THE CITY-zen

ROADSHOW
COLIN ENERGY SCENARIOS

Siebe Broersma, Riccardo Pulselli, Han Vandevyvere, Kirstin O' Regan, Aimee McAvoy, Cathal Crumley, Brendan Holbeach
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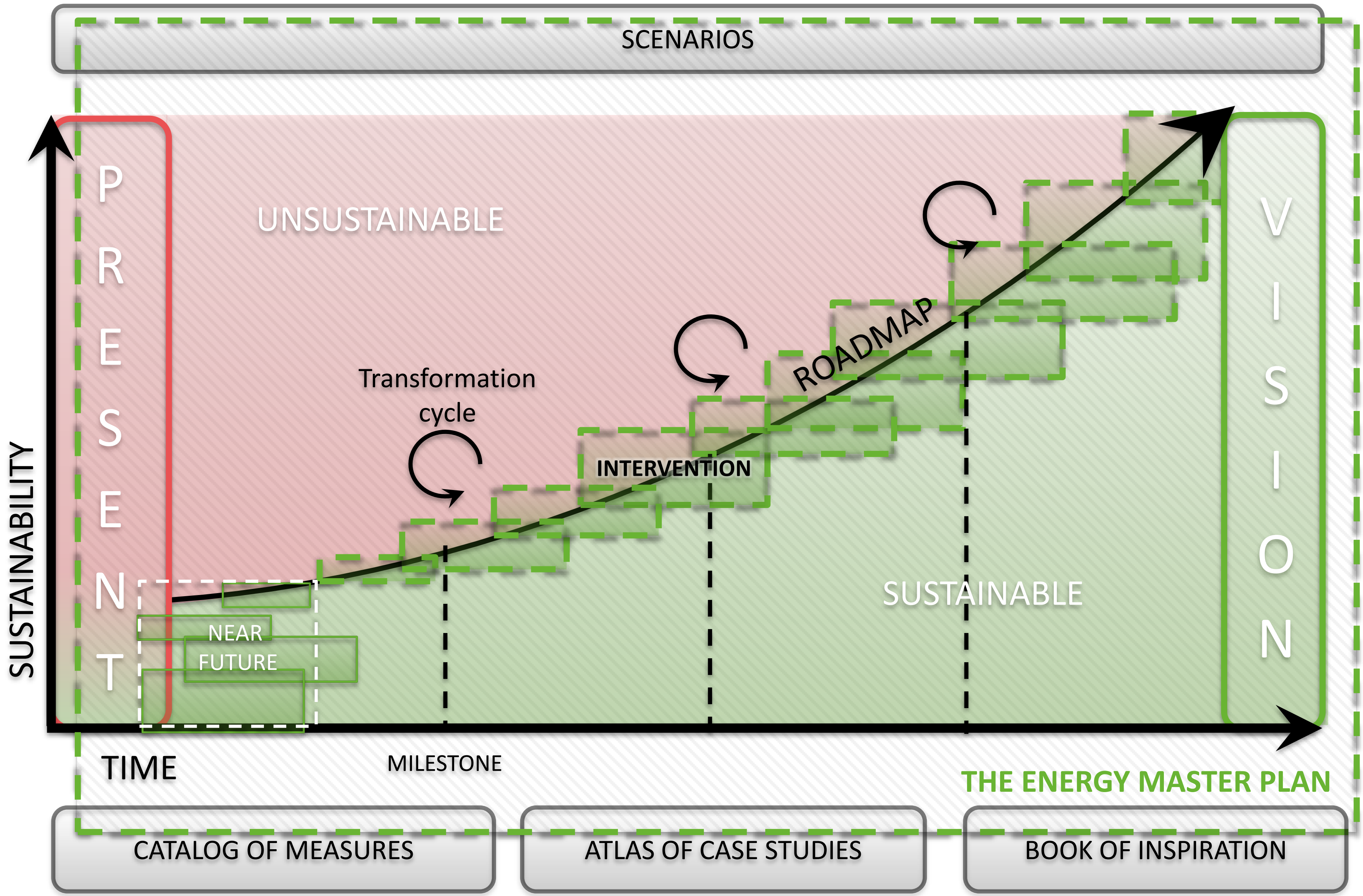
ENERGY MASTER PLAN FRAMEWORK



CARBON FOOTPRINT PER HOUSE = 5.92 t CO_2eq/yr

households 2.68 n.
avg floor area 82.6 m^2
avg built area 35.4 m^2

CARBON EMISSION
5.55 t CO_2eq

ENERGY

electricity demand 3191 kWh/yr
heat demand 15383 kWh/yr
gas for heating (52% of households) 1042 m^3/yr
oil for heating (48% of households) 926 kg/yr

