CITY-ZEN ROADSHOW ‘SEVILLA’
TECNOLÓGÍAS FUTURAS

THE LCA OF A CONSTRUCTION PRODUCT

Future technologies
Sustainable technologies and projects in Seville

SUSTAINABLE CONSTRUCTION in Andalusia

CITY-zen
New urban energy

Gestión de Urbanismo

Gerencia de Urbanismo

HUELLA DE CARBONO DE MENORCA

HUELLA DE CARBONO

ENERGÍA

28.640 ha

AGUA

470 ha

MOVILIDAD

18.530 ha

RESIDUOS

3.800 ha

Menorca: 92.348 habitantes.
311.230 hab. + turistas.
69.400 m2.
TECNOLOGÍAS FUTURAS

THE LCA OF A CONSTRUCTION PRODUCT

- Maintenance
- Repair, replacement, refurbishment
- Building's operational use
PARALLEL TALLERS

DAYS
2 - 4
PARALLEL TALLERS

DAYS
2 - 4

CITY-zen
New urban energy
PARALLEL TALLERS

DAYS 2 - 4
JUEGO SERIO ‘Go2Zero’
JUEGO SERIO ‘Go2Zero’
<table>
<thead>
<tr>
<th></th>
<th>HOUSEHOLD ENERGY USE</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>AVG EU</td>
<td>D</td>
<td>E</td>
<td>F</td>
<td>G</td>
</tr>
<tr>
<td>6</td>
<td>Madelyn</td>
<td>kWh/yr</td>
<td>kWh/yr</td>
<td>kWh/yr</td>
<td>kWh/yr</td>
</tr>
<tr>
<td>7</td>
<td>Jorge</td>
<td>670</td>
<td>3.177</td>
<td>335</td>
<td>113</td>
</tr>
<tr>
<td>8</td>
<td>Covadonga</td>
<td>0,5</td>
<td>0,8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Patricia</td>
<td>0,4</td>
<td>0,0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Juan</td>
<td>0,4</td>
<td>0,1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>Alejandra</td>
<td>0,4</td>
<td>0,0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>Pablo</td>
<td>0,5</td>
<td>0,1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>Regina</td>
<td>0,3</td>
<td>0,3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>John</td>
<td>1,0</td>
<td>1,0</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**SEVILLA: UNA CIUDAD DE BAJAS EMISIONES!**

**CITY-zen**
New urban energy
WALKING TOUR

DAY 3 (WED)
WALKING TOUR

DAY 3
(WED)

CITY-zen
New urban energy
PARALLEL TALLERS
VISIÓN SEVILLA SOSTENIBLE
Unit kg CO$_2$eq and the GLOBAL WARMING Potential

GWP100: CO$_2$ = 1; CH$_4$ = 34; N$_2$O = 298
ANDALUCIA (2015)

Electricity production 83.0 TWh

**THERMO-ELECTRICITY 54.98 TWh (66.2%)**
- Natural gas 19.0 TWh (22.9%)
- Coal 34.70 TWh (41.8%)
- Oil and others 1.28 TWh (1.5%)

**RENEWABLE 27.98 TWh (30.8%)**
- Solar thermal 13.70 TWh (16.5%)
- Solar PV 1.60 TWh (1.9%)
- Hydro 0.59 TWh (0.6%)
- Wind 6.39 TWh (6.2%)
- Biomass 5.70 TWh (5.6%)
- Geothermal –
- Biofuel & Waste –

