2013 back)	3,101,905	1,034,526
Finmeccanica	1,730,325	72,677
BAE Systems	3,458,532	145,921
Boeing Company	4,205,000	728,000
General Dynamics	NA	NA

Table 43: Illustrative Split of 'Facility Energy Use' and 'Operational Energy Use' for the Companies Included in the Research for 2013 (MWh). Note that 'Facility Energy Use' is assumed as the following fields from Tables 41 and 42 above: Electricity; Steam; Cooling; All Gases; All Solid Fuels. 'Operational Energy Use' is assumed to be: All Liquid Fuels. Manipulating the data is for illustrative purposes to compare to the defence department energy usage data but will be subject to some error (some liquid fuels will be used for facility purposes and vice versa). (Source: CDP Academic Dataset: Sections 11.2 and 11.3 (2014))

	2010	2011	2012	2013	2014
Thales	***15,483***	***15,753***	***14,223***	***14,488***	***14,332***
United Technologies Corporation	52,924	54,324	58,182	57,702	62,622
Lockheed Martin Corporation	45,186	45,802	46,501	47,136	46,160
Northrop Grumman Corp	40,746	35,046	26,356	34,482	25,115
Raytheon Company	24,883	25,183	24,855	25,970	25,100
Airbus Group (EADS NV from 2013 back)	***58,817***	***58,817***	***58,817***	***67,924***	***71,161***
Finmeccanica	***18,596***	***21,362***	***20,784***	***20,661***	***21,083***
BAE Systems	***28,055***	***28,055***	***28,055***	***24,819***	***29,087***
Boeing Company	68,254	64,307	69,496	81,554	86,561
General Dynamics	31,964	32,122	30,992	30,930	30,852

Table 44: Revenues for the Companies Included in the Research 2010-2014 ($m). Data taken from Annual Reports and CDP Academic Dataset (some values subject to conversion where not originally published in dollars (highlighted bold italics); Exchange Rates Used of 1.6 USD to 1 GBP; 1.2 USD to 1 Euro)

	2009-10	2010-11	2011-12	2012-13	2013-14
UK MoD ($m)	***60,790***	***60,986***	***59,482***	***56,336***	***59,813***
UK MoD (£m)	37,994	38,116	37,176	35,210	37,383

Table 45: UK MoD Budget 2009-10 to 2013-14 (£m and converted to $m). (Source: Ministry of Defence, 2014m; 2015a; 2016b). Exchange Rate Used of 1.6 USD to 1 GBP

	2009-10	2010-11	2011-12	2012-13	2013-14
US DoD ($m)	691,000	687,000	645,500	577,600	581,200

Table 46: US DoD Budget 2009-10 to 2013-14 ($m). (Source: Department of Defense, 2014f: p.1-4)

Organisation	Headcount	Source(s)
US DoD	3,200,000	World Economic Forum Website (World Economic Forum, 2015)
UK MoD	220,500	UK Defence Statistics Compendium 2013 (Ministry of Defence, 2014b)
Thales	66,000	2013 Registration Document (Thales, 2014a)
United Technologies Corporation	212,000	2013 Annual Report (United Technologies, 2014a)
Lockheed Martin Corporation	115,000	2013 Annual Report (Lockheed Martin, 2014a)
Northrop Grumman Corp	65,300	2013 Annual Report (Northrop Grumman, 2014a)
Raytheon Company	63,000	2013 Annual Report (Raytheon, 2014a)
Airbus Group (EADS NV from 2013 back)	144,061	2013 Annual Report (Airbus Group, 2014a)
Finmeccanica	65,578	2013 Annual Report (Finmeccanica, 2014a)
BAE Systems	84,600	2013 Annual Report (BAE Systems, 2014)
Boeing Company	168,400	2013 Annual Report (Boeing Company, 2014a)
General Dynamics	96,000	2013 Annual Report (General Dynamics, 2014)

Table 47: 2013 headcount for all organisations included in the research sample

	Percentage Products	Percentage Services	Source
Lockheed Martin	80%	20%	2013 Annual Reports (some interpretation of data/narrative required)
Boeing	NA	NA	
BAE Systems	NA	NA	
Raytheon	NA	NA	
Northrop Grumman	57%	43%	
General Dynamics	NA	NA	
Airbus	85%	15%	
United Technologies	57%	43%	
Finmeccanica	72%	28%	
Thales	78%	22%	

Table 48: Revenue split between the ‘product sales’ and ‘services sales’ for the companies included in this research. (Source(s): Lockheed Martin, 2014a; Northrop Grumman, 2014a; Airbus Group, 2014a; United Technologies, 2014a; Finmeccanica 2014a; Thales, 2014a)

Organisation	Percentage Sales to Customer					
	US DoD	Other US Government	Foreign Military Sales	Direct Military Sales	Other	Source
Lockheed Martin	61%	21%	8.5%	8.5%	1%	2013 Annual Reports (some interpretation of data/narrative required)
Boeing	34%		Split not available			
Raytheon	68%	4%	13%	14%	1%	
Northrop Grumman	86%		10%		4%	
General Dynamics	49%	9%	3%	19%	19%	
United Technologies	16%		Split not available			

Table 49: Details of the major customers for the companies included in this research, and the percentage of revenues received from these customers where available (US). (Source(s): Lockheed Martin, 2014a; Boeing, 2014a; Raytheon, 2014a; Northrop Grumman, 2014a; General Dynamics, 2014a; United Technologies, 2014a)

Organisation	Percentage Sales to Customer				
	Home Defence Ministry	**Rest of Europe**	**US**	**Rest of World**	**Source**
BAE Systems	26%	NA - included in Rest of World	37%	37%	2013 Annual Reports (some interpretation of data/narrative required)
Airbus	Split not available				
Finmeccanica	18%	39%	23%	20%	
Thales	29%	30%	10%	30%	

Table 50: Details of the major customers for the companies included in this research, and the percentage of revenues received from these customers where available (Europe). (Source(s): BAE Systems, 2014; Airbus Group, 2014a; Finmeccanica, 2014a; Thales, 2014a)

Main Topic	Keyword	Relevant Variations / Interpretations to Cover	Search Criteria to Best Cover	Potential misinterpretation risks
Climate Change	Climate Change	Climate / climatic / UN Framework Convention on Climate Change	Climat	Manual to avoid generic reference to 'business climate'
		extreme weather; changing weather patterns	Weather	Low risk as document set unlikely to discuss weather in general terms
		Global Warming	Global Warming	None
	Emissions	Emission / emissions / emit	Emission	None
			Emit	emitting noise' and financial term 'reemit')
		Offset / offsetting / offsets	Offset	Potential for 'defence offsets' interpretation
	Greenhouse Gases	Greenhouse Gas / GHG	Greenhouse	None
			GHG	None
		Carbon / Carbon equivalent / Carbon Dioxide / Carbon dioxide equivalent / CO_2 / CO_2e / Carbon Neutral / Zero Carbon / hydrofluorocarbons / perfluorocarbons (below)	Carbon	Some risk (carbon fibre etc.)
			CO_2	Some risk of suffix issues
		Methane / (CH_4)	Methane	None
			CH_4	Some risk of suffix issues
		Nitrous Oxide (N_2O)	Nitrous Oxide	None
			N_20	Some risk of suffix issues
		Hydro fluorocarbons (HFCs) - full words incl carbon search	HFC	Some risk of suffix issues
		Perfluorocarbons (PFCs) - full words covered incl in carbon search	PFCs	Some risk of suffix issues
		Sulphur Hexafluoride; (SF_6)	Hexafluoride	None
			SF_6	Some risk of suffix issues
Energy		Energy / Energy Storage / Energy Security / energy generation / Wind Energy / Solar Energy / ocean/tidal energy / geothermal	Energy	Some risk in terms of 'energy' of people etc
		Fuel / Fossil Fuel / Clean Fuel / Fuel Efficiency / Fuel Burn / Refuel / Biofuel / Alt Fuel / Synthetic Fuel / fuel (blend) / Combustion fuels	Fuel	Many interpretations but nearly all relevant so low risk
		Oil	Oil	Risk of inclusion in other words
		Diesel	Diesel	Low risk
		Petrol	Petrol	Low risk
		Power/Power Generation/Wind Power/Solar Power/Hydropower/ ocean-wave-tidal power/geothermal power/uninterruptible power	Power	Some risk as many potential interpretations in a non-electrical context
		Electricity/electric/electrical/Electricity Generation/hydroelectric	electr	None
		Gas / Natural Gas / LPG / refrigerant gas / gasoline	Gas	Risk that it is part of other words
		Renewable	Renewable	None
		Biomass	Biomass	None
		Hybrid / hybri (energy context)	Hybri	Some risk of other interpretations (financial interpretation / 'hybrid conflict')
		grid / microgrid / smart grid / distributed generation	Grid	Some risk of other interpretations other than electrical grids