CARBON EMISSION
0.2 t CO_2eq

MOBILITY

vehicles 0.6 n.
driven distance 1314 km/yr

CARBON EMISSION
0.17 t CO_2eq

WASTE MANAGEMENT

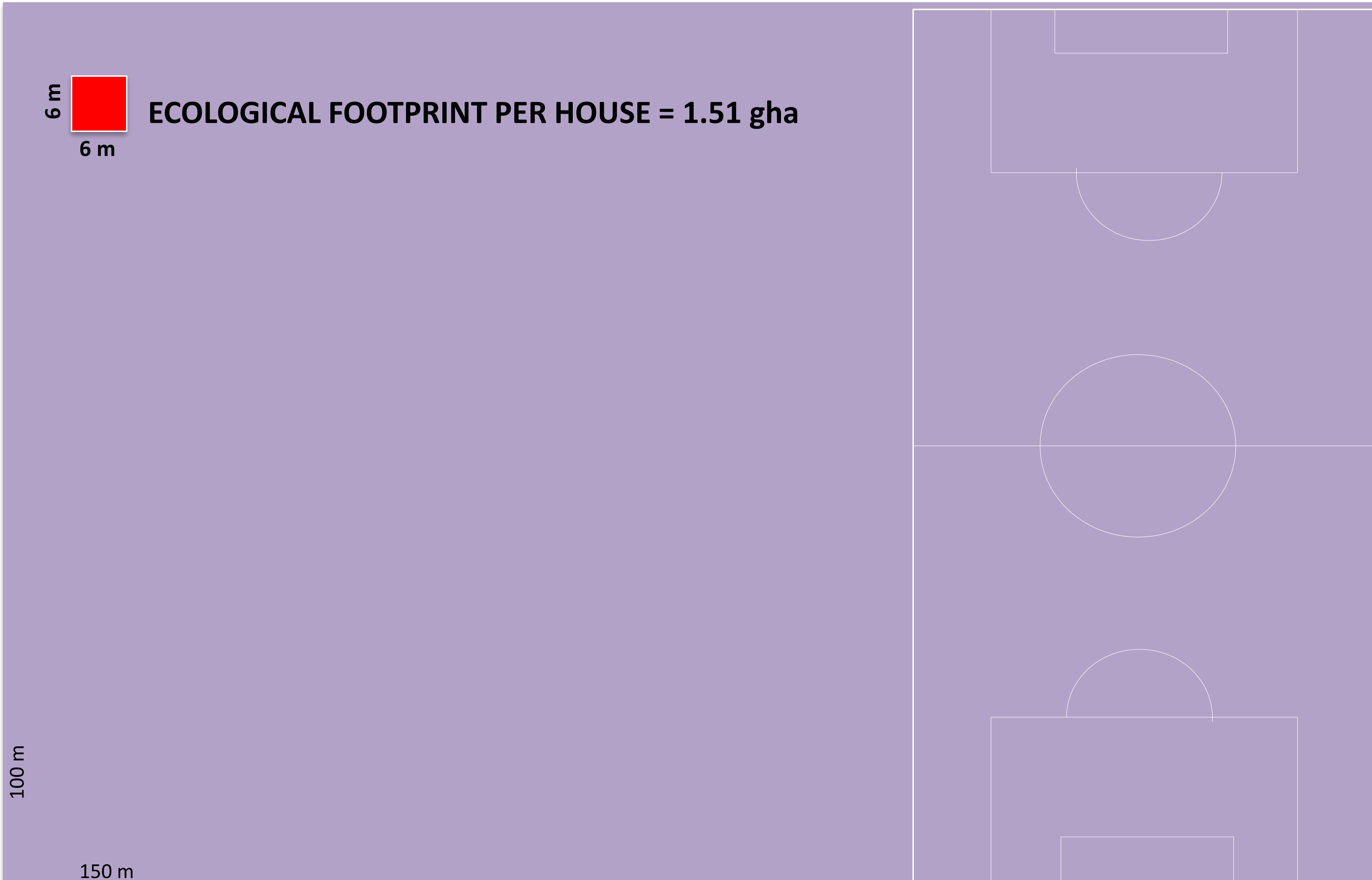
waste production 284 kg/yr
waste to landfill 40%
waste to energy 16%
waste to recycling & compost 44%