**ELECTRICITY EMISSION FACTOR**
(LCA based)

0.534 kg CO₂eq/kWh

*Source: Agencia Andaluza de la Energía*
# CARBON ACCOUNTING

## CARBON FOOTPRINT ASSESSMENT OF THE PROVINCE OF SEVILLA

<table>
<thead>
<tr>
<th>Sector</th>
<th>Total CO₂eq/yr</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Residential Energy</strong></td>
<td>1,945,729</td>
<td><em>Source: Agencia Andaluza de la Energía</em></td>
</tr>
<tr>
<td>Electricity</td>
<td>3,223.84 GWh/yr</td>
<td></td>
</tr>
<tr>
<td>Natural gas</td>
<td>345.41 GWh/yr</td>
<td></td>
</tr>
<tr>
<td>Diesel</td>
<td>182.59 GWh/yr</td>
<td></td>
</tr>
<tr>
<td>LGP</td>
<td>650.12 GWh/yr</td>
<td></td>
</tr>
<tr>
<td>Biomass + thermosolar</td>
<td>594.29 GWh/yr</td>
<td></td>
</tr>
<tr>
<td><strong>Services</strong></td>
<td>1,282,478</td>
<td><em>Source: Anuario Estatístico de la Ciudad de Sevilla</em></td>
</tr>
<tr>
<td>Electricity</td>
<td>2,329.49 GWh/yr</td>
<td></td>
</tr>
<tr>
<td>Natural gas</td>
<td>252.37 GWh/yr</td>
<td></td>
</tr>
<tr>
<td>Diesel</td>
<td>36.05 GWh/yr</td>
<td></td>
</tr>
<tr>
<td>LPG</td>
<td>13.06 GWh/yr</td>
<td></td>
</tr>
<tr>
<td>Biomass + biogas</td>
<td>124.44 GWh/yr</td>
<td></td>
</tr>
<tr>
<td><strong>Primary Sector</strong></td>
<td>551,995</td>
<td></td>
</tr>
<tr>
<td>Electricity</td>
<td>282.61 GWh/yr</td>
<td></td>
</tr>
<tr>
<td>Natural gas</td>
<td>143.05 GWh/yr</td>
<td></td>
</tr>
<tr>
<td>Diesel</td>
<td>1,337.45 GWh/yr</td>
<td></td>
</tr>
<tr>
<td>LPG</td>
<td>6.98 GWh/yr</td>
<td></td>
</tr>
<tr>
<td>Biodiesel + bioethanol</td>
<td>73.27 GWh/yr</td>
<td></td>
</tr>
<tr>
<td><strong>Industrial Energy</strong></td>
<td>1,360,389</td>
<td></td>
</tr>
<tr>
<td>Electricity</td>
<td>1,600.29 GWh/yr</td>
<td></td>
</tr>
<tr>
<td>Coal</td>
<td>8.14 GWh/yr</td>
<td></td>
</tr>
<tr>
<td>Natural gas</td>
<td>1,761.95 GWh/yr</td>
<td></td>
</tr>
<tr>
<td>Diesel</td>
<td>24.42 GWh/yr</td>
<td></td>
</tr>
<tr>
<td>LPG</td>
<td>58.15 GWh/yr</td>
<td></td>
</tr>
<tr>
<td>Petroleum</td>
<td>909.47 GWh/yr</td>
<td></td>
</tr>
<tr>
<td>Biomass + biogas</td>
<td>377.98 GWh/yr</td>
<td></td>
</tr>
<tr>
<td><strong>Mobility</strong></td>
<td>2,910,884</td>
<td></td>
</tr>
<tr>
<td>Electricity</td>
<td>79.08 GWh/yr</td>
<td></td>
</tr>
<tr>
<td>Diesel</td>
<td>7,572.29 GWh/yr</td>
<td></td>
</tr>
<tr>
<td>Fuels</td>
<td>3,230.82 GWh/yr</td>
<td></td>
</tr>
<tr>
<td><strong>Waste Management</strong></td>
<td>210,981</td>
<td></td>
</tr>
<tr>
<td>Collected quantity</td>
<td>871,725 t/yr</td>
<td></td>
</tr>
<tr>
<td>Waste to landfill</td>
<td>155,952 t/yr</td>
<td></td>
</tr>
<tr>
<td>Composting</td>
<td>330,514 t/yr</td>
<td></td>
</tr>
<tr>
<td><strong>Water Management</strong></td>
<td>46,430</td>
<td></td>
</tr>
<tr>
<td>Water use</td>
<td>79,367,702 m³/yr</td>
<td></td>
</tr>
</tbody>
</table>

*Source: Agencia Andaluza de la Energía*  
*Source: Anuario Estatístico de la Ciudad de Sevilla*
CARBON FOOTPRINT ASSESSMENT OF THE PROVINCE OF SEVILLA