Table 51: Energy & Climate Change Keyword Term-set

Keyword	Relevant Variations / Interpretations to Cover	Search Term	Automatic / Manual Search	General Documents			Specialist Documents				
				Quadrennial Defense Review 2014 (DoD, 2014a)	National Military Strategy 2015 (DoD, 2015a)	Strategic Management Plan FY2014-15 (DoD, 2013a)	DoD Strategic Sustainability Performance Plan 2014 (DoD, 2014b)	DoD's Operational Energy Strategy 2011 (DoD, 2011a)	Operational Energy Annual Report 2014 (DoD, 2015b)	Annual Energy Management Report 2014 (DoD, 2015c)	DoD Climate Change Adaptation Roadmap 2014 (DoD, 2014c)
				88 pages	***24 pages***	***38 pages***	***116 pages***	***21 pages***	***48 pages***	***193 pages***	***20 pages***
Climate Change	Climate/climatic/UN Framework Convention on Climate Change	Climat	Manual	7	0	0	214	0	0	3	142
	extreme weather; changing weather patterns	Weather	Automate	3	0	0	14	2	1	9	12
	Global Warming	Global Warming	Automate	0	0	0	3	3	0	0	0
Emissions	Emission / emissions / emit	Emission	Automate	1	0	0	74	0	1	4	2
		Emit	Manual	0	0	0	1	0	0	0	0
	Offset / offsetting / offsets	Offset	Manual	0	0	0	0	0	0	0	0
Greenhouse Gases	Greenhouse Gas / GHG	Greenhouse	Automate	1	0	0	21	2	1	4	2
		GHG	Automate	0	0	0	29	0	0	5	0
	Carbon / Carbon equivalent / Carbon Dioxide / Carbon dioxide equivalent / CO_2 / CO_2e / Carbon Neutral / Zero Carbon / hydrofluorocarbons / perfluorocarbons (below)	Carbon	Manual	1	0	0	8	0	0	0	0
		CO_2	Manual	0	0	0	14	0	2	6	0
	Methane / (CH_4)	Methane	Automate	0	0	0	10	0	0	2	0
		CH_4	Manual	0	0	0	0	0	0	0	0
	Nitrous Oxide (N_2O)	Nitrous Oxide	Manual	0	0	0	0	0	0	0	0
		N_20	Manual	0	0	0	0	0	0	0	0
	Hydro fluorocarbons (HFCs) - full words incl in carbon search	HFC	Manual	0	0	0	0	0	0	0	0
	Perfluorocarbons (PFCs) - full words incl in carbon search	PFCs	Manual	0	0	0	10	0	0	0	0
	Sulphur Hexafluoride; (SF_6)	Hexafluoride	Manual	0	0	0	0	0	0	0	0
		SF_6	Manual	0	0	0	0	0	0	0	0
Energy	Energy/Energy Storage /Energy Security/energy generation/Wind Energy/Solar Energy/ocean/tidal	Energy	Manual	13	1	26	483	242	346	1002	12

	energy/geothermal energy										
	Fuel/Fossil Fuel/Clean Fuel/Fuel Efficiency/Fuel Burn/Refuel/Biofuel/Alternative Fuel/Synthetic Fuel/fuel (blend)/Combustion fuels	Fuel	Automate	7	0	0	120	80	252	65	2
	Oil	Oil	Manual	0	0	0	5	13	0	16	0
	Diesel	Diesel	Automate	0	0	0	4	0	2	8	0
	Petrol	Petrol	Automate	0	0	0	26	9	7	34	0
	Power/Power Generation/Wind Power/Solar Power/ Hydropower/ocean/tidal power/geothermal power/ uninterruptible power	Power	Manual	0	0	0	63	12	165	66	0
	Electricity/electric/electrical/Electricity Generation/hydroelectric	electr	Automate	0	0	0	155	11	145	138	2
	Gas / Natural Gas / LPG / refrigerant gas / gasoline	Gas	Manual	2	0	0	37	1	7	67	0
	Renewable	Renewable	Automate	2	0	0	98	2	3	170	0
	Biomass	Biomass	Automate	0	0	0	4	0	3	6	0
	Hybrid / hybri (energy context)	Hybri	Manual	0	0	0	18	2	9	8	0
	grid / microgrid / smart grid / distributed generation	Grid	Manual	0	0	0	15	4	8	54	1
			Climate Change Refs	***13***	***0***	***0***	***398***	***7***	***5***	***33***	***158***
			Energy Refs	***24***	***1***	***26***	***1,028***	***376***	***947***	***1,634***	***17***
			Climate Change Refs per 10 Pages	***1***	***0***	***0***	***34***	***3***	***1***	***2***	***79***
			Energy Refs per 10 pages	***3***	***0***	***7***	***89***	***179***	***197***	***85***	***9***

Table 52: 'Keyword Count Qualitative Dataset' for US DoD Documents Included in the Analysis

Keyword	Relevant Variations / Interpretations to Cover	Search Term	Automatic / Manual Search	General Documents				Specialist Documents		
				National Security Strategy 2010 (Cabinet Office, 2010a)	UK SDSR 2010 (Cabinet Office, 2010b)	MoD Annual Report and Accounts 2012-13 (MoD, 2014k)	MoD Business Plan 2012-15 (MoD, 2012a)	MoD Sustainable Development Strategy 2011-2030 (MoD, 2011b)	Sustainable MoD Annual Report 2014-15 (MoD, 2015a)	MoD Greening Government Commitments report 2012-13 (MoD 2013a)
				39 pages	75 pages	174 pages	18 pages	31 pages	34 pages	14 pages
Climate Change	Climate / climatic / UN Framework Convention on Climate Change	Climat	Manual	8	13	10	0	14	20	14
	extreme weather; changing weather patterns	Weather	Automate	1	0	2	0	0	2	2
	Global Warming	Global Warming	Automate	0	0	0	0	0	0	0
Emissions	Emission / emissions / emit	Emission	Automate	2	0	3	2	10	41	23
		Emit	Manual	0	0	0	0	1	0	0
	Offset / offsetting / offsets	Offset	Manual	0	0	0	0	0	1	0
Greenhouse Gases	Greenhouse Gas / GHG	Greenhouse	Automate	0	0	2	2	2	15	7
		GHG	Automate	0	0	0	0	6	15	5
	Carbon / Carbon equivalent / Carbon Dioxide / Carbon dioxide equivalent / CO_2 / CO_2e / Carbon Neutral / Zero Carbon / hydrofluorocarbons / perfluorocarbons (below)	Carbon	Manual	2	6	2	0	1	11	12
		CO_2	Manual	0	0	0	0	3	3	10
	Methane / (CH_4)	Methane	Automate	0	0	0	0	0	1	1
		CH_4	Manual	0	0	0	0	0	1	1
	Nitrous Oxide (N_2O)	Nitrous Oxide	Manual	0	0	0	0	0	1	1
		N_20	Manual	0	0	0	0	0	1	1
	Hydro fluorocarbons (HFCs) - full words incl carbon search	HFC	Manual	0	0	0	0	0	1	1
	Perfluorocarbons (PFCs) - full words incl in carbon search	PFCs	Manual	0	0	0	0	0	1	1
	Sulphur Hexafluoride; (SF_6)	Hexafluoride	Manual	0	0	0	0	0	1	1
		SF_6	Manual	0	0	0	0	0	1	1
	Energy / Energy Storage / Energy Security / energy generation / Wind Energy / Solar Energy / ocean-wave-tidal energy / geothermal energy	Energy	Manual	8	55	6	0	15	59	36
	Fuel / Fossil Fuel / Clean Fuel / Fuel Efficiency / Fuel Burn / Refuel / Biofuel / Alternative Fuel / Synthetic Fuel / fuel	Fuel	Automate	3	9	29	2	9	10	4

	(blend) / Combustion fuels									
	Oil	Oil	Manual	2	7	13	0	1	2	4
	Diesel	Diesel	Automate	0	0	0	0	0	5	6
	Petrol	Petrol	Automate	0	0	0	0	0	1	3
	Power / Power Generation / Wind Power / Solar Power / Hydropower / ocean-wave-tidal power / geothermal power / uninterruptible power	Power	Manual	1	4	3	0	1	2	2
	Electricity / electric / electrical / Electricity Generation / hydroelectric	electr	Automate	4	14	12	0	0	5	7
	Gas / Natural Gas / LPG / refrigerant gas / gasoline	Gas	Manual	1	10	9	2	2	18	13
	Renewable	Renewable	Automate	0	0	0	0	1	3	1
	Biomass	Biomass	Automate	0	0	0	0	0	0	0
	Hybrid / hybri (energy context)	Hybri	Manual	0	0	0	0	0	0	0
	grid / microgrid / smart grid / distributed generation	Grid	Manual	1	2	0	0	0	1	2
			Climate Change Refs	***13***	***19***	***19***	***4***	***37***	***116***	***81***
			Energy Refs	***20***	***101***	***72***	***4***	***29***	***106***	***78***
			Climate Change Refs per 10 Pages	***3***	***3***	***1***	***2***	***12***	***34***	***58***
			Energy Refs per 10 pages	***5***	***13***	***4***	***2***	***9***	***31***	***56***

Table 53: 'Keyword Count Qualitative Dataset' for UK MoD Documents Included in the Analysis