CARBON UPTAKE
- 3 kg CO_2eq

GARDEN

private garden 9.9 m^2

CARBON FOOTPRINT PER HOUSE
includes energy use, car driving and waste management



ECOLOGICAL FOOTPRINT PER HOUSE

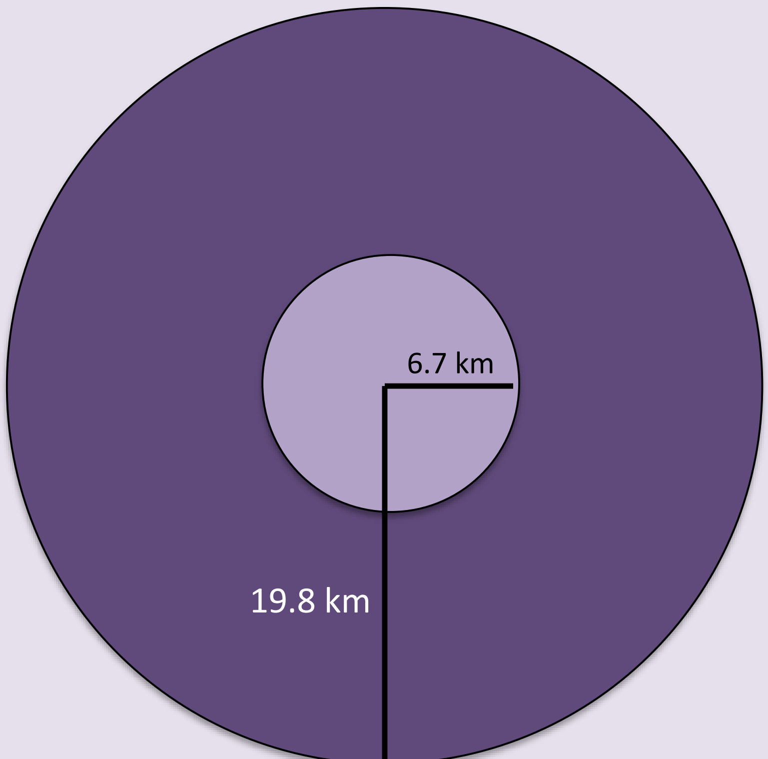
includes energy use, car driving and waste management

TOTAL ECOLOGICAL FOOTPRINT per HOUSEHOLD

avg. ecological footprint per capita: 5 gha/person; 2.7 people/household

COLIN DISTRICT ECOLOGICAL FOOTPRINT, HOUSEHOLD RATE = 13,951 gha

COLIN DISTRICT TOTAL ECOLOGICAL FOOTPRINT = 124,071 gha



households n. 9259
Population 24,814 n.
avg ecological footprint 5gha/person

HOUSEHOLDS RATE includes:
energy use
car driving
waste management

TOTAL FOOTPRIN includes:
purchased goods
food consumption
extended transport
other waste

COLIN DISTRICT ECOLOGICAL FOOTPRINT

avg ecological footprint 5 gha per person

MEASURES

From the catalogue of measures (single techniques, measures, combination of technologies)
From the atlas of case studies (built examples)

MEASURE

GEO/TECH	kWh/ha, climate parameters
TECH	Efficiency, requirements, combination opportunities
ECON/FIN	€ / kWh, financing, subsidies
LEGAL	Laws, regulations, procedures
SOCIAL	Stakeholder, commitment, mindset

CATALOG OF MEASURES

ATLAS OF CASE STUDIES

MEASURES

List of potentially suitable energy measures

Energy Efficiency

- Insulation;
  - roof
  - high performance windows
  - Wall
  - Floor
- Air tightness
- Installation efficiency
  - upgrade heating installation
  - efficient mechanical ventilation/ ventilation with heat recovery
- Add greenhouse
- Demolition & reconstruction
- Urban densification with higher building compactness
- Smart grid (electric – demand side management)

List of potentially suitable energy provision measures

- PV on roofs (facades); road-side PV; PV power plant
- Solar thermal on roofs; Solar thermal plant; Road solar collector
- Large wind turbine; Micro wind turbine
- Biomass
  - individual biomass boiler
  - local heat network + central boiler/ CHP
  - local heat network + bio digester + CHP
- Heat pump individual (incl buffer),
  - on air
  - ground loop heat exchanger (horizontal)
  - ground loop heat exchanger (vertical)
- Collective heat pump + heat network
  - ground loop heat exchanger (horizontal)
  - ground loop heat exchanger (vertical)
  - H/C storage in aquifer; in ground; watertank
- Waste heat utilization
- Smart grid (electric)

MEASURES

List of non-technical measures

- Behavioural change
- Subsidies
- Local energy company (e.g. cooperative)
- Smart financing scemes

SUITABLE ENERGY SYSTEMS

Combined energy measures:

Scheme 1: Basic short term individual improvement (standard home renovation) + long term scenario development

- Basic insulation + high performance individual condensing gas boiler
  - Insulation;
    - roof
    - high performance windows
    - insulating existing cavity of walls
    - improving air tightness
  - Installation efficiency
    - upgrade heating installation: individual condensing boiler
    - basic mechanical ventilation
  - Optional:
    - PV-roof
    - Solar thermal boiler
- Next phase planning
  - organise LT stepwise transition to high energy performance
  - organise corresponding financial planning
  - at the neighbourhood scale: (1) plan urban **densification** on empty spaces where appropriate and (2) plan **replacement** of worst performing patrimony (demolition and reconstruction on site or elsewhere). Approach prevents dislocating people expect to new and better housing.