CARBON ACCOUNTING

CARBON FOOTPRINT
8,308,886 t CO₂eq/yr

FORESTLAND GRABBING
6155 km² forestland

existing forestland
4220 km² forest i.e. 70%

Sevilla Province
14,036 km²

Housing
23%
Services
15%
Primary sector
7%
Industry (energy use)
16%
Transport (includes flights)
35%
Waste management
3%
Water management
1%
CARBON ACCOUNTING
HOUSEHOLD PROFILE
<table>
<thead>
<tr>
<th>Category</th>
<th>Metric</th>
<th>CO₂eq/year</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>SEVILLA HOUSEHOLD (DISTRICT SUR)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Avg inhab.</td>
<td>2.6 n.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gross floor surface</td>
<td>70 m²</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>ENERGY DEMAND</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>E - Cooling</td>
<td>2,591 kg CO₂eq</td>
<td>49.4%</td>
<td></td>
</tr>
<tr>
<td>E - Lighting &amp; appliances</td>
<td>3,177 kWh/m²</td>
<td></td>
<td></td>
</tr>
<tr>
<td>H – Heating (energy mix)</td>
<td>1,116 kWh/m²</td>
<td></td>
<td></td>
</tr>
<tr>
<td>H – DHW (energy mix)</td>
<td>1,204 kWh/m²</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>MOBILITY</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Driven km/house</td>
<td>6,410 km/yr</td>
<td>44%</td>
<td>i.e. 30 km/car day</td>
</tr>
<tr>
<td><strong>WASTE MANAGEMENT</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Waste per household</td>
<td>1162.9 kg/yr</td>
<td>5.4%</td>
<td>i.e. 449 kg/cap</td>
</tr>
<tr>
<td>Waste to energy</td>
<td>0.4 %</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Waste to landfill</td>
<td>17.9 %</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Organic waste</td>
<td>37.9 %</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Recycled</td>
<td>44.2 %</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>WATER MANAGEMENT</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water use per household</td>
<td>106 m³/yr</td>
<td>1.2%</td>
<td>i.e. 112 L/day cap</td>
</tr>
<tr>
<td><strong>CARBON ACCOUNTING</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CARBON FOOTPRINT ASSESSMENT OF THE AVG. HOUSEHOLD IN SEVILLA (DISTRICT SUR)</td>
<td>5.92 t CO₂eq/yr</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ENERGY DEMAND</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>E - Cooling</td>
<td>5.04 t CO₂eq/yr</td>
<td></td>
<td></td>
</tr>
<tr>
<td>E - Lighting &amp; appliances</td>
<td>5.70 t CO₂eq/yr</td>
<td></td>
<td></td>
</tr>
<tr>
<td>H – Heating (energy mix)</td>
<td>8.50 t CO₂eq/yr</td>
<td></td>
<td></td>
</tr>
<tr>
<td>H – DHW (energy mix)</td>
<td>5.60 t CO₂eq/yr</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MOBILITY</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Driven km/house</td>
<td>49.4%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>WASTE MANAGEMENT</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Waste per household</td>
<td>4.293 kWh/yr</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Waste to energy</td>
<td>2,360 kWh/yr</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Waste to landfill</td>
<td>8.50 t CO₂eq/yr</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Organic waste</td>
<td>5.60 t CO₂eq/yr</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Recycled</td>
<td>5.25 t CO₂eq/yr</td>
<td></td>
<td></td>
</tr>
<tr>
<td>WATER MANAGEMENT</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water use per household</td>
<td>112 L/day cap</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
CARBON FOOTPRINT ASSSESSMENT OF THE AVG. HOUSEHOLD IN SEVILLA (DISTRICT SUR)

SEVILLA HOUSEHOLD

Ref: 2014-2015
People: 2.6 inhab./house
Avg surface: 70 m²/house
Electricity: 4293 kWh/yr
Heat: 1204 kWh/yr
(mix: 19% CH₄, 10% diesel, 37% LPG, 34% RES)
Mobility: 30 km/day x 1.06 car/house
Waste: 1.16 t/house yr
Water: 106 m³/house yr

The carbon footprint offset of one household is equivalent to 0.39 ha forestland

Source: Agencia Andaluza de la Energía; Anuario Estatístico de la Ciudad de Sevilla 2017
CARBON ACCOUNTING
NEIGHBOURHOOD
What is the impact of the Barrio Tiro de Linea?

1 km

BARRIO TIRO DE LINEA
14,000 inhabitants; 5364 households
BARRIO TIRO DE LINEA
14,000 inhabitants; 5364 households

Carbon Footprint: 28,136 t CO$_2$-eq
Forestland grabbing: 2084 ha
BARRIO TIRO DE LINEA
14,000 inhabitants; 5364 households

- **ELECTRICITY**: 12700 MWh
- **HEAT ENERGY**: 23000 MWh
- **MOBILITY**: 34400 km/house yr
- **WASTE**: 6240 t (1160 kg/house)
- **WATER**: 568,000 m³ (106 m³/house)

**Carbon Footprint**: 28,136 t CO₂-eq
**Forestland grabbing**: 2084 ha

- 12205 t CO₂-eq; 904ha forestland
- 1694 t CO₂-eq; 125ha forestland
- 12380 t CO₂-eq; 917ha forestland
- 1526 t CO₂-eq; 113ha forestland
- 332 t CO₂-eq; 25ha forestland
IMAGINE YOUR CITY