Keyword	Relevant Variations / Interpretations to Cover	Search Term	Automatic / Manual Search	General Documents (2013 Annual Report unless otherwise stated)									
				Airbus (Airbus Group, 2014a)	BAE Systems * (BAE Systems, 2015a)	Boeing (Boeing Company, 2014a)	Finmeccanica (Finmeccanica, 2014a)	General Dynamics (General Dynamics, 2014)	Lockheed Martin (Lockheed Martin, 2014a)	Northrop Grumman (Northrop Grumman, 2014a)	Raytheon (Raytheon, 2014a)	Thales Registration (Thales, 2014a)	United Technologies (United Technologies, 2014a)
				68 pages	**168 pages**	**148 pages**	**272 pages**	**84 pages**	**110 pages**	**104 pages**	**142 pages**	**266 pages**	**88 pages**
Climate Change	Climate / climatic / UN Framework Convention on Climate Change	Climat	Manual	2	1	0	0	0	2	1	0	38	60
	extreme weather; changing weather patterns	Weather	Automate	0	0	4	2	1	0	1	8	2	5
	Global Warming	Global Warming	Automate	0	0	0	0	0	0	0	0	2	0
Emissions	Emission / emissions / emit	Emission	Automate	11	19	3	13	1	0	3	2	56	11
		Emit	Manual	0	0	1	0	0	0	0	0	1	0
	Offset / offsetting / offsets	Offset	Manual	0	0	0	0	0	9	0	0	0	0
Greenhouse Gases	Greenhouse Gas / GHG	Greenhouse	Automate	1	12	1	7	0	0	2	0	13	3
		GHG	Automate	0	0	0	0	0	0	0	0	6	0
	Carbon / Carbon equivalent / Carbon Dioxide / Carbon dioxide equivalent / CO_2 / CO_2e / Carbon Neutral / Zero Carbon / hydrofluorocarbons / perfluorocarbons	Carbon	Manual	2	5	0	1	0	2	0	0	6	7
		CO_2	Manual	2	7	0	1	0	0	0	0	28	2
	Methane / (CH_4)	Methane	Automate	0	1	0	0	0	0	0	0	0	0
		CH_4	Manual	0	0	0	0	0	0	0	0	0	0
	Nitrous Oxide (N_2O)	Nitrous Oxide	Manual	0	1	0	0	0	0	0	0	0	0
		N_20	Manual	0	0	0	0	0	0	0	0	0	0
	Hydro fluorocarbons (HFCs) - full words incl carbon search	HFC	Manual	0	0	0	0	0	0	0	0	0	0
	Perfluorocarbons (PFCs) - full words covered incl in carbon search	PFCs	Manual	0	0	0	0	0	0	0	0	0	0
	Sulphur Hexafluoride; (SF_6)	Hexafluoride	Manual	0	1	0	0	0	0	0	0	0	0
		SF_6	Manual	0	0	0	0	0	0	0	0	3	0
	Energy / Energy Storage / Energy Security / energy generation / Wind Energy / Solar	Energy	Manual	3	13	6	26	0	16	3	10	92	23

	Energy / ocean-wave-tidal energy / geothermal energy												
	Fuel / Fossil Fuel / Clean Fuel / Fuel Efficiency / Fuel Burn / Refuel / Biofuel / Alternative Fuel / Synthetic Fuel / fuel (blend) / Combustion fuels	Fuel	Automate	20	2	25	0	2	2	1	0	13	12
	Oil	Oil	Manual	2	3	0	0	0	1	0	0	7	5
	Diesel	Diesel	Automate	0	0	0	0	0	0	0	0	0	1
	Petrol	Petrol	Automate	0	2	0	0	0	0	0	0	0	0
	Power / Power Generation / Wind Power / Solar Power / Hydropower / ocean-wave-tidal power / geothermal power / uninterruptible power	Power	Manual	2	7	6	1	5	3	3	3	10	95
	Electricity / electric / electrical / Electricity Generation / hydroelectric	Electr	Automate	13	108	26	88	7	9	73	58	3	28
	Gas / Natural Gas / LPG / refrigerant gas / gasoline	Gas	Manual	2	13	2	9	0	3	2	0	8	9
	Renewable	Renewable	Automate	1	0	0	1	0	2	0	0	15	1
	Biomass	Biomass	Automate	0	0	0	0	0	0	0	0	0	0
	Hybrid / hybri (energy context)	Hybri	Manual	3	7	0	1	0	0	0	0	1	0
	grid / microgrid / smart grid / distributed generation	Grid	Manual	0	0	0	0	0	0	0	0	0	1
			Climate Change Refs	18	47	9	24	2	13	7	10	155	88
			Energy Refs	46	155	65	126	14	36	82	71	149	175
			Climate Change Refs per 10 Pages	3	3	1	1	0	1	1	1	6	10
			Energy Refs per 10 pages	7	9	4	5	2	3	8	5	6	20

Table 54: 'Keyword Count Qualitative Dataset' for Defence Company Documents Included (General Documents)

Keyword	Relevant Variations / Interpretations to Cover	Search Term	Automatic / Manual Search	Specialist Documents (2013 CR / Sustainability Reports unless otherwise stated)									
				Airbus (Airbus Group, 2014b)	BAE Systems* (BAE Systems, 2015b)	Boeing Environment Report (2014b) & Citizenship Report (2014c)	Finmeccanica (Finmeccanica, 2014b)	General Dynamics (General Dynamics, 2012)	Lockheed Martin (Lockheed Martin, 2014b)	Northrop Grumman (Northrop Grumman, 2014b)	Raytheon (Raytheon, 2014b)	Thales (Thales, 2014b)	United Technologies (No standalone CR / Sustainability Report)
				71 pages	**44 pages**	**68 pages**	**179 pages**	**17 pages**	**70 pages**	**52 pages**	**36 pages**	**116 pages**	**NA**
Climate Change	Climate / climatic / UN Framework Convention on Climate Change	Climat	Manual	11	3	1	14	0	15	19	16	24	
	extreme weather; changing weather patterns	Weather	Automate	4	0	0	0	0	7	1	7	2	
	Global Warming	Global Warming	Automate	1	0	0	0	0	0	1	0	1	
Emissions	Emission / emissions / emit	Emission	Automate	94	16	68	70	10	24	30	11	36	
		Emit	Manual	2	0	3	1	0	0	1	0	0	
	Offset / offsetting / offsets	Offset	Manual	0	0	2	0	0	1	3	0	0	
Greenhouse Gases	Greenhouse Gas / GHG	Greenhouse	Automate	11	3	13	10	4	6	15	8	3	
		GHG	Automate	2	0	1	6	3	4	39	4	1	
	Carbon / Carbon equivalent / Carbon Dioxide / Carbon dioxide equivalent / CO_2 / CO_2e / Carbon Neutral / Zero Carbon / hydrofluorocarbons / perfluorocarbons (below)	Carbon	Manual	6	5	42	11	1	31	14	4	5	
		CO_2	Manual	53	5	3	1	1	2	5	1	37	
	Methane / (CH_4)	Methane	Automate	0	0	0	1	0	0	0	0	0	
		CH_4	Manual	0	0	0	0	0	0	0	0	0	
	Nitrous Oxide (N_2O)	Nitrous Oxide	Manual	0	0	0	0	0	0	0	0	0	
		N_20	Manual	0	0	0	0	0	0	0	0	0	
	Hydro fluorocarbons (HFCs) - full words incl carbon search	HFC	Manual	0	0	0	0	0	0	0	0	0	
	Perfluorocarbons (PFCs) - full words covered incl in carbon search	PFCs	Manual	0	0	0	0	0	0	0	0	0	
	Sulphur Hexafluoride; (SF_6)	Hexafluoride	Manual	0	0	0	0	0	0	0	0	0	
		SF_6	Manual	0	0	0	0	0	0	0	0	3	

	Energy / Energy Storage / Energy Security / energy generation / Wind Energy / Solar Energy / ocean-wave-tidal energy / geothermal energy	Energy	Manual	66	28	67	84	8	132	44	22	45	
	Fuel / Fossil Fuel / Clean Fuel / Fuel Efficiency / Fuel Burn / Refuel / Biofuel / Alternative Fuel / Synthetic Fuel / fuel (blend) / Combustion fuels	Fuel	Automate	57	13	107	11	2	14	1	3	16	
	Oil	Oil	Manual	7	1	7	12	0	3	2	0	4	
	Diesel	Diesel	Automate	2	3	0	8	0	0	1	0	0	
	Petrol	Petrol	Automate	0	0	2	1	0	0	0	0	0	
	Power / Power Generation / Wind Power / Solar Power / Hydropower / ocean-wave-tidal power / geothermal power / uninterruptible power	Power	Manual	10	6	20	2	4	24	4	1	4	
	Electricity / electric / electrical / Electricity Generation / hydroelectric	Electr	Automate	31	10	15	79	14	33	13	11	18	
	Gas / Natural Gas / LPG / refrigerant gas / gasoline	Gas	Manual	25	6	19	21	7	12	24	9	9	
	Renewable	Renewable	Automate	5	1	5	9	0	14	8	3	1	
	Biomass	Biomass	Automate	4	0	1	0	0	1	0	0	0	
	Hybrid / hybri (energy context)	Hybri	Manual	3	6	0	0	0	1	0	0	1	
	grid / microgrid / smart grid / distributed generation	Grid	Manual	0	2	5	3	0	15	0	0	0	
			Climate Change Refs	***184***	***32***	***133***	***114***	***19***	***90***	***128***	***51***	***112***	***NA***
			Energy Refs	***210***	***76***	***248***	***230***	***35***	***249***	***97***	***49***	***98***	***NA***
			Climate Change Refs per 10 Pages	***26***	***7***	***20***	***6***	***11***	***13***	***25***	***14***	***10***	***NA***
			Energy Refs per 10 pages	***30***	***17***	***36***	***13***	***21***	***36***	***19***	***14***	***8***	***NA***