Scenario 1: Basic short term individual improvement (standard home renovation) + long term scenario development at Woodside

Action | Result

Existing Neighbourhood

- Minimal insulation

Heat demand 4200 MWh/y
Electricity demand 874 MWh/y
CO_2 emissions 1516 t CO_2eq/y

Basic Insulation Solution
Insulation;
- Roof
- High performance windows
- Insulating existing cavity of walls
- Improving air tightness
- Installation efficiency
- Changing heating system
- Basic mechanical ventilation

H 2706 MWh/y
E 874 MWh/y
CO_2 (avoided) 371 t CO_2eq/y

Optional

- PV-roof
- Solar thermal boiler

Next Planning Phase

- Organise LT stepwise transition to high energy performance
- Organise corresponding financial planning
- At the neighbourhood scale:

1. plan urban densification on empty spaces where appropriate and

2. plan replacement of worst performing patrimony (demolition and reconstruction on site or elsewhere).

Approach prevents dislocating people expect to new and better housing.

Phase A

H 1982 MWh/y
E 640 MWh/y
CO2 (avoided) 777 t CO_2eq/y

Phase B

H 991 MWh/y
E 320 MWh/y
CO2 (avoided) 420 t CO_2eq/y

Phase C

H 0 MWh/y
E 0 MWh/y
CO2 (avoided) 420 t CO_2eq/y


Bottière-Chênaie, Nantes, France


Hannover Kronsberg, Habitat


Anemoon Project, Tienen


Hannover Kronsberg, Habitat


Orsoyer Strasse, Düsseldorf, Germany

Calculations scheme 1.

1. Basic retrofit + densification and replacement				energy demand	energy saved	CO2 emmision	avoided CO2
Woodside area				(MWh/y)	(MWh/y)	(t CO2eq/y)	(t CO2eq/y)
0	N houses	273					
	heat demand	4200105	kWh	4200		1042	
	electricity demand	873600	kWh	874		474	
	Total:			**5074**		**1516**	
1	heat demand after retrofit	120	kWh/m2				
	heat demand neighbourhood	2705976	kWh/y	2706	1494		371
2	N old houses	200					
	N new houses	146					
	electricity demand	640000	kWh	640	234		127
	heat demand	1982400	kWh	1982	2218		550
3	N old houses	100					
	N new houses	346					
	electricity demand	320000	kWh	320	320		174
	heat demand	991200	kWh	991	991		246
4	N old houses	0					
	N new houses	546					
	electricity demand	0	kWh	0	320		174
	heat demand	0	kWh	0	991		246

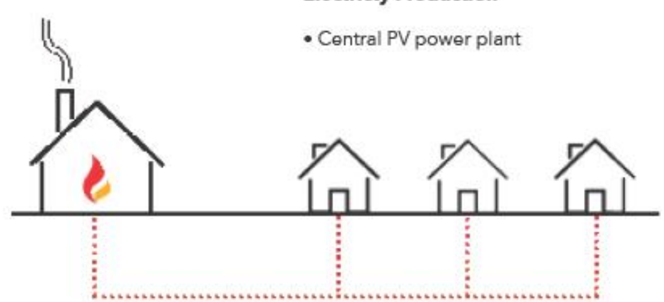
Combined energy measures:

Scheme 2: Biomass based high performance neighbourhood with deep renovation and PV

- High performance improvement
  - insulation;
    - roof
    - high performance windows
    - walls
    - floors
  - optional: greenhouse addition, other high performance additions to dwellings based on family needs
  - air tightness
  - installation efficiency
    - change heating system
    - efficient mechanical ventilation / ventilation with heat recovery
- Biomass
  - local heat network + central boiler
- PV
  - PV on roof tops
  - central small PV power plant

Scenario 2: Biomass based high performance neighbourhood with deep renovation at Laural Bank & Glenwood

Eco Zathe Heat and Power Plant, Leeuwarden



Action	Result	
Existing build • Heat demand • Electricity demand • CO_2 emissions	Heat demand Electricity demand CO_2 emissions	5600 MWh/y 1165 MWh/y 2021 t CO_2eq/y
High performance improvement Insulation; • Roof • High performance windows • Walls • Floors Air Tighness Installation Efficiency; • change heating system • efficient mechanical ventilation / ventilation with heat recovery	H E CO_2 (avoided) Area for Biomass Waste from maintenance of green space	1503 MWh/y 1165 MWh/y 1016 t CO_2eq/y 119 Hectares (Half of Colin)
Electricity production • PV on roofs **Optional:** • Greenhouse addition, other high performance additions to dwellings based on family needs	H E CO2 (avoided) PV per roof	1503 MWh/y 284 MWh/y 478 t CO_2eq/y 18m²
Biomass • Local heat network + Central boiler **Electricty Production** • Central PV power plant	H E CO2 (avoided) Area of PV power plant	0 MWh/y 0 MWh/y 527 t CO_2eq/y 2076m²

SUITABLE ENERGY SYSTEMS

Calculations scheme 2.