Sevilla

La mirada innovadora

400 años
TAPPING INTO THE POTENTIAL
MOVIENDO

COMPARTIENDO SE LLEGA MÁS LEJOS

#MOBILITYWEEK

CITYzen
New urban energy
Copenhague expertos en movilidad:
Si dejas el espacio para conducir en coche, la gente usará el coche
Si dejas el espacio para ir en bicicleta, la gente usará la bicicleta
peatones, bicis, coches, buses (travías)
MOVIENDO
How Seville transformed itself into the cycling capital of southern Europe
TIRO DE LÍNEA
TIRO DE LÍNEA
GREEN HEROS CTUED
NEVERTHELESS
NEVERTHELESS
DISRUPTIVE CHANGE
Equipa Urbanista

City-zen roadie
- Prof. Greg Keeffe (Queens University Belfast)

Interpreter and guest roadie
- Jesús Cardona (Nontrópia)

Student facilitators
- Dora Vancsó (TU Delft)
- Laura Solarino (TU Delft)
- Antigoni Karaiskou (TU Delft)
Equipa Energetica

City-zen roadies
- Prof. Andy van den Dobbelsteen (TU Delft)
- Dr. Riccardo Pulselli (Università di Siena)
- Matteo Maccanti (Università di Siena)
- Dr. Han Vandevyvere (EnergyVille)
- Dr. Leen Peeters (Think!E)

Student facilitators
- Eva Farrugia (TU Delft)
- Michael Cobb (TU Delft)
- Álvaro Rodriguez García (TU Delft)
CITY-ZEN ROADMAPPING SCHEME

[City-zen WP4T2 team, image by Siebe Broersma and Michiel Fremouw, TU Delft]

catalogue of measures
book of inspiration
What does the sustainable city look like in 2050?

Hammarby Sjöstad, Stockholm
Aims of the Roadshow energy studio

Main aim: to support Sevilla in its energy transition from fossil fuels to renewable sources

Stepped objectives

1. Creating a good overview of energy demand, supply and local potentials
2. Converting energy usage to a carbon footprint
3. Finding solutions to get to net zero-carbon developments
   - Reduce the energy demand (urban planning, building design, appliances)
   - Reuse waste energy (program, attune, exchange, store)
   - Produce renewables (sun, wind, water, soil, air, biomass, humans)
4. Involve solutions for non-building sectors:
   - Transportation
   - Waste (water) treatment
   - Economic developments
5. Calculate the carbon emissions reduced and remaining carbon footprint
Climate data

Conclusion: mean temperature $\approx 18^\circ C \rightarrow$ soil perfect for cooling/pre-heating
Water – Guadalquivir & Sevilla

What is happening here?
MACRO SCALE
WATER IN THE CITY
Reconnect the city to the Guadalquivir and use flowing water to cool and humidify it
MACRO SCALE
WATER IN THE CITY
Reconnect the city to the Guadalquivir and use flowing water to cool and humidify it.
Tiro de Línea
Meso Scale
Capture & Store

A combination of rainwater collection, filtering, evaporative cooling and a playground.
**MICRO SCALE**
**CAPTURE & USE**

Use of cisterns underneath the streets which link to the water squares.
MICRO SCALE
CAPTURE & REUSE
Condensate Irrigation from Heat Exchangers
Tiro de Línea
Water infra
Water – green – energy hubs
Urban Heat Island: Normalised Difference Vegetation Index

Herrera-Gomez S., Quevedo-Nolasco A., Pérez-Urrestarazu L. (2017); The role of green roofs in climate change mitigation - A case study in Seville (Spain); Building and Environment 123, p. 575-584
Percentage of green roofs needed due to climate change

<table>
<thead>
<tr>
<th>Period</th>
<th>SERES climatic scenario</th>
<th>T_{max}^{CC} (°C)</th>
<th>ΔT_{max} (°C)</th>
<th>Landsat 7 ETM-</th>
<th>Percentage of roofs to vegetate (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>NDVI_{CC} (dim)</td>
<td>S_{CC}^{ag} (ha)</td>
</tr>
<tr>
<td>2011–2040</td>
<td>A2</td>
<td>3.5</td>
<td>3.5</td>
<td>0.47</td>
<td>1257</td>
</tr>
<tr>
<td>2041–2070</td>
<td>A2</td>
<td>5.0</td>
<td>5.0</td>
<td>0.52</td>
<td>1414</td>
</tr>
<tr>
<td>2071–2100</td>
<td>A2</td>
<td>6.0</td>
<td>6.0</td>
<td>0.56</td>
<td>1519</td>
</tr>
</tbody>
</table>