Table 55: ‘Keyword Count Qualitative Dataset’ for Defence Company Documents Included (Specialist Documents)

Organisation	Target Type	Target	Target Year	Baseline Year	Source	Notes
UK MoD	GHG Reduction Target (Scope 1 & 2)	25%	2014/15	2009/10	Sustainable MoD Annual Report 2014/15 (MoD, 2015a)	Linked to 'Greening Government Commitments' - Applies to facility energy use
	GHG Reduction Target (Scope 3)	25%	2014/15	2009/10	Sustainable MoD Annual Report 2014/15 (MoD, 2015a)	Relates to domestic air flights
British Army	Operational Energy Reduction Target	18%	2020	2009/10	Defence Plan 15 (Not publicly available)	Also requirement for services to 'advise on how they would manage' fuel price rises (25% by 2025; 75% by 2035)
Royal Navy	Operational Energy Reduction Target	22%	2020	2009/10	Defence Plan 15 (Not publicly available)	As above
Royal Air Force	Operational Energy Reduction Target	27%	2020	2009/10	Defence Plan 15 (Not publicly available)	As above
US DoD	GHG Reduction Target (Scope 1 & 2)	34%	2020	2008	Strategic Sustainability Performance Plan 2014 (DoD, 2014b)	Applies to 'facility energy use', linked to wider federal energy management programme
	GHG Reduction Target (Scope 3)	13.5%	2020	2008	Strategic Sustainability Performance Plan 2014 (DoD, 2014b)	Applies to 'goal subject' Scope 3 emissions (mostly relate to business travel)
	GHG Reduction Target (Scope 3)	7%	2020	2011	Strategic Sustainability Performance Plan 2014 (DoD, 2014b)	Applies to employee air travel
	GHG Reduction Target (Scope 3)	30%	2020		Strategic Sustainability Performance Plan 2014 (DoD, 2014b)	Percentage of employees teleworking 1 day per fortnight
	Facility Energy Intensity Target	37.5%	2020	2003	Strategic Sustainability Performance Plan 2014 (DoD, 2014b)	Energy intensity target related to domestic facilities
	Facility Energy Procurement Target	18%	2020		Strategic Sustainability Performance Plan 2014 (DoD, 2014b)	Procurement of renewable energy for domestic facilities
US Army	Facility Energy Generation Target		2020		Army Vision for Net Zero (NREL, 2013)	5 sites to become 'net zero' in energy use by 2020; 25 sites by 2030
US Navy	GHG Reduction Target	50%	2015		A Navy Vision for the 21st Century (Dept of the Navy, 2010a)	Applies to 'non-tactical fossil fuel usage'
	Operational Energy Reduction Target	15%	2020		A Navy Vision for the 21st Century (Dept of the Navy, 2010a)	Reduce overall fuel consumption afloat by 50%
	Operational Energy Procurement Target	50%	2020		A Navy Vision for the 21st Century (Dept of the Navy, 2010a)	Half of all USN energy afloat to be made of alternative energy sources (e.g. biofuel blends)

	Facility Energy Generation Target	50%	2020		A Navy Vision for the 21st Century (Dept of the Navy, 2010a)	50% of facilities will be produced renewably by 2020 / 50% of facilities to be net-zero consumers by 2020
US Air Force	Operational Energy Intensity Target	10%	2020	2011	US Air Force Energy Strategic Plan (US Air Force, 2013)	Improve aviation energy efficiency' by 10% by 2020
	Facility Energy Reduction Target	15%	2020	2010	US Air Force Energy Strategic Plan (US Air Force, 2013)	Applies to all facility energy
Airbus					Context Report for BAE Systems (Not publicly available)	
BAE Systems					Context Report for BAE Systems (Not publicly available)	
Boeing	GHG Reduction Target	0%	2017	2012	Context Report for BAE Systems (Not publicly available)	Maintain emissions at 2012 levels by 2017
Finmeccanica					Context Report for BAE Systems (Not publicly available)	
General Dynamics					Context Report for BAE Systems (Not publicly available)	
Lockheed Martin	GHG Reduction Target (Scope 1 & 2)	35%	2020	2010	Context Report for BAE Systems (Not publicly available)	Applies to US/UK
	Facility Energy Reduction Target	25%	2020	2010	Context Report for BAE Systems (Not publicly available)	
Northrop Grumman	GHG Reduction Target (Scope 1 & 2)	25%	2014	2008	Context Report for BAE Systems (Not publicly available)	
Raytheon	GHG Reduction Target (Scope 1 & 2)	10%	2015		Context Report for BAE Systems (Not publicly available)	
	Facility Energy Reduction Target	10%	2015		Context Report for BAE Systems (Not publicly available)	
Thales	GHG Intensity Target (Scopes 1-3)		2015		Context Report for BAE Systems (Not publicly available)	Reduce by 10kgCO_2e per 1,000 Euro Revenue
	Facility Energy Intensity Target		2015		Context Report for BAE Systems (Not publicly available)	Reduce by 10toe per 1,000 Euro Revenue
United Technologies					United Technologies Annual Reports 2013-15 (United Technologies, 2014a; 2015a; 2016a)	

Table 56: GHG and Energy Targets Summary for the Organisations Included in this Research

	2010	2011	2012	2013	2014	2015	2016
Airbus	69	52	70	97	95	95	NA
BAE Systems	58	56	69	69	77	88	NA
Boeing	86	92	89	96	97	99	NA
Finmeccanica	64	80	81	83	75	86	NA
General Dynamics	No resp	No resp	No resp	No resp	No resp	No resp	No resp
Lockheed Martin	76	90	93	91	98	100	NA
Northrop Grumman	68	80	90	99	98	100	NA
Raytheon	68	71	90	98	97	98	NA
Thales	44	80	68	88	90	98	NA
United Technologies	54	58	70	87	72	97	NA

Table 57: CDP Climate Change Questionnaire - Disclosure Scores (Note from 2016 CDP are only publishing ‘Performance Scores’)

	2010	2011	2012	2013	2014	2015	2016
Airbus	B	D	C	B	B	C	B
BAE Systems	D	E	C	C	C	D	B
Boeing	B	B	B	A-	B	B	A-
Finmeccanica	C	C	C	B	C	C	B
General Dynamics	No resp	No resp	No resp	No resp	No resp	No resp	No resp
Lockheed Martin	B	A	A	A	A	A-	A
Northrop Grumman	C	C	A	A	A	A-	A-
Raytheon	B	C	B	A	B	A	A-
Thales	NA	B	C	C	A	A-	A-
United Technologies	B	D	C	B	C	A	A-

Table 58: CDP Climate Change Questionnaire - Performance Scores

	Third Party Assurance of GHGs?	Assurance Standard	Level of Assurance
Thales	Yes	ISAE3000	Limited
United Technologies Corporation	Yes (not complete at time of publication for CDP / Scope 3 data not assured)	ISO14064-3	Limited
Lockheed Martin Corporation	Yes	ISO14064-3	Limited
Northrop Grumman Corp	Yes	ISO14064-3	Reasonable
Raytheon Company	Yes	ISO14064-3	Limited
Airbus Group	Yes	ISAE3000	Reasonable
Finmeccanica	Yes	ISAE3000	Limited
BAE Systems	Yes	ISAE3000	Limited
Boeing Company	Yes	DNV Verisustain Protocol/ Verification Protocol for Sustainability Reporting	Limited
General Dynamics	Not disclosed	NA	NA
UK MoD	Yes (where subject to GCC targets)	Not disclosed	Not disclosed
US DoD	Not disclosed	NA	NA

Table 59: Assurance standards used for Organisational Carbon Accounts (Source(s): CDP Academic Dataset, Sustainable MoD Annual Report (Ministry of Defence, 2014m; 2015a; 2016b))

	IAEG Member?	IAEG GHG Guidance Mentioned in Public Reporting?	IAEG GHG Guidance Publicly Adopted?
Thales	Yes	Yes	Not explicit (but Standard aligned to GHG Protocol)
United Technologies Corporation	Yes	No	No
Lockheed Martin Corporation	Yes	No	No
Northrop Grumman Corp	Yes	Yes	Not explicit (but Standard aligned to GHG Protocol)
Raytheon Company	Yes	No	No
Airbus Group	Yes	No	No
Finmeccanica	No	No	No
BAE Systems	Yes (business-level)	No	No
Boeing Company	Yes	Yes	Yes (referenced as referred to, alongside GHG Protocol - but Boeing methodology not formally tied to either of these)
General Dynamics	No	No	No
UK MoD	NA	NA	NA
US DoD	NA	NA	NA