2. High performance retrofit & biomass heat network & PV				energy demand	energy saved	CO2 emmision	avoided CO2
Lauralbankstreet & Glenwood				(MWh/y)	(MWh/y)	(t CO2eq/y)	(t CO2eq/y)
0	N houses	364					
	heat demand	5600140	kWh	5600		1389	
	electricity demand	1164800	kWh	1165		632	
	Total:			**6765**		**2021**	
1	A-label heat demand	50	kWh/m2				
	heat demand	1503320	kWh	1503	4097		1016
2	harvestable woody biomass per hectare	12667	kWh/ha				
	hectare needed to heat the area	119	ha	0	1503		373
3	avg solar insolation	876	kWh/m2hor-y				
	avg solar insolation	912	kWh/m2-30deg-y				
	avg PV system efficiency	15%					
	projected hor surface area buildings	12878	m2				
	avg hor surf area per house	35,4	m2				
	av available part for solar production	50%					
	available surface per house	17,7	m2				
	annual elctricity production on roofs	880855	kWh	284	881		478
	stil needed electricity	283945	kWh				
	PV power plant	2076	m2	0	284		154

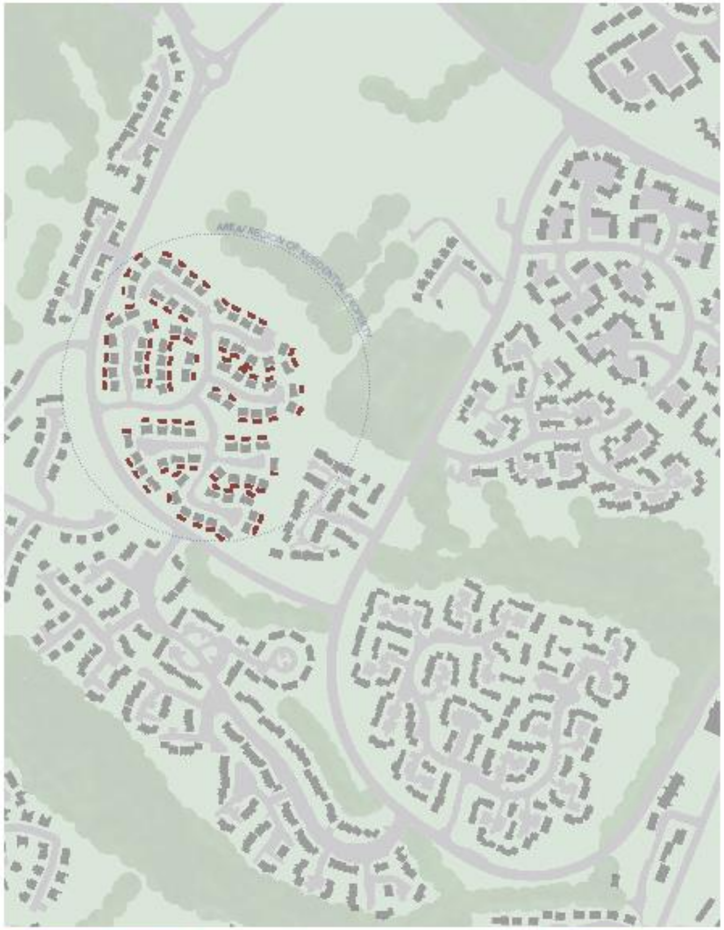
Combined energy measures:

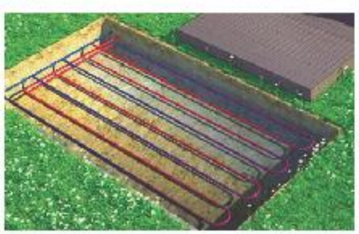
Scheme 3A: Heat pump based high performance individual with deep renovation (horizontal collectors)

- High performance improvement
  - insulation;
    - roof
    - high performance windows
    - walls
    - floors
  - optional: greenhouse addition, other high performance additions to dwellings based on family needs
  - air tightness
  - installation efficiency
    - change heating system
    - efficient mechanical ventilation / ventilation with heat recovery
- Heat pump
  - individual HP + buffer (e.g. 200 l)
  - horizontal heat exchanger
- PV on roofs

Note: PV is added to become fully energy neutral

Scenario 3a: Heat pump based high performance individual with deep renovation (horizontal collectors) at Glenkeen





Horizontal heat exchanger

	Action	Result
	**Existing build** • Heat demand • Electricity demand • CO_2 emissions	Heat demand 1631 MWh/y Electricity demand 339 MWh/y CO_2 emissions 589 t CO_2eq/y
	**High performance improvement** Insulation; • Roof • High performance windows • Walls • Floors Air Tighness Installation Efficiency; • change heating system • efficient mechanical ventilation / ventilation with heat recovery	H 438 MWh/y E 339 MWh/y CO_2 (avoided) 296 t CO_2eq/y
	**Optional** • Greenhouse addition, other high performance additions to dwellings based on family needs	
	**Heat Pump** • Individual HP + buffer (e.g. 200 l) • Horizontal heat exchanger **PV on roofs**	H 0 MWh/y E 448 MWh/y CO2 (avoided) 89 t CO_2eq/y Electricity demand goes up due to the use of the heatpump H 0 MWh/y E 0 MWh/y CO2 (avoided) 236 t CO_2eq/y PV area: 30m2/house

Calculations scheme 3A.