Herrera-Gomez S., Quevedo-Nolasco A., Pérez-Urrestarazu L. (2017); The role of green roofs in climate change mitigation - A case study in Seville (Spain); Building and Environment 123, p. 575-584
Different green solutions for different street sections

Percentage of street shaded with different height/widths

Streets in danger of overheating

![Diagram and Table]

PASSIVE ENERGY
RENOVATION STRATEGIES
INNER-CITY DENSITIES - SELF SHADING

INCREASED SHADING MEANS COOLER PATHS TO WALK ALONG AND COOLER BUILDINGS
New Stepped Strategy for energy-positive (re) design

1. Reduce the demand
   a) Smart bioclimatic design
   b) Energy-efficient appliances

2. Reuse waste energy
   a) Recover heat/cold from exhaust air and waste water (buildings)
   b) Attune urban functions programmatically (neighbourhoods)
   c) Exchange heat, cold and electricity (neighbourhoods)
   d) Store heat, cold and electricity (neighbourhoods-districts)
   e) Use industrial waste heat (city)

3. Produce renewable energy
   a) Solar
   b) Wind
   c) Water
   d) Air
   e) Geothermal
   f) Biomass
   g) Human
## Typical facades and roofs

<table>
<thead>
<tr>
<th>Nombre</th>
<th>Transmitancia</th>
<th>Capas materiales</th>
<th>Secciones</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fachada 1</td>
<td>U = 2.65 W/m² K</td>
<td>&quot;1 pie LP metro o catalán 40 mm &lt; G &lt; 60 mm&quot; + &quot;Enlucido de yeso 1000 &lt; d &lt; 1300&quot;</td>
<td><img src="Image" alt="Diagram" /></td>
</tr>
<tr>
<td>Fachada 2</td>
<td>U = 1.57 W/m² K</td>
<td>&quot;1 pie LP metro o catalán 40 mm &lt; G &lt; 60 mm&quot; + cámara no ventilada vertical de 3 cm + &quot;Tabique de LH sencilla 50 mm &lt; Espesor &lt; 60 mm&quot; + &quot;Enlucido de yeso 1000 &lt; d &lt; 1300&quot;</td>
<td><img src="Image" alt="Diagram" /></td>
</tr>
<tr>
<td>Fachada 3</td>
<td>U = 2.46 W/m² K</td>
<td>&quot;Enlucido de yeso 1000 &lt; d &lt; 1300&quot; + bloque de hormigón de áridos densos de espesor 120 = &quot;Enlucido de yeso 1000 &lt; d &lt; 1300&quot;</td>
<td><img src="Image" alt="Diagram" /></td>
</tr>
<tr>
<td>Fachada 4</td>
<td>U = 2.35 W/m² K</td>
<td>&quot;Piedra caliza dura 2000 &lt; d &lt; 2590&quot;</td>
<td><img src="Image" alt="Diagram" /></td>
</tr>
<tr>
<td>Suelo 1</td>
<td>U = 3.06 W/m² K</td>
<td>&quot;Mortero de cemento o cal para albañilería y para revoco/enlucido d &gt; 2000&quot; + hormigón con áridos ligeros con densidad entre 1800 y 2000</td>
<td><img src="Image" alt="Diagram" /></td>
</tr>
<tr>
<td>Suelo 2</td>
<td>U = 2.32 W/m² K</td>
<td>&quot;Mortero de cemento o cal para albañilería y para revoco/enlucido d &gt; 2000&quot; + &quot;FU Entrevigado cerámico-Canto 250 mm&quot; + &quot;Enlucido de yeso 1000 &lt; d &lt; 1300&quot;</td>
<td><img src="Image" alt="Diagram" /></td>
</tr>
</tbody>
</table>

---

**Cubiertas**

- **U = 1.65 W/m² K**
  - "Plaqueta o baldosa cerámica" + "Tablero de partículas con cemento d < 1300" + cámara horizontal ligeramente ventilada + "FU Entrevigado cerámico-Canto 250 mm" + "Enlucido de yeso 1000 < d < 1300"

- **U = 0.71 W/m² K**
  - "Teja de arcilla cocida" + "Tablero contrachapado 700 < d < 900" + "EPS Poliestireno Expandido [0.037 W/(mK)]" + "FU Entrevigado cerámico-Canto 250 mm" + "Enlucido de yeso 1000 < d < 1300"