Table 60: Organisations endorsing the IAEG's GHG Reporting Standard (IAEG, 2016). (Source(s): All 'General' and 'Specialist' documents described in section **3.3.3**)

	BAE Systems	**United Technologies**	**General Dynamics (2011)**	**Lockheed Martin**	**Finmeccanica**	**Northrop Grumman**	**Boeing Company**	**Raytheon Company**	**Thales**	**Airbus Group**
Business travel	Y	Y		Y	Y	Y	Y	Y	Y	
Upstream transportation and distribution				Y	Y	Y		Y		
Downstream transportation and distribution				Y	Y	Y				
Employee commuting				Y		Y			Y	
Fuel and energy related activities (not incl in scope 1 & 2)				Y	Y			Y		
Waste generated in operations				Y	Y			Y		
Upstream leased assets (lease cars in these cases)					Y				Y	
Purchased goods and services				***Y***	***Y****					
Use of sold products				***Y***						
End of life treatment of sold products										
Capital goods										
Processing of sold products										
Downstream leased assets										
Franchises										
Investments										

Table 61: Summary of 2014 Scope 3 Reporting from the Defence Companies Included in this Research (organised in descending order from the 'most reported' to 'least reported' category). (Source: Quantitative Dataset **3.4.1**, Tables 32-40)

*Reliability of Finmeccanica data very questionable for this category despite submitting a value to CDP

Domain	UK Combat Platform	Main Contractor
Air	Tornado Bomber	BAE Systems
Air	Tornado Fighter	BAE Systems
Air	Eurofighter / Typhoon	BAE Systems
Air	Nimrod Patrol Aircraft	BAE Systems
Air	F-35	Lockheed Martin
Land	Warrior AIFV	Alvis Vickers (now BAE Systems)
Land	Challenger II Tank	Alvis Vickers (now BAE Systems)
Land	Merlin Helicopter	Westland (now Finmeccanica)
Land	Lynx Helicopter	
Land	Apache Helicopter	
Land	Chinook Helicopter	Boeing
Land	Hercules Transport Plane	Lockheed Martin
Land	C-17 Globemaster Transport Plane	Boeing
Sea	QE Carrier	BAE Systems
Sea	Type 45 Destroyer	BAE Systems
Sea	Type 26 Frigate	BAE Systems
Sea	Other Complex Warships	BAE Systems (6); Yarrows 15 (now BAE Systems); Vickers 20 (now BAE Systems); Swan Hunter 18; Vosper 25; Cammell Laird 6
Sea	Harrier Jet	BAE Systems
Sea	Astute Submarines	BAE Systems
Sea	Successor Submarines	BAE Systems

Table 62: Showing UK combat platforms and the main supplying company. Source: Page, 2007: p.254-255). Note this is not an exhaustive list, and the supply relationships can be more complex than implied in the table.

Appendix B: CDP Climate Change Questionnaire (CDP, 2017)

CDP's 2017 Climate Change Information Request

CDP works to reduce companies' greenhouse gas emissions and mitigate climate change risk. In 2016, 827 investors with over US$100 trillion in assets backed CDP's climate change information request.

The following set of questions form CDP's climate change information request. Companies are asked to answer these questions in the Online Response System (ORS) provided by CDP through its website. As such, this document is a representation of the request and whilst the questions will remain the same, the format may differ online particularly where drop down options and tables have been included for ease of response. Guidance is available on the CDP website from December 2016 which details all of the options available and provides screen shots of the ORS to aid companies in completing the request.

We request a reply to the following questions by 29 June 2017.

Please respond to the information request using our Online Response System (ORS). In early February 2017, instructions on how to access the ORS will be sent to you by e-mail. If you are unable to respond via the ORS, please e-mail respond@cdp.net. In addition to investor signatories to the letter requesting your response which accompanies this request, you may also be asked to share your response with the members of CDP's supply chain program if they are your customers. In this case, you will be notified by email in early April 2017 and asked for your approval for this.

We encourage companies to consult CDP's 2017 climate change reporting guidance and CDP's 2017 climate change scoring methodology at www.cdp.net/guidance, as well as use the guidance within the ORS. Please answer the questions as comprehensively as possible. Where you do not have all of the information requested, please respond with what you have as this is more valuable to investors than no response at all.

We encourage companies to assess the relevance of questions in accordance with the principles of "The Greenhouse Gas Protocol: A Corporate Accounting and Reporting Standard (Revised Edition)" developed by the World Resources Institute and the World Business Council for Sustainable Development (www.ghgprotocol.org). According to these principles, information is relevant if it contains the detail that users, both internal and external to the company, need for their decision-making.

Where questions have been amended from 2016 to 2017, this is indicated next to the relevant questions.

Sector-specific Question Modules and Instructions

In addition to questions CC0-15 that follow, specific questions have been prepared for companies in the Electric Utilities, Auto and Auto Component Manufacture, Oil and Gas, Information and Communications Technology, and Food, Beverage and Tobacco sectors. This is part of a strategic move by CDP to a more sector based approach. These modules will be presented within the ORS and can be previewed on the CDP website. Companies with businesses in these sectors should answer questions CC1-15 for all businesses within their consolidated boundary and provide information specific to businesses in those sectors in answer to the additional questions.

Introduction

CC0. Introduction

CC0.1 Introduction
Please give a general description and introduction to your organization

CC0.2 Reporting Year
Please state the start and end date of the year for which you are reporting data

CC0.3 Country list configuration
Please select the countries for which you will be supplying data

CC0.4 Currency selection
Please select the currency in which you would like to submit your response

CC0.6 Modules
Here companies can choose to respond to a sector module if this has not already been allocated to them by CDP

Management

CC1. Governance

Group and Individual Responsibility

CC1.1 Where is the highest level of direct responsibility for climate change within your organization?

If "Board or individual/sub-set of the Board or other committee appointed by the Board"; "Senior Manager/Officer"; or, "Other Manager/Officer":

CC1.1a Please identify the position of the individual or name of the committee with this responsibility

Individual Performance

CC1.2 Do you provide incentives for the management of climate change issues, including the attainment of targets?

If yes: CC1.2a Please provide further details on the incentives provided for the management of climate change issues

Who is entitled to benefit from these incentives?	The type of incentives	Incentivized performance indicator	Comment

CC2. Strategy

Risk Management Approach

CC2.1 Please select the option that best describes your risk management procedures with regard to climate change risks and opportunities

If "Integrated into multi-disciplinary company-wide risk management processes" or "A specific climate change risk management process" is selected, answer questions CC2.1a - 2.1c:

CC2.1a Please provide further details on your risk management procedures with regard to climate change risks and opportunities

Frequency of monitoring	To whom are results reported?	Geographical areas considered	How far into the future are risks considered?	Comment

CC2.1b Please describe how your risk and opportunity identification processes are applied at both company and asset level

CC2.1c How do you prioritize the risks and opportunities identified?

If "There are no documented processes for assessing and managing risks and opportunities from climate change" is selected:

CC2.1d Please explain why you do not have a process in place for assessing and managing risks and opportunities from climate change, and whether you plan to introduce such a process in the future

Main reason for not having a process	Do you plan to introduce a process?	Comment

Management

Business Strategy
CC2.2 Is climate change integrated into your business strategy?

If yes: CC2.2a Please describe the process of how climate change is integrated into your business strategy and any outcomes of this process **(CDP 2016 CC2.2a, amended)**

If no: CC2.2b Please explain why climate change is not integrated into your business strategy

CC2.2c Does your company use an internal price on carbon? **(CDP 2016 CC2.2c, amended)**

If yes: CC2.2d Please provide details and examples of how your company uses an internal price on carbon **(CDP 2016 CC2.2d, amended)**

Engagement with Policy Makers
CC2.3 Do you engage in activities that could either directly or indirectly influence public policy on climate change through any of the following? (tick all that apply)

- Direct engagement with policy makers
- Funding research organizations
- Trade associations
- Other
- No

If "Direct engagement with policy makers" is ticked:
CC2.3a On what issues have you been engaging directly with policy makers?

Focus of legislation	Corporate position	Details of engagement	Proposed legislative solution

If "Trade associations" is ticked:
CC2.3b Are you on the Board of any trade associations or provide funding beyond membership?

If yes: CC2.3c Please enter the details of those trade associations that are likely to take a position on climate change legislation

Trade association	Is your position on climate change consistent with theirs?	Please explain the trade association's position	How have you, or are you attempting to, influence the position?

If "Funding research organizations" is ticked:
CC2.3d Do you publicly disclose a list of all the research organizations that you fund?

If "Other" is ticked:
CC2.3e Please provide details of the other engagement activities that you undertake

If "Direct engagement", "Trade associations", "Funding research organizations" or "Other" is ticked:

CC2.3f What processes do you have in place to ensure that all of your direct and indirect activities that influence policy are consistent with your overall climate change strategy?