3A. high perf retrofit individual with deep renovation (horizontal collectors)				energy demand	energy saved	CO2 emmision	avoided CO2
Glenkeen				(MWh/y)	(MWh/y)	(t CO2eq/y)	(t CO2eq/y)
0	N houses	106					
	heat demand	1630810	kWh	1631		404	
	electricity demand	339200	kWh	339		184	
	Total:			**1970**		**589**	
1	A-label heat demand	50	kWh/m2				
	heat demand	437780	kWh	438	1193		296
2	Indiv heat pump with hor heat exchangers	4	C.O.P.				
	heat demand	0	kWh	0			
	new electricity demand for heat pump	109445		109	328		81
	total electricity demand	448645		449			
3	avg solar insolation	912	kWh/m2-30deg-y				
	avg PV system efficiency	15%					
	available surface per house	30,0	m2				
	annual elctricity production on roofs	435024	kWh	14	435		236
	stil needed electricity/ excess energy	13621	kWh	14			

SUITABLE ENERGY SYSTEMS

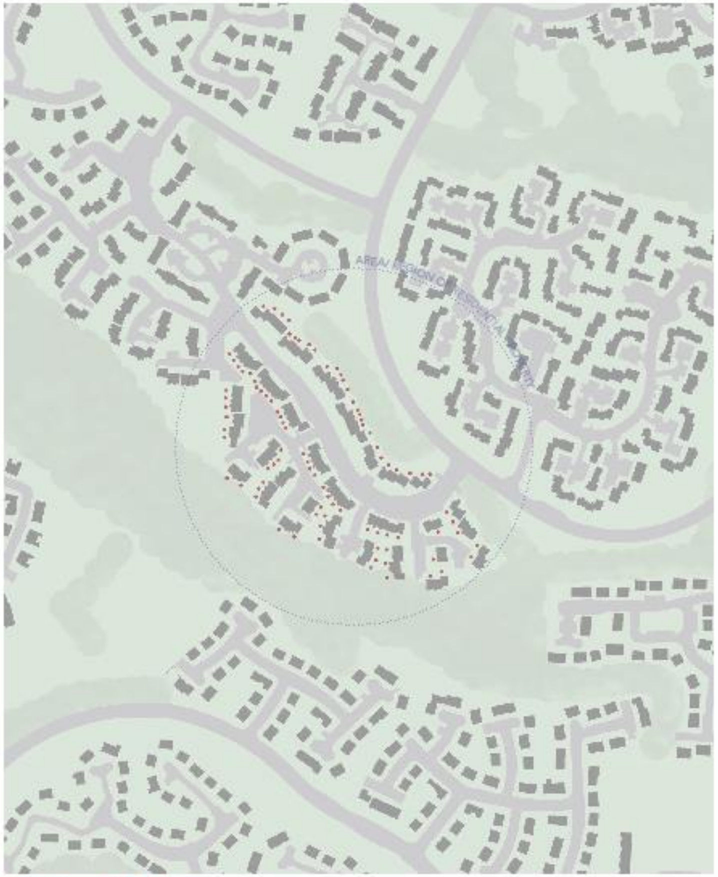
Combined energy measures:

Scheme 3B: Heat pump based high performance individual with deep renovation (vertical collectors)

- High performance improvement
  - insulation;
    - roof
    - high performance windows
    - walls
    - floors
  - optional: greenhouse addition, other high performance additions to dwellings based on family needs
  - air tightness
  - installation efficiency
    - change heating system
    - efficient mechanical ventilation / ventilation with heat recovery
- Heat pump
  - individual HP + buffer (e.g. 200 l)
  - vertical heat exchanger
- PV on roofs

Note: PV is added to become fully energy neutral

Scenario 3b: Heat pump based high performance individual with deep renovation (vertical collectors) at Glenbawn



Vertical Heat pump collectors

Deep renovation - External wall Insulation

Action		Result	
	**Existing build** • Heat demand • Electricity demand • CO_2 emissions	Heat demand Electricity demand CO_2 emissions	2031 MWh/y 422 MWh/y 733 t CO_2eq/y
	**High performance improvement** Insulation; • Roof • High performance windows • Walls • Floors Air Tighness Installation Efficiency; • change heating system • efficient mechanical ventilation / ventilation with heat recovery	H E CO_2 (avoided)	545 MWh/y 422 MWh/y 368 t CO_2eq/y
	**Optional** • Greenhouse addition, other high performance additions to dwellings based on family needs		
	**Heat Pump** • Individual HP + buffer (e.g. 200 l) • Vertical heat exchanger	H E CO2 (avoided) Electricity demand goes up due to the use of the heatpump	0 MWh/y 531 MWh/y 108 t CO_2eq/y
	PV on roofs	H E CO2 (avoided) PV area: 30m2/house	0 MWh/y -10 MWh/y 238 t CO_2eq/y

Calculations scheme 3B.