- **U = 1.62 W/m² K**
  - "Teja de arcilla cocida" + "Tablero contrachapado 700 < d < 900" + "FU Entrevigado cerámico-Canto 250 mm" + "Enlucido de yeso 1000 < d < 1300"

---

[Gobierno de España/IDAE; Escala de calificación energética – Edificios existentes; Madrid, 2011]
Energy renovation options

- **Minimal**
  - Simple & cheap
  - Saves most cooling needs

- **Wrap up**
  - More extensive & expensive
  - Saves a lot of cooling and heating needs

- **Solar skin**
  - Technical solution
  - Reduces most cooling needs
  - Produces a lot of electricity

- **Green veil**
  - Green solution
  - Reduces most cooling needs and saves heating
  - Combined with PV roof: produces electricity

- **Combination of all 4 possible**
PV porn

- **PV shell over the building, East to West**
  - Catches sun in the morning, afternoon, evening
  - Continuous production during the day
  - Estimated yield with a 20x10x12 m block: 64 MWh

- **Main issue: electricity storage**
  - Daytime domestic activities
  - Central battery storage
  - Electric vehicles
  - Heat pump charging the heat/cold storage
Soil energy options – from passive to active

- Ground duct with solar chimney
- Heat pump with horizontal collector
- Heat pump with vertical collector
- Heat & cold storage in an aquifer
ACTIVE ENERGY RENOVATION STRATEGIES
INDIVIDUAL

Vertical soil collectors, individual heat pumps, PV panels and heat exchangers
ACTIVE ENERGY RENOVATION STRATEGIES
COLLECTIVE

Collective system with a cool/warm air supply and a professionally-managed system.
ACTIVE ENERGY RENOVATION STRATEGIES
COMMUNAL

A hot and cold grid will supply energy to the neighbourhood on a communal scale.
PV: 4.2 kW/flat $\rightarrow$ 4200 €
PV: 4.2 kW/flat → 4200 €

Green: 4000 €/ housing block
PV: 4.2 kW/flat → 4200 €

Borehole: 1250 €/flat
Heat pump & tubing: 4000 €/flat

Green: 4000 €/housing block
PV: 4.2 kW/flat $\rightarrow$ 4200 €

Green: 4000 €/ housing block

Borehole: 1250 €/flat
Heat pump & tubing: 4000 €/flat

$\rightarrow$ Investment 4200 € + (4000 €)/3 + 1250 € + 4000 € = 10 783 €
$\rightarrow$ Annual energy cost 630 €
$\rightarrow$ Annual maintenance 100 €

$\rightarrow$ 10 year balance: 18 083 €
PV: 4.2 kW/flat → 4200 €

Borehole: 1250 €/flat
Heat pump & tubing: 4000 €/flat

ENERGY COOPERATIVE
→ Sells heat, cold and electricity @ 0.15 €/kWh
→ 10 year balance: 18 083 € → 120 553 kWh

Green: 4000 €/housing block
PV: 4.2 kW/flat → 4200 €

Green: 4000 €/housing block

Borehole: 1250 €/flat
Heat pump & tubing: 4000 €/flat

ENERGY COOPERATIVE
→ Sells heat, cold and electricity @ 0.15 €/kWh
→ 10 year balance: 18 083 € → 120 553 kWh > 20 years energy use

> life-time of equipment
Trash on the streets

Mierda...
An energy cooperative could involve waste processing

- Collection of waste
- Repair and reuse
- Recycling
- Digestion of organic waste
- Production of biogas for restaurants
Tiro de Línea sostenible

- Rainwater collection and usage
- Green infrastructure
- Energy renovation of buildings
- Energy cooperations that serve energy hubs
- Clean waste management
- Sustainable mobility: bikes and electric cars
El Corte Nuevo
El Corte Nuevo detail
Plaza de Aguas
Plaza de Aguas detail
Rambla verde
Tiro de Línea sostenible

- PV Roofs and Shading
- Solar Awnings
- More Green
- Tropical PV Roofs
- Santa Gaia Church
- Rainwater Collection and Storage in Streets
- Green Facades & Roofs
- New Infill Block with Retail
- Smart Heat & Cold Exchange Between Mixed Functions Around the Market
- Swimming Pool as Heat/Cold Storage (Summer/Winter)
- Aquifer Heat and Cold Storage with Communal Heat Pump System
- Collective Heat Pump System for Cooling & Heating
CARBON FOOTPRINT MITIGATION MEASURES
BARRIO TIRO DE LINEA
14,000 inhabitants; 5364 households

