 Contribution of the Spanish built environment to the climate change. Implication to legal frameworks

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INTRODUCTION

RECENT OBSERVED TRENDS IN CLIMATE
RECENT OBSERVED EXTREME EVENTS

CLIMATE CHANGE

GREENHOUSE GAS EMISSIONS

NATURAL

Residential and tertiary sectors → 40% of final energy consumption in the EC

ANTROPHOGENIC
To assess the impact of the Spanish built environment on climate change and the implication to legal frameworks

- Assessing the impact of the Spanish built environment on climate change
- Effectiveness gaps on the assessment of the impact of the Spanish built environment on climate change
- Legal framework
- Effectiveness gaps on current legal framework
- Conclusions and recommendations for policymakers

**EUROPEAN UNION**

**Buildings sector (2004)**

**Final energy consumption**

471.7 Mtoe (41.3% of the total EU-25 final energy use)

<table>
<thead>
<tr>
<th>Sector</th>
<th>Energy Consumption</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residential</td>
<td>172.1 Mtoe</td>
<td>36.46%</td>
</tr>
<tr>
<td>Tertiary</td>
<td>299.7 Mtoe</td>
<td>63.53%</td>
</tr>
</tbody>
</table>

**Greenhouse gas emissions**

732 million tonnes of CO₂ (19.0% of the total EU-25 dioxide emissions)

<table>
<thead>
<tr>
<th>Sector</th>
<th>Emissions</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residential</td>
<td>470 million tn</td>
<td>64.20%</td>
</tr>
<tr>
<td>Tertiary</td>
<td>262 million tn</td>
<td>35.80%</td>
</tr>
</tbody>
</table>

(European Commission - Energy and Transport in Figures 2006)
### Contribution of the Spanish built environment to the climate change. Implication to legal frameworks

#### ASSESSING THE IMPACT

#### OF THE SPANISH BUILT ENVIRONMENT ON CLIMATE CHANGE

**SPAIN**

<table>
<thead>
<tr>
<th>Buildings sector</th>
<th>Final energy consumption</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residential buildings</td>
<td>14.4 Mtoe 58.91%</td>
</tr>
<tr>
<td>Tertiary sector</td>
<td>10.9 Mtoe 43.08%</td>
</tr>
<tr>
<td>Residential buildings</td>
<td>8.9 Mtoe 61.40%</td>
</tr>
<tr>
<td>Tertiary sector</td>
<td>5.6 Mtoe 38.60%</td>
</tr>
<tr>
<td>Office buildings</td>
<td>33.00%</td>
</tr>
<tr>
<td>Restaurants-accommod</td>
<td>30.00%</td>
</tr>
<tr>
<td>Commercial buildings</td>
<td>22.00%</td>
</tr>
<tr>
<td>Hospitals</td>
<td>11.00%</td>
</tr>
<tr>
<td>Educational buildings</td>
<td>4.00%</td>
</tr>
<tr>
<td>End-use equipments</td>
<td>4.00%</td>
</tr>
</tbody>
</table>

**Introduction**

25.3 Mtoe (year 2004)
(27 % of the total Spanish final energy use)

14.5 Mtoe (year 2000)
(16 % of the total Spanish final energy use)

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**SPAIN**

<table>
<thead>
<tr>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Greenhouse gas emissions</td>
</tr>
<tr>
<td>25 million tonnes of CO₂</td>
</tr>
<tr>
<td>(12.0% of the total Spanish dioxide emissions)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Sector</th>
<th>Emissions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residential sector</td>
<td>68.91%</td>
</tr>
<tr>
<td>Commercial/institutional sector</td>
<td>31.09%</td>
</tr>
</tbody>
</table>

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*European Commission - Energy and Transport figures 2009*

*Spanish Ministry of Industry and IDEA Efficiency and Saving Strategy in Spain (ES) 2004-2012*

*UNFCCC Framework Convention on Climate Change, National Inventory Submissions 2005: Spain*
ASSESSING THE IMPACT
OF THE SPANISH BUILT ENVIRONMENT ON CLIMATE CHANGE

CATALONIA

Final energy consumption

2.16 Mtoe
(average energy consumption in a dwelling 7800 kWh/yea)

<table>
<thead>
<tr>
<th>Energy Type</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heating</td>
<td>33%</td>
</tr>
<tr>
<td>End-use equipments</td>
<td>33%</td>
</tr>
<tr>
<td>Water heating</td>
<td>26%</td>
</tr>
</tbody>
</table>

Greenhouse gas emissions

4.2 million tonnes of CO₂
(average greenhouse gas emissions in a dwelling: 1290 Kg of CO₂/year)