If "No" is ticked:

CC2.3g Please explain why you do not engage with policy makers

CC3. Targets and Initiatives

Targets

CC3.1 Did you have an emissions reduction or renewable energy consumption or production target that was active (ongoing or reached completion) in the reporting year?**)**

If you have an absolute target:

CC3.1a Please provide details of your absolute target **(CDP 2016 CC3.1a, amended)**

If you have an intensity target:

CC3.1b Please provide details of your intensity target **(CDP 2016 CC3.1b, amended)**

CC3.1c Please also indicate what change in absolute emissions this intensity target reflects

The following details are requested for targets (in Questions CC3.1a and CC3.1b), to be inputted in tables in the ORS:

- Scope
- % of emissions in scope
- % reduction from base year
- Metric denominator (intensity targets only)
- Base year covered by target
- Base year emissions
- Target year
- Is this a science-based target?
- Comment

Direction of change anticipated in absolute Scope 1+2 emissions at target completion?	% change anticipated in absolute Scope 1+2 emissions	Direction of change anticipated in absolute Scope 3 emissions at target completion?	% change anticipated in absolute Scope 3 emissions	Comment

If you have a renewable energy consumption or production target:

CC3.1d Please provide details of your renewable energy consumption and/or production target in your direct operations

ID	Energy types covered by target	Base year	Base year energy for energy type covered (MWh)	% renewable energy in base year	Target year	% renewable energy in target year	Comment

Management

For all types of target, also:

CC3.1e For all of your targets, please provide details on the progress made in the reporting year

% complete (time)	% complete (emissions or renewable energy)	Comment

If you do not have a target:

CC3.1f Please explain: (i) why you do not have a target; and (ii) forecast how your emissions will change over the next five years

Emissions Reduction Initiatives

CC3.2 Do you classify any of your existing goods and/or services as low carbon products or do they enable a third party to avoid GHG emissions?

If yes: CC3.2a Please provide details of your products and/or services that you classify as low carbon products or that enable a third party to avoid GHG emissions

Level of aggregation	Description of product/ Group of products	Are you reporting low carbon product/s or avoided emissions?	Taxonomy, project or methodology used to classify product/s as low carbon or to calculate avoided emissions	% revenue from low carbon product/s in the reporting year	% R&D in low carbon product/s in the reporting year	Comment

CC3.3 Did you have emissions reduction initiatives that were active within the reporting year (this can include those in the planning and/or implementation phases)

If yes, complete questions CC3.3a, CC3.3b and CC3.3c:

CC3.3a Please identify the total number of projects at each stage of development, and for those in the implementation stages, the estimated CO_2e savings

Stage of development	Number of projects	Total estimated annual CO_2e savings in metric tonnes CO_2e (only for rows marked *)
Under investigation		
To be implemented*		
Implementation commenced*		
Implemented*		
Not to be implemented		

CC3.3b For those initiatives implemented in the reporting year, please provide details in the table below

Activity type	Description of activity	Estimated annual CO_2e savings (metric tonnes CO_2e)	Scope	Voluntary/ Mandatory	Annual monetary savings (unit currency – as specified in CC0.4)	Investment required (unit currency – as specified in CC0.4)	Payback period	Estimated lifetime of the initiative	Comment

CC3.3c What methods do you use to drive investment in emissions reduction activities?

Method	Comment

If no: CC3.3d If you do not have any emissions reduction initiatives, please explain why not

CC4. Communications

CC4.1 Have you published information about your organization's response to climate change and GHG emissions performance for this reporting year in places other than in your CDP response? If so, please attach the publication(s)

Publication	Status	Page/Section reference	Attach the document	Comment

Risks & Opportunities

CC5. Climate Change Risks

CC5.1 Have you identified any inherent climate change risks that have the potential to generate a substantive change in your business operations, revenue or expenditure? (Tick all that apply)

Please identify the relevant categories:

- Risks driven by changes in regulation
- Risks driven by changes in physical climate parameters
- Risks driven by changes in other climate-related developments

CC6. Climate Change Opportunities

CC6.1 Have you identified any inherent climate change opportunities that have the potential to generate a substantive change in your business operations, revenue or expenditure? (Tick all that apply)

Please identify the relevant categories:

- Opportunities driven by changes in regulation
- Opportunities driven by changes in physical climate parameters
- Opportunities driven by changes in other climate-related developments

For all of the inherent risks and/or opportunities identified, please provide the following details in the table provided in the ORS:

- Risk/Opportunity driver
- Description
- Potential impact
- Timeframe
- Direct/Indirect
- Likelihood
- Magnitude of impact
- Estimated financial implications of the risk/opportunity before taking action
- Methods you are using to manage this risk/opportunity
- Costs associated with these actions

Where inherent risks and/or opportunities have not been identified for any of the categories:

Please explain why you do not consider your organization to be exposed to these risks/opportunities that have the potential to generate a substantive change in your business operations, revenue or expenditure

Emissions

CC7. Emissions Methodology

CDP requests companies to provide responses to questions CC8, CC9 and CC10 for the three years prior to the current reporting year if you have not done so before or if this is the first time you have answered a CDP information request

Base year

CC7.1 Please provide your base year and base year emissions (Scopes 1 and 2)

Use the table in the ORS to provide the following details for Scopes 1 and 2:

- Base year
- Scope 1 base year emissions (metric tonnes CO_2e)
- Scope 2 location-based base year emissions (metric tonnes CO_2e)
- Scope 2 market-based base year emissions (metric tonnes CO_2e)

Methodology

CC7.2 Please give the name of the standard, protocol or methodology you have used to collect activity data and calculate Scope 1 and Scope 2 emissions

If you have selected "Other":

CC7.2a If you have selected "Other" in CC7.2 please provide details of the standard, protocol or methodology you have used to collect activity data and calculate Scope 1 and Scope 2 emissions

CC7.3 Please give the source for the global warming potentials you have used

Gas	Reference

CC7.4 Please give the emissions factors you have applied and their origin; alternatively, please attach an Excel spreadsheet with this data at the bottom of this page

Fuel/Material/Energy	Emission Factor	Unit	Reference

CC8. Emissions Data

Boundary

CC8.1 Please select the boundary you are using for your Scope 1 and 2 greenhouse gas inventory

Select from

- Financial control
- Operational control
- Equity share
- Other

Emissions

Scope 1 and 2 Emissions Data

CC8.2 Please provide your gross global Scope 1 emissions figures in metric tonnes CO_2e

CC8.3 Please describe your approach to reporting Scope 2 emissions **(CDP 2016 CC8.3, amended)**

Scope 2, location-based	Scope 2, market-based (if applicable)	Comment

CC8.3a Please provide your gross global Scope 2 emissions figures in metric tonnes CO_2e

Scope 2, location-based	Scope 2, market-based (if applicable)	Comment

CC8.4 Are there any sources (e.g. facilities, specific GHGs, activities, geographies, etc.) of Scope 1 and Scope 2 emissions that are within your selected reporting boundary which are not included in your disclosure?

If yes: CC8.4a Please provide details of the sources of Scope 1 and Scope 2 emissions that are within your selected reporting boundary which are not included in your disclosure

Source	Relevance of Scope 1 emissions from this source	Relevance of location-based Scope 2 emissions from this source	Relevance of market-based Scope 2 emissions from this source (if applicable)	Explain why the source is excluded

Data Accuracy

CC8.5 Please estimate the level of uncertainty of the total gross global Scope 1 and 2 emissions figures that you have supplied and specify the sources of uncertainty in your data gathering, handling and calculations

Scope	Uncertainty range	Main sources of uncertainty	Please expand on the uncertainty in your data
1			
2 (location-based)			
2 (market-based)			

External Verification or Assurance

CC8.6 Please indicate the verification/assurance status that applies to your reported Scope 1 emissions

Emissions

If Scope 1 emissions have been subject to third party verification or assurance (complete or underway):

CC8.6a Please provide further details of the verification/assurance undertaken for your Scope 1 emissions, and attach the relevant statements

Verification or assurance cycle in place	Status in the current reporting year	Type of verification or assurance	Attach the statem-ent	Page/ Section reference	Relevant standard	Proportion of reported Scope 1 emissions verified (%)

If "No third party verification or assurance – regulatory CEMS required" is selected:

CC8.6b Please provide further details of the regulatory regime to which you are complying that specifies the use of Continuous Emission Monitoring Systems (CEMS)

Regulation	% of emissions covered by the system	Compliance period	Evidence of submission

CC8.7 Please indicate the verification/assurance status that applies to at least one of your reported Scope 2 emissions figures

If Scope 2 emissions have been subject to third party verification or assurance (complete or underway):

CC8.7a Please provide further details of the verification/assurance undertaken for your location-based and/or market-based Scope 2 emissions, and attach the relevant statements

Location-based or market-based figure?	Verification or assurance cycle in place	Status in the current reporting year	Type of verification or assurance	Attach the statement	Page/ Section reference	Relevant standard	Proportion of reported Scope 2 emissions verified (%)

CC8.8 Please identify if any data points have been verified as part of the third party verification work undertaken, other than the verification of emissions figures reported in CC8.6, CC8.7 and CC14.2

Additional data points verified	Comment

Carbon Dioxide Emissions from Biologically Sequestered Carbon

CC8.9 Are carbon dioxide emissions from biologically sequestered carbon relevant to your organization?

If yes: 8.9a Please provide the emissions from biologically sequestered carbon relevant to your organization in metric tonnes CO_2

Emissions

CC9. Scope 1 Emissions Breakdown

CC9.1 Do you have Scope 1 emissions sources in more than one country?