ELECTRICITY 12700 MWh
HEAT ENERGY 23000 MWh
MOBILITY 34400 km/house yr
WASTE 6240 t (1160 kg/house)
WATER 568,000 m³ (106 m³/house)

Pacman is coming...
BARRIO TIRO DE LINEA
14,000 inhabitants; 5364 households

- **ELECTRICITY** 12700 MWh
- **HEAT ENERGY** 23000 MWh
- **MOBILITY** 34400 km/house yr
- **WASTE** 6240 t (1160 kg/house)
- **WATER** 568,000 m³ (106 m³/house)

**PASSIVE SYSTEMS**
greening, shading, low emission paint
(20% houses)
-50% cooling (-1700MWh)
BARRIO TIRO DE LINEA
14,000 inhabitants; 5364 households

- ELECTRICITY 12700 MWh
- HEAT ENERGY 23000 MWh
- MOBILITY 34400 km/house yr
- WASTE 6240 t (1160 kg/house)
- WATER 568,000 m3 (106 m3/house)

THERMAL INSULATION
roof/facade retrofitting
(30% houses)
-50% cooling (-2500 MWh)
-75% heating (-1450 MWh)
**ELECTRICITY** 12700 MWh

**HEAT ENERGY** 23000 MWh

**MOBILITY** 34400 km/house yr

**WASTE** 6240 t (1160 kg/house)

**WATER** 568,000 m³ (106 m³/house)

**BARRIO TIRO DE LINEA**
14,000 inhabitants; 5364 households

25ha

**Behavioural changes**
LED lights, air conditioning (80% houses)
-50% electric lighting (-2400 MWh)
BARRIO TIRO DE LINEA
14,000 inhabitants; 5364 households

- ELECTRICITY 12700 MWh
- HEAT ENERGY 23000 MWh
- MOBILITY 34400 km/house yr
- WASTE 6240 t (1160 kg/house)
- WATER 568,000 m³ (106 m³/house)

HEAT PUMP (household scale)
(30% houses)
-75% heating (-1500 MWh)
-75% DHW (-1400 MWh)
+20% electricity (+360 MWh)
BARRIO TIRO DE LINEA
14,000 inhabitants; 5364 households

- ELECTRICITY 12700 MWh
- HEAT ENERGY 23000 MWh
- MOBILITY 34400 km/house yr
- WASTE 6240 t (1160 kg/house)
- WATER 568,000 m3 (106 m3/house)

HEAT PUMP
(neighbourhood scale)
(60% houses)
-75% heating (-3000 MWh)
-75% DHW (-2800 MWh)
+20% electricity (+720 MWh)
BARRIO TIRO DE LINEA
14,000 inhabitants; 5364 households

- ELECTRICITY 12700 MWh
- HEAT ENERGY 23000 MWh
- MOBILITY 34400 km/house yr
- WASTE 6240 t (1160 kg/house)
- WATER 568,000 m3 (106 m3/house)

PV panels (building block scale) (30% houses) -100% electricity (-7000 MWh)
BARRIO TIRO DE LINEA
14,000 inhabitants; 5364 households

- **ELECTRICITY**: 12700 MWh
- **HEAT ENERGY**: 23000 MWh
- **MOBILITY**: 34400 km/house yr
- **WASTE**: 6240 t (1160 kg/house)
- **WATER**: 568,000 m3 (106 m3/house)

**Electric bike sharing**
-15% private car use
-100% fuel
+20% electricity for appliances
BARRIO TIRO DE LINEA
14,000 inhabitants; 5364 households

- ELECTRICITY 12700 MWh
- HEAT ENERGY 23000 MWh
- MOBILITY 34400 km/house yr
- WASTE 6240 t (1160 kg/house)
- WATER 568,000 m³ (106 m³/house)

Bike to school/work
(-30% private car use)
-100% fuel
ELECTRICITY 12700 MWh
HEAT ENERGY 23000 MWh
MOBILITY 34400 km/house yr
WASTE 6240 t (1160 kg/house)
WATER 568,000 m3 (106 m3/house)

BARRIO TIRO DE LINEA
14,000 inhabitants; 5364 households

25ha

Electric car recharger station
(10% electric cars)
-100% fuel
+40% electricity for appliances
BARRIO TIRO DE LINEA
14,000 inhabitants; 5364 households

- **ELECTRICITY**: 12700 MWh
- **HEAT ENERGY**: 23000 MWh
- **MOBILITY**: 34400 km/house yr
- **WASTE**: 6240 t (1160 kg/house)
- **WATER**: 568,000 m³ (106 m³/house)