CONCLUSIONS

EFFECTIVENESS GAPS ON THE ASSESSMENT OF THE IMPACT
OF THE SPANISH BUILT ENVIRONMENT ON CLIMATE CHANGE

INITIAL EMBODIED ENERGY

- Manufacturing of materials
- Transport to site
- Construction process

LIFE CYCLE

Use

- Maintenance
- Demolition
- Construction

Energy consumed in:
- Removal of old materials
- Transport and waste treatment
- Manufacturing of materials
- Transport to site
- Construction process

RECURRING EMBODIED ENERGY

Energy consumed in:
- Lighting and appliances
- Heating / Cooling
- Hot water heating

DATA PROVIDED BY OFFICIAL STATISTICS
### Results from three single-unit dwelling located in Sweden with a lifespan of 50 years [Adalberth, 1997b]:

<table>
<thead>
<tr>
<th>Activity</th>
<th>Energy Use (GJ/m²)</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manufacturing energy use during construction phase</td>
<td>3.00</td>
<td>10.07%</td>
</tr>
<tr>
<td>Energy use for construction materials transportation during the construction phase</td>
<td>0.13</td>
<td>&lt; 1%</td>
</tr>
<tr>
<td>Energy use during the erection of the building</td>
<td>0.24</td>
<td>&lt; 1%</td>
</tr>
<tr>
<td>Manufacturing energy use during renovation phase</td>
<td>1.36</td>
<td>4.36%</td>
</tr>
<tr>
<td>Energy use for construction materials transportation during the renovation phase</td>
<td>Negligible</td>
<td>-</td>
</tr>
<tr>
<td>Energy use during the occupation</td>
<td>0.50 (GJ/m²/year)</td>
<td>83.95%</td>
</tr>
<tr>
<td>Energy use during the demolition of the building</td>
<td>0.04</td>
<td>&lt; 1%</td>
</tr>
<tr>
<td>Energy use for waste transportation during the demolition phase</td>
<td>0.06</td>
<td>&lt; 1%</td>
</tr>
</tbody>
</table>

Embodied energy ≈ 16.00%

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### Results from 24 buildings located in Australia with a lifespan of 50 years [Pullen, 2000]:

<table>
<thead>
<tr>
<th>Activity</th>
<th>Energy Use (GJ/m²)</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial manufacturing energy</td>
<td>5.90</td>
<td>9.73%</td>
</tr>
<tr>
<td>Recurring manufacturing energy</td>
<td>4.00</td>
<td>6.60%</td>
</tr>
<tr>
<td>Energy use during the erection of the building</td>
<td>0.23</td>
<td>0.38%</td>
</tr>
<tr>
<td>Energy use in on-site activities during maintenance</td>
<td>0.17</td>
<td>0.28%</td>
</tr>
<tr>
<td>Energy use during the occupation</td>
<td>50.39</td>
<td>83.00%</td>
</tr>
<tr>
<td>Energy use during the demolition of the building</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

Embodied energy: 17.00%
### Effectiveness Gaps on the Assessment of the Impact of the Spanish Built Environment on Climate Change

**Results from an office building located in Finland with a lifespan of 50 years [Junnila et al., 2006]:**

<table>
<thead>
<tr>
<th>Energy Type</th>
<th>Embodied Energy [GJ/m²]</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial embodied energy</td>
<td>4.50</td>
<td>8.51%</td>
</tr>
<tr>
<td>Recurrent embodied energy</td>
<td>2.15</td>
<td>4.07%</td>
</tr>
<tr>
<td>Demolition embodied energy</td>
<td>0.18</td>
<td>0.34%</td>
</tr>
<tr>
<td>Energy use during operational phase</td>
<td>46.00</td>
<td>87.07%</td>
</tr>
</tbody>
</table>

Embodied energy: 12.92%  

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### Effectiveness Gaps on the Assessment of the Impact of the Spanish Built Environment on Climate Change

**Results from an office building located in Canada with a lifespan of 50 years [Cole and Kernan, 1996]:**

<table>
<thead>
<tr>
<th>Material</th>
<th>Embodied Energy [GJ/m²]</th>
<th>Recurring Embodied Energy [GJ/m²]</th>
<th>Operational Energy [GJ/m²-year]</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>25 years</td>
<td>50 years</td>
</tr>
<tr>
<td>With underground parking</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wood</td>
<td>4.54</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Steel</td>
<td>5.13</td>
<td>2.56</td>
<td>6.55</td>
</tr>
<tr>
<td>Concrete</td>
<td>4.79</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No underground parking</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wood</td>
<td>4.26</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Steel</td>
<td>4.86</td>
<td>2.52</td>
<td>6.32</td>
</tr>
<tr>
<td>Concrete</td>
<td>4.52</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Embodied energy: 12.00%±18.00%
6th Meeting of the CIB W108 on Climate Change and the Built Environment

LEGAL FRAMEWORK

1979 First World Climate Conference by the World Meteorological Organization


1992 United Nations Framework Convention on Climate Change


- All Member States shall limit CO₂ emissions by improving energy efficiency in buildings (implementing energy certification programs, etc) not later than 31 December 1994.