3B. high perf retrofit individual with deep renovation (vertical collectors)				energy demand	energy saved	CO2 emmision	avoided CO2
Glenkeen				(MWh/y)	(MWh/y)	(t CO2eq/y)	(t CO2eq/y)
0	N houses	132					
	heat demand	2030820	kWh	2031		504	
	electricity demand	422400	kWh	422		229	
	Total:			**2453**		**733**	
1	A-label heat demand	50	kWh/m2				
	heat demand	545160	kWh	545	1486		368
2	Indiv heat pump with hor heat exchangers	5	C.O.P.				
	heat demand	0	kWh	0			
	new electricity demand for heat pump	109032		109	436		108
	total electricity demand	531432		531			
3	avg solar insolation	912	kWh/m2-30deg-y				
	avg PV system efficiency	15%					
	available surface per house	30,0	m2				
	annual elctricity production on roofs	541728	kWh	-10	542		294
	stil needed electricity/ excess energy	-10296	kWh	-10			

Combined energy measures:

Scheme 3C: Heat pump based high performance individual with deep renovation (air to water)

- High performance improvement
  - insulation;
    - roof
    - high performance windows
    - walls
    - floors
  - optional: greenhouse addition, other high performance additions to dwellings based on family needs
  - air tightness
  - installation efficiency
    - change heating system
    - efficient mechanical ventilation / ventilation with heat recovery
- Heat pump
  - individual HP + buffer (e.g. 200 l)
  - air to water
- PV on roofs

Note: PV is added to become fully energy neutral

SUITABLE ENERGY SYSTEMS

Combined energy measures:

Scheme 4: central solar thermal power plant with seasonal high temperature buffer

- Basic insulation
  - Insulation;
    - roof
    - high performance windows
    - insulating existing cavity of walls
    - improving air tightness
  - Installation efficiency
    - changing heating system
    - basic mechanical ventilation
- Collective central solar thermal power plant
- Local heat network
- Collective heat pumps
- PV on roofs

Note 1: may not be feasible without deep building renovation
Note 2: PV is add to become fully energy neutral

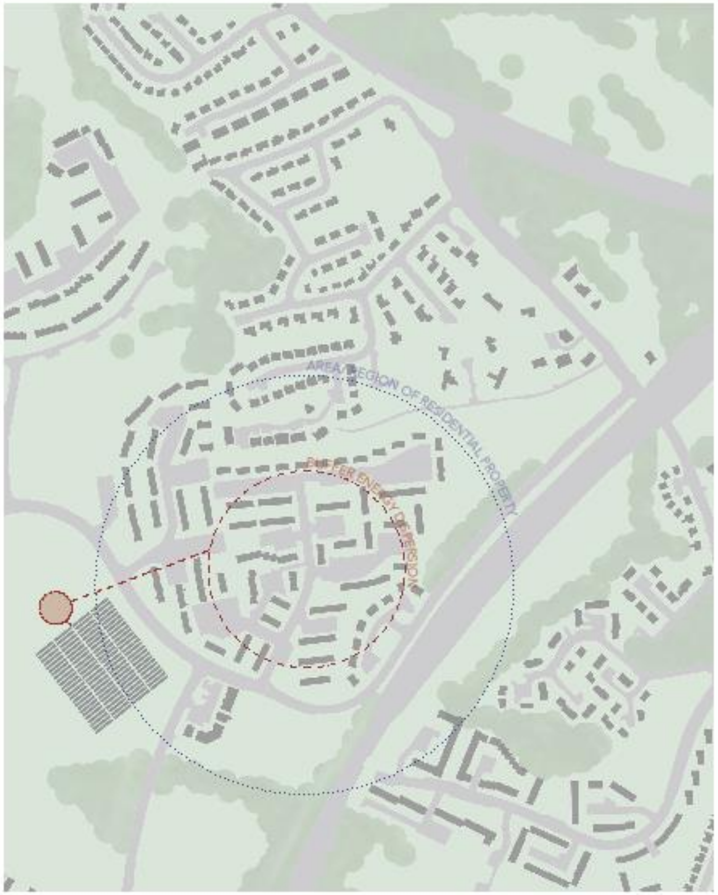
Combined energy measures:

Scheme 5: Wind based energy cooperative & with power to heat seasonal high temp buffer + PV on roofs

- Basic insulation
  - Insulation;
    - roof
    - high performance windows
    - insulating existing cavity of walls
    - improving air tightness
  - Installation efficiency
    - changing heating system
    - basic mechanical ventilation
- Collective central solar thermal power plant(s)
- Large collective buffer(s)
- Power to heat (from wind)
- Local heat network(s)
- PV on roofs