If yes: CC9.1a Please break down your total gross global Scope 1 emissions by country/ region

***Electric utilities** should report emissions by country/region using the tables in EU2*

***Oil and gas** sector companies are requested to provide breakdowns of emissions by value chain segment and activity in the OG module*

***ICT companies** can use the sector module to respond to CC9.2d*

***FBT companies** can use the sector module to provide a breakdown of their emissions by activity*

Country/Region	Scope 1 metric tonnes CO_2e

CC9.2 Please indicate which other Scope 1 emissions breakdowns you are able to provide (tick all that apply)

- By business division (CC9.2a)
- By facility (CC9.2b)
- By GHG type (CC9.2c)
- By activity (CC9.2d)

Where a breakdown option has been ticked, a table appears to allow you to enter the relevant emissions data

CC10. Scope 2 Emissions Breakdown

CC10.1 Do you have Scope 2 emissions sources in more than one country?

If yes: CC10.1a Please break down your total gross global Scope 2 emissions and energy consumption by country/region

***Oil and gas** sector companies are requested to provide the breakdown of emissions by value chain segment as shown in OG2*

***ICT companies** can use the sector module to respond to CC10.2c*

Country/Region	Scope 2, location-based (metric tonnes CO2e)	Scope 2, market-based (metric tonnes CO_2e)	Purchased and consumed electricity, heat, steam or cooling (MWh)	Purchased and consumed low carbon electricity, heat, steam or cooling (MWh) accounted in market-based approach

CC10.2 Please indicate which other Scope 2 emissions breakdowns you are able to provide (tick all that apply)

- By business division (CC10.2a)
- By facility (CC10.2b)
- By activity (CC10.2c)

Where a breakdown option has been ticked, a table appears to allow you to enter the relevant emissions data

Emissions

CC11. Energy

CC11.1 What percentage of your total operational spend in the reporting year was on energy?

CC11.2 Please state how much heat, steam, and cooling in MWh your organization has purchased and consumed during the reporting year

Energy type	MWh
Heat	
Steam	
Cooling	

CC11.3 Please state how much fuel in MWh your organization has consumed (for energy purposes) during the reporting year

CC11.3a Please complete the table by breaking down the total "Fuel" figure entered above by fuel type

Fuels	MWh

CC11.4 Please provide details of the electricity, heat, steam or cooling amounts that were accounted at a low carbon emission factor in the market-based Scope 2 figure reported in CC8.3a **(CDP 2016 CC11.4, amended)**

Basis for applying a low carbon emission factor	MWh consumed associated with low carbon electricity, heat, steam or cooling	Emissions factor (in units of metric tonnes CO2e per MWh)	Comment

CC11.5 Please report how much electricity you produce in MWh, and how much electricity you consume in MWh

Total electricity consumed (MWh)	Consumed electricity that is purchased (MWh)	Total electricity produced (MWh)	Total renewable electricity produced (MWh)	Consumed renewable electricity that is produced by company (MWh)	Comment

Emissions

CC12. Emissions Performance

Emissions History

CC12.1 How do your gross global emissions (Scope 1 and 2 combined) for the reporting year compare to the previous year?

If emissions have increased, decreased or remained the same overall:

CC12.1a Please identify the reasons for any change in your gross global emissions (Scope 1 and 2 combined) and for each of them specify how your emissions compare to the previous year

Reason	Emissions value (percentage)	Direction of change	Please explain and include calculation
Emissions reduction activities			
Divestment			
Acquisitions			
Mergers			
Change in output			
Change in methodology			
Change in boundary			
Change in physical operating conditions			
Unidentified			
Other			

CC12.1b Is your emissions performance calculations in CC12.1 and CC12.1a based on a location-based Scope 2 emissions figure or a market-based Scope 2 emissions figure?

Emissions Intensity

CC12.2 Please describe your gross global combined Scope 1 and 2 emissions for the reporting year in metric tonnes CO_2e per unit currency total revenue

Intensity figure =	Metric numerator (Gross global combined Scope 1 and 2 emissions)	Metric denominator: Unit total revenue	Scope 2 figure used	% change from previous year	Direction of change from previous year	Reason for change
	metric tonnes CO_2e					

Emissions

CC12.3 Please provide any additional intensity (normalized) metrics that are appropriate to your business operations

Intensity figure =	Metric numerator (Gross global combined Scope 1 and 2 emissions)	Metric denominator	Metric denominator: Unit total	Scope 2 figure used	% change from previous year	Direction of change from previous year	Reason for change
	metric tonnes CO_2e						

***ICT companies** can use the sector module to respond to this question*

CC13. Emissions Trading

CC13.1 Do you participate in any emissions trading schemes?

If yes: CC13.1a Please complete the following table for each of the emission trading schemes in which you participate

Scheme name	Period for which data is supplied	Allowances allocated	Allowances purchased	Verified emissions in metric tonnes CO_2e	Details of ownership

And if "Yes" or "No, but we anticipate doing so within the next 2 years":

CC13.1b What is your strategy for complying with the schemes in which you participate or anticipate participating?

CC13.2 Has your organization originated any project-based carbon credits or purchased any within the reporting period?

If yes: CC13.2a Please provide details on the project-based carbon credits originated or purchased by your organization in the reporting period **(CDP 2016 CC13.2a, amended)**

Credit origination or credit purchase	Project type	Project identification	Verified to which standard	Number of credits (metric tonnes CO_2e)	Number of credits (metric tonnes CO_2e): Risk adjusted volume	Credits cancelled	Purpose, e.g. compliance

Emissions

CC14. Scope 3 Emissions

CC14.1 Please account for your organization's Scope 3 emissions, disclosing and explaining any exclusions

***Auto-manufacturers** should refer to the sector module before completing question CC14.1*

Sources of Scope 3 emissions	Evaluation status	metric tonnes CO_2e	Emissions calculation methodology	Percentage of emissions calculated using data obtained from suppliers or value chain partners	Explanation
Purchased goods and services					
Capital goods					
Fuel-and-energy-related activities (not included in Scope 1 or 2)					
Upstream transportation and distribution					
Waste generated in operations					
Business travel					
Employee commuting					
Upstream leased assets					
Investments					
Downstream transportation and distribution					
Processing of sold products					
Use of sold products					
End of life treatment of sold products					
Downstream leased assets					
Franchises					
Other (upstream)					
Other (downstream)					

CC14.2 Please indicate the verification/assurance status that applies to your reported Scope 3 emissions

If Scope 3 emissions have been subject to third party verification or assurance (complete or underway):

CC14.2a Please provide further details of the verification/assurance undertaken, and attach the relevant statements

Verification or assurance cycle in place	Status in the current reporting year	Type of verification or assurance	Attach the statement	Page/ Section reference	Relevant standard	Proportion of reported Scope 3 emissions verified (%)

Emissions

CC14.3 Are you able to compare your Scope 3 emissions for the reporting year with those for the previous year for any sources?

If yes: CC14.3a Please identify the reasons for any change in your Scope 3 emissions and for each of them specify how your emissions compare to the previous year

Sources of Scope 3 emissions	Reason for change	Emissions value (percentage)	Direction of change	Comment

CC14.4 Do you engage with any of the elements of your value chain on GHG emissions and climate change strategies? (Tick all that apply)

- Yes, our suppliers
- Yes, other partners in the value chain
- Yes, our customers
- No, we do not engage

If "Yes, our customers" or "Yes, other partners in the value chain" is ticked:
CC14.4a Please give details of methods of engagement, your strategy for prioritizing engagements and measures of success

If "Yes, our suppliers" is ticked
CC14.4b To give a sense of scale of this engagement, please give the number of suppliers with whom you are engaging and the proportion of your total spend that they represent **(CDP 2016 CC14.4b and CC14.4c, amended)**

Type of engagement	Number of suppliers	% of total spend (direct and indirect)	Impact of engagement

If "No, we do not engage" is ticked:
CC14.4c Please explain why you do not engage with any elements of your value chain on GHG emissions and climate change strategies, and any plans you have to develop an engagement strategy in the future **(CDP 2016 CC14.4d)**

Sign Off

CC15.1 Please provide the following information for the person that has signed off (approved) your CDP climate change response **(CDP 2016 CC15.1, amended)**

Name	Job title	Corresponding job category

Important Information

CDP is an independent not-for-profit organization that has been requesting information relating to carbon and climate change on behalf of investors since 2002.

Thousands of organizations from across the world's major economies measure and disclose their environmental information through CDP. CDP puts this information at the heart of financial and policy decision-making and its goal is to collect and distribute high quality information that motivates investors, corporations and governments to act to prevent dangerous climate change and protect our natural resources.

To find out more about CDP and the previous responses from other organizations, please refer to our website at www.cdp.net.

Why is this request from a group of shareholders and lenders to a group of companies rather than from an individual shareholder or lender to an individual company?

1. To reduce the reporting burden – one standardized request that requires one corporate response that is then delivered by CDP to multiple investors (note that CDP also works with the Global Reporting Initiative (GRI) to ensure that this request and the GRI indicators are closely aligned and complementary); and
2. To standardize responses and data – data is captured and presented back to investors in a common format.