PV panels sharing (neighbourhood scale)
(40% houses)
-100% electricity (-10000 MWh)
BARRIO TIRO DE LINEA
14,000 inhabitants; 5364 households

- ELECTRICITY 12700 MWh
- HEAT ENERGY 23000 MWh
- MOBILITY 34400 km/house yr
- WASTE 6240 t (1160 kg/house)
- WATER 568,000 m³ (106 m³/house)

Tram line
(district Sur scale)
(-40% private car use)
-100% fuels
BARRIO TIRO DE LINEA
14,000 inhabitants; 5364 households

- **ELECTRICITY** 12700 MWh
- **HEAT ENERGY** 23000 MWh
- **MOBILITY** 34400 km/house yr
- **WASTE** 6240 t (1160 kg/house)
- **WATER** 568,000 m³ (106 m³/house)

Differentiated waste
(100% house)
-70% waste-to-landfill
BARRIO TIRO DE LINEA
14,000 inhabitants; 5364 households

- **ELECTRICITY** 12700 MWh
- **HEAT ENERGY** 23000 MWh
- **MOBILITY** 34400 km/house yr
- **WASTE** 6240 t (1160 kg/house)
- **WATER** 568,000 m$^3$ (106 m$^3$/house)

Differentiated waste (avoided landfill)
(100% house)
-100% waste-to-landfill
ELECTRICITY 12700 MWh
HEAT ENERGY 23000 MWh
MOBILITY 34400 km/house yr
WASTE 6240 t (1160 kg/house)
WATER 568,000 m³ (106 m³/house)

BARRIO TIRO DE LINEA
14,000 inhabitants; 5364 households

Existing parks
New green assets
RE surplus
(neghbourhood scale)
ELECTRICITY 12700 MWh
HEAT ENERGY 23000 MWh
MOBILITY 34400 km/house yr
WASTE 6240 t (1160 kg/house)
WATER 568,000 m3 (106 m3/house)

BARRIO TIRO DE LINEA
14,000 inhabitants; 5364 households

TENED CONFIANZA... GO TO ZERO!!!
Professor Greg Keeffe
Head of School
Natural and Built Environment
Queens University
Belfast.

Dora Vancso
Laura Solarino
Antigoni Karaiskou
TU Delft

‘Dream no small dreams for they have no power to move the hearts of men. ’ - Von Goethe
Barrios urbanism
Barrios urbanism
Over-roaded Urbanism
How big is big enough!
Hard edge
City desire line
Permeable/non-permeable space
Cars cars and more cars
Surveyed and non-surveyed space
Over-centralised space
Over-scaled external space
Correctly proportioned space
Seville Climate Projections. UK Met Office

<table>
<thead>
<tr>
<th>Year</th>
<th>Average Temp</th>
<th>Average High</th>
<th>Maximum Temp</th>
</tr>
</thead>
<tbody>
<tr>
<td>2017</td>
<td>19.4</td>
<td>35</td>
<td>45</td>
</tr>
<tr>
<td>2070</td>
<td>24</td>
<td>45</td>
<td>55</td>
</tr>
</tbody>
</table>

Climate similar to Dubai by 2070

Correctly proportioned space
Perforated urbanism
Perforated urbanism
Unpack the neighbourhood
Unpack the neighbourhood
Unpack the neighbourhood
Unpack the neighbourhood
Unpack green space – make oases
Unpack green space – make oases
Unpack green space – make oases
Densify urban space – create shade
Densify urban space – create shade
Make small green routes
Make small green routes
Unpack green space – make oases
Unpack green space – make oases
Reclaim the street – with car-share!
Reclaim the street – with car-share!
Reclaim the street – with car-share!
Reclaim the street – with car-share!
Reclaim the street – with car-share!
Bike-friendly routes go through the neighbourhood.
Repack the neighbourhood
Unpacking the market makes new exciting public space.
Unpacking the market makes new exciting public space
Unpacking the market makes new exciting public space
Unpacking the market makes new exciting public space.
Unpacking the market makes new exciting public space
To conclude

NOW
STEP 1: 25% GREEN
Unpacking the market makes new exciting public space

STEP 2: 50% GREEN

Meso | Rooftop Garden, Larger Courtyard | Rules
Ability to sit comfortably and meet friends
More greenery
Shaded

CITYzen
New urban energy
STEP 3: 75% GREEN
STEP 4: 100% GREEN
Muchas gracias.