Note: scenario based on Northern Ireland situation with excess wind electricity

Scenario 5: Wind based energy cooperative & with power to heat seasonal high temp buffer at Cherry Shilin



Zoneiland, Almere

Concerto, Slazburg

Action | Result

Existing build

- Heat demand
- Electricity demand
- CO_2 emissions

Heat demand	3862 MWh/y
Electricity demand	803 MWh/y
CO_2 emissions	1394 t CO_2eq/y

Basic insulation

Insulation;

- Roof
- High performance windows
- Insulating existing cavity of walls
- Improving air tightness

Air Tighness

Installation Efficiency;

- change heating system
- efficient mechanical ventilation / ventilation with heat recovery

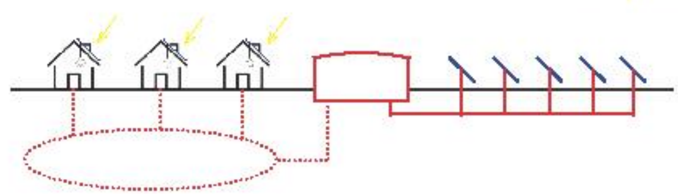
H	2073 MWh/y
E	803 MWh/y
CO_2 (avoided)	444 t CO_2eq/y

- **Collective central solar thermal power plant(s)**
- **Large collective buffer(s) based on solar and power to heat (from wind)**
- **Local heat network(s)**

H	0 MWh/y
E	803 MWh/y
CO2 (avoided)	478 t CO_2eq/y

- **PV on roofs**

H	0 MWh/y
E	0 MWh/y
CO2 (avoided)	995 t CO_2eq/y
PV per roof	30m²



Note: scenario based on Northern Ireland situation with excess wind electricity

Calculations scheme 5

5. Solar thermal powered heat network + wind excess and PV electricity				energy demand	energy saved	CO2 emmision	avoided CO2
Cherry Shilin				(MWh/y)	(MWh/y)	(t CO2eq/y)	(t CO2eq/y)
0	N houses	251					
	heat demand	3861635	kWh	3862		958	
	electricity demand	803200	kWh	803		436	
	Total:			**4665**		**1394**	
1	heat demand after retrofit	100	kWh/m2				
	heat demand neighbourhood	2073260	kWh/y	2073	1788		444
2	solar thermal production	2500	kWh/4.3m2				
	solar thermal production	581	kWh/m2				
	amount of power to heat from wind	33%					
	amount of heat from solar collectors	67%					
	system efficiency solar collectors and buffer	50%					
	electricity into heat from wind turbines	684176	kWh/y	1389	684		344
	heat produced by solar collectors	2778168	kWh/y	705	0		175
	area of solar collectors	4778	m2				
	area of solar collectors per house	19	m2				
	storage buffer per household	12	m3				
	total storage	3012	m3				
3	avg solar insolation	912	kWh/m2-30deg-y				
	avg PV system efficiency	15%					
	available surface per house	30,0	m2				
	annual electricity production on roofs	1030104	kWh	0	-227		995

Combined energy measures:

Scheme 6a: Maximum PV + wind with individual seasonal heat buffers

- Basic insulation
  - Insulation;
    - roof
    - high performance windows
    - insulating existing cavity of walls
    - improving air tightness
  - Installation efficiency
    - changing heating system
    - basic mechanical ventilation
- Maximum rooftop PV + PV farms
- Individual seasonal buffers and/or V2G storage
- Individual heat pumps (see other schemes)

Note 1: scenario based on Northern Ireland situation with excess wind electricity
Note 2: may not be feasible without deep building renovation
Note 3: batteries not required as grid can take variations

Combined energy measures:

Scheme 6b: Maximum PV + wind with collective seasonal heat buffers

- Basic insulation
  - Insulation;
    - roof
    - high performance windows
    - insulating existing cavity of walls
    - improving air tightness
  - Installation efficiency
    - changing heating system
    - basic mechanical ventilation
- Maximum rooftop PV + PV farms
- Collective seasonal buffers (may be supplemented with solar thermal)
- Combination of individual and collective heat pumps (see other schemes)

Note 1: scenario based on Northern Ireland situation with excess wind electricity
Note 2: may not be feasible without deep building renovation
Note 3: batteries not required as grid can take variations

SUITABLE ENERGY SYSTEMS

Combined energy measures:

Scheme 7: Deep geothermal + district heating + urban densification

- Basic insulation
  - Insulation;
    - roof
    - high performance windows
    - insulating existing cavity of walls
    - improving air tightness
  - Installation efficiency
    - upgrade heating installation: individual condensing boiler
    - basic mechanical ventilation
- Single deep geothermal CHP plant for Colin or Colin+
- Local heat network
- Urban densification both for housing needs and for increasing local heat demand nearby plant

Towards a roadmap

- Design 1 or more future visions with technical interventions that meet the final goals
- Back-casting: put the technical interventions on a timeline
- What are drivers and barriers to reach the targets?
- Define non-technical actions that deal with the barriers.