However, companies should not consider their CDP response a means of complying with any regulatory requirement to share financially sensitive non-public information with the market.

Which companies will be asked to respond in 2017?
Companies participating in CDP's programs are selected using economic (market) and environmental criteria. Please refer to our website at https://www.cdp.net/samples to learn more about the companies targeted by each program and the selection criteria used.

How can a company confirm its participation?
On receipt of the emailed request, please register via the URL provided. If you have not received the request via e-mail please e-mail respond@cdp.net to confirm your participation in CDP 2017. **Please note that your response is subject to CDP's Terms for responding companies – investor climate change request which are set out on the following pages.**

What is the legal status of CDP?
CDP Worldwide (CDP) is a UK Registered Charity no. 1122330 and a company limited by guarantee registered in England no. 05013650. The charity has wholly owned subsidiaries in Germany and China and companies in Australia, Brazil and India over which it exercises control through majority Board representation. In the US, CDP North America, Inc. is an independently incorporated affiliate which has United States IRS 501(c)(3) charitable status.

Terms for responding companies – investor climate change request

1. DEFINITIONS

Billing Company: means the organization determined in accordance with the table at the end of these terms.

CDP: means CDP Worldwide, a charitable company registered with the Charity Commission of England and Wales (registered charity no. 1122330 and a company number 05013650). References to "**we**", "**our**" and "**us**" in these terms are references to CDP and the Billing Company.

Deadline: means 29 June 2017.

Fee: means the fee set out in the table at the end of these terms, which is exclusive of any applicable taxes.

Information Request: means CDP's 2017 Climate Change Information Request.

Responding Company: means the company responding to the Information Request. References to "**you**" and "**your**" in these terms are references to the Responding Company.

2. PARTIES

The parties to these terms shall be CDP, the Billing Company (where the Billing Company is not CDP) and the Responding Company.

3. THESE TERMS

These are the terms that apply when you respond to our Information Request. If you do not agree to these terms please contact us at respond@cdp.net to discuss them with us.

4. RESPONDING TO OUR INFORMATION REQUEST

General. When responding to our Information Request, you will be given a choice as to whether your response can be made public or whether your response is non-public. We strongly encourage you to make your response public.

Deadline for responding. You must submit your response to us using our online response system by the Deadline for your response to be eligible for scoring and inclusion in any reports.

Public responses. If you agree that your response can be made public, we may use and make it available for all purposes that we decide (whether for a fee or otherwise), including, for example, making your responses available on our website, to our investor signatories and other third parties and scoring your response (including publishing your score).

Non-public responses. If your response is non-public, we may use it only as follows:

(a) make it available as soon as it is received by CDP to our investor signatories (as listed on our website) either directly or through Bloomberg terminals, for any use within their organizations but not for publication unless any data from your response has been anonymized or aggregated in such manner that it has the effect of being anonymized;

(b) make it available as soon as it is received by CDP to our group companies and affiliates (for example, CDP North America, Inc), our country partners, research partners, report writers and scoring partners:

Terms for responding companies – investor climate change request

(i) to score your response and to publish that score; and

(ii) for any other use within their organizations but not for publication unless any data from your response has been anonymized or aggregated in such manner that it has the effect of being anonymized.

Amending your response. You may amend a response that you have submitted at any time before the Deadline. After the Deadline has passed, your response can only be amended by our staff and we may charge a fee. Please note that any changes that you make to your response after the Deadline may not be reflected in any score or in any report.

Scoring of responses. If you submit your response to us using our online response system by the Deadline your response will be scored. If you submit your response after the Deadline but on or before 29 September 2017 you can choose to request an ‘On-Demand’ score for a fee. Please email scorefeedback@cdp.net for more information.

5. FEE

Fee. We are a not-for-profit organization and charge certain companies an annual administrative fee to enable us to maintain the disclosure system. Unless you are exempt from paying the Fee, as set out below, if you are listed, incorporated or headquartered in a country that is listed in the next paragraph, you are required to pay the Fee plus any applicable taxes. The Fee is payable once regardless of how many responses (climate change, forests and water) you submit in 2017. Please note that we may charge an additional fee if you want to change your response after you have submitted your response and you are seeking to make the change after the Deadline or if you submit your response after the Deadline and you would like it to be scored.

Countries where the Fee applies. A Responding Company will be required to pay the Fee if it is listed, incorporated or headquartered in any one of the following countries:

Argentina, Australia, Austria, Bahamas, Belgium, Brazil, Canada, Cayman Islands, Channel Islands, Chile, Colombia, Denmark, Finland, France, Germany, Hong Kong, Iceland, India, Indonesia, Ireland, Italy, Luxembourg, Malaysia, Mexico, Netherlands, Norway, Peru, Philippines, Portugal, Singapore, South Africa, South Korea, Spain, Sweden, Switzerland, Taiwan, Thailand, the UK or the USA.

Exemptions from the Fee. A Responding Company is exempt from paying the Fee if:

(a) it falls within one of CDP’s investor samples and it has not submitted a response to CDP in the last three years; or

(b) it is responding only to CDP’s supply chain request.

Please note we will decide in our absolute discretion as to whether the Fee is payable or not and we will notify you before you submit your response. A full list of companies in our investor samples is available on our website.

Payment of the Fee. You must pay the Fee by credit or debit card or request an invoice via CDP’s online portal, which must be paid within such time as set out in the invoice. Please note that you will not be able to submit your response unless you have paid the Fee, you have requested an invoice or you are exempt from paying the Fee.

Terms for responding companies – investor climate change request

6. RIGHTS IN THE RESPONSES

Ownership. All intellectual property rights in your response will be owned by you or your licensors.

License. You grant to us, or shall procure for us, a perpetual, irrevocable, non-exclusive, assignable, sub-licensable, royalty-free and global license to use your response and all intellectual property rights in your response for all purposes.

7. IMPORTANT REPRESENTATIONS

You confirm that:

(a) the person submitting the response to us is authorized by you to submit the response;

(b) you have obtained all necessary consents and permissions to submit the response to us; and

(c) the response that you submit does not infringe the rights of any third party.

8. LIABILITY

We do not exclude or limit in any way our liability to you where it would be unlawful to do so. This includes liability for death or personal injury caused by our negligence or the negligence of our employees, agents or subcontractors; for fraud or fraudulent misrepresentation.

We are not liable for business losses. Subject to these terms, CDP and the Billing Company have no liability to you in any circumstances for any loss of revenue, loss of profit, loss of business, business interruption, loss of business opportunity, loss of goodwill, loss of reputation, loss of, damage to or corruption of data or software or any indirect or consequential loss or damage.

Exclusion of liability. Subject to these terms, CDP and the Billing Company have no liability to you in any circumstances arising from the submission of your response to us, our use of your response and/or the use of your response by any third parties.

Limitation of liability. Subject to these terms, CDP and the Billing Company's total liability to you in all circumstances shall be limited to an amount equivalent to the Fee or to £625 if you are not required to pay the Fee.

9. GENERAL

We may transfer our rights to someone else. We may transfer our rights and obligations under these terms to another organization.

Nobody else has any rights under these terms. These terms are between you and us. No other person shall have any rights to enforce any of its terms.

Entire agreement. These terms constitute the entire agreement between you and us unless you also choose to share your response with supply chain members, in which case you will also be subject to our Terms for responding companies – supply chain request.

Variation. CDP (acting on its own behalf and the Billing Company's behalf, if applicable) reserves the right to change these terms at any time. Such changes shall be effective immediately or such other time as CDP elects. In the event of any materially adverse changes, you may request to withdraw your response within 30 days of us notifying you of the change.

Terms for responding companies – investor climate change request

If a court finds part of these terms illegal, the rest will continue in force. Each of the paragraphs of these terms operates separately. If any court or relevant authority decides that any of them are unlawful, the remaining paragraphs will remain in full force and effect.

Governing law and jurisdiction. These terms are governed by English law and you and us both agree to the exclusive jurisdiction of the English courts to resolve any dispute or claim arising out of or in connection with these terms or their subject matter or formation.

Language. If these Terms are translated into any language other than English, the English language version will prevail.

10. FEE

Location of Responding Company	Fee (exclusive of any applicable taxes)
UK	£625
Europe (excluding UK)	€925
Rest of the world	US$975

11. BILLING COMPANY

Billing Company	CDP Worldwide	CDP Worldwide (Europe) gGmbH	CDP North America, Inc	Carbon Disclosure Project (Latin America)	Carbon Disclosure Project India
Location of Responding Company	Australia	Austria	Canada	Argentina	India
	Bahamas	Belgium	USA	Brazil	
	Cayman Islands	Denmark		Chile	
	Channel Islands	Finland		Colombia	
	Hong Kong	France		Mexico	
	Indonesia	Germany		Peru	
	Ireland	Iceland			
	Malaysia	Italy			
	Philippines	Luxembourg			
	Singapore	Netherlands			
	South Africa	Norway			
	South Korea	Portugal			
	Taiwan	Spain			
	Thailand	Sweden			
	United Kingdom	Switzerland			

If the Responding Company is located in a territory that is not listed in the table above, the Billing Company shall be CDP Worldwide.