Introduction Objective Assessing the Impact Legal framework Conclusions

1997 Kyoto Protocol

- Reduce emissions of greenhouse gases by 5% in relation to 1990 levels between 2008 and 2012


- Methodology for calculating the energy performance of buildings
- Application of performance standards on new and existing buildings
- Certification schemes for all buildings


- Total quantity of CO₂ emission allowances available and how this target is divided among the various individual plants covered by the system: energy, steel, cement, glass, brick making, and paper/cardboard.

Introduction Objective Assessing the Impact Legal framework Conclusions
LEGAL FRAMEWORK

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**Effectiveness Gaps on Current Legal Framework**

**Energy Performance Building Directive**

**Energy Regulation**
- Building Technical Code
- Revision - Spanish Regulation on Thermal Installations in Buildings

**Transposition to Spanish Legislation**
- Royal Decree 47/2007 - Basic procedure for the certification of energy efficiency in the construction of new buildings

**Energy Certification**

**Operational Energy**
- Energy consumed in:
  - Lighting and appliances
  - Heating / Cooling
  - Hot water heating

**Recurring Embodied Energy**
- Energy consumed in:
  - Removal of old materials
  - Transport and waste treatment
  - Manufacturing of materials
  - Transport to site
  - Construction process

**Initial Embodied Energy**
- Energy consumed in:
  - Manufacturing of materials
  - Transport to site
  - Construction process

**Demolition Embodied Energy**
- Energy consumed in:
  - Demolition process
  - Waste transport
  - Waste treatment

**Life-Cycle**
- Use
- Maintenance
- Abandonment
- Demolition

**Introduction**
**Objective**
**Assessing the impact**
**Legal framework**
**Conclusions**

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**Legal Framework**

**Directive 2002/91/EC on the energy performance of buildings**

**Energy Regulation**
- Building Technical Code

**Transposition to Spanish Legislation**
- Royal Decree 47/2007 - Basic procedure for the certification of energy efficiency in the construction of new buildings

**Energy Certification**

- Only quantitative data about the energy demand during the use phase of a building is provided (KWh/Year and Kg CO₂/Year)
- Some types of buildings (as the industrial ones or warehouses) are not included
## Conclusions

### Spanish Buildings Sector

<table>
<thead>
<tr>
<th>SPANISH BUILDINGS SECTOR</th>
<th>OPERATIONAL ENERGY</th>
<th>EMBODIED ENERGY</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>16% - 27% of the total final energy use</td>
<td>≈ 18% of the total final energy consumption, depending on:</td>
</tr>
<tr>
<td></td>
<td>12% of total greenhouse gas emissions</td>
<td>- the anticipated useful life of the building</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- frequency of maintenance</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- type of construction</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- pattern of occupants' energy consumption</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- climate</td>
</tr>
</tbody>
</table>

### Contribution of the Spanish built environment to the climate change. Implication to legal frameworks

**ENERGY REGULATION**
- Buildings sector is not included within the Spanish Emission Trading Scheme.
- Energy efficiency requirements are introduced at the building design stage in line with the Energy Performance Building Directive by means of the Building Technical Code, the revision of the current Spanish regulation on thermal installations in buildings and the Royal Decree on energy certification in buildings.
- All three instruments are only focused on the operational energy
- They does not cover all types of buildings

**ENERGY CERTIFICATION**
- It is only focused on the operational energy
- It does not cover all types of buildings

**REPORTING ENERGY CONSUMPTION**
- Embodied energy should be taken into account when reporting energy consumption because what is not assessed cannot be improved
CONCLUSIONS

FURTHER STEPS

DEVELOPMENT OF AN HOMOGENEOUS MODEL OF LIFE CYCLE ANALYSIS FOR THE EVALUATION OF THE ENERGY CONSUMPTION OF THE “INDUSTRIAL PLANT” SYSTEM AND ITS ASSOCIATED EMISSIONS

The model will quantify the energetic consumption of industrial buildings along all their life cycle (and their associate emissions) and it will allow the comparison of their energetic performance.

- The model will contribute to the definition of the sustainable specification in the planning phase.
- This method will be also useful for all design stakeholders who would have a decision making tool in terms of environmental incidence of different project solutions.
- It will establish the basis for a future environmental certification of industrial buildings, including all the life cycle of a building.