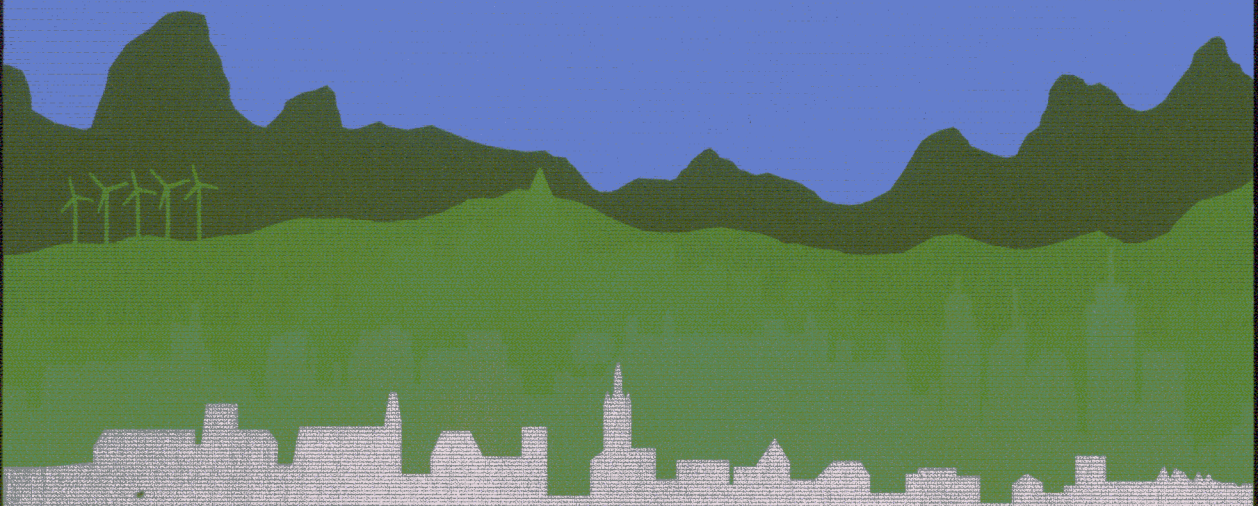
SMART ENERGY REGIONS

Editors: Phil Jones, Werner Lang, Jo Patterson and Philipp Geyer.



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This publication is supported by COST.

ESF Provides the COST Office through an EC contract

COST is supported by the EU RTD Framework Programme

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This book may be cited as:
COST Action TU1104 – Smart Energy Regions

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Published by:
The Welsh School of Architecture, Cardiff University,
Bute Building, King Edward VII Avenue, CARDIFF, CF10 3NB, UK.

Smart Energy Regions
Publication date: May, 2014
ISBN - 978-1-899895-14-4

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SPAIN

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1. OVERVIEW OF THE REGION

The Autonomic Community of Madrid is one of the seventeen entities in the Spanish Constitutional Monarchy with a Parliamentary Government according to the Constitution of 1978. It is the third biggest region in Spain with 6.5 million inhabitants in an area of 8,022 km^2 (810 inhabitants per km^2). The capital is the Municipality of Madrid, which is the capital of Spain. It is located in the geographic centre of the Spanish Peninsula.

The levels of authorities include: the National Government, the Regional Autonomic Government and the Local Municipality. Due to the Autonomic Government, the Regional Parliament defines its own legislation in several areas.

The economic situation is characterised by a GDP of around €26,580 per capita (the second highest in the country in 2012). Its economy is based on approximately 76% in services, 13% in industry, 11% in construction and 0.2% in agriculture. The service sector is one of the most important sectors in the economy of the region; this region has the greatest concentration of major companies with respect to the rest of the country, and collectively the largest number of new technology companies as well.

The employment rate was 51.1% of active population in the 2012.

Energy demand and supply of the Region
The regional energy strategy is based on the National Energy Efficient Action Plan 2011–2020 (NEEAP) and the Regional Community of Madrid Strategic Action Plan 2004 – 2012, that is still in action.

The total energy consumption of the region was 118,533 TWh in 2012, equivalent to 11.4% of the total national consumption. It is subdivided into four main sectors: transport with 60,197 TWh (50.8%), domestic with 27,865 TWh (23.5%), services with 15,898 TWh (13.4%) and industrial sector with 10,106 TWh (8.5%). (*Figure 1*).

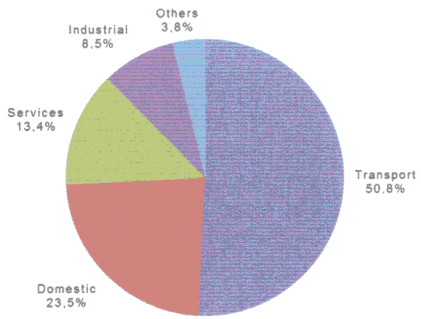


Figure 1 – Total energy consumption in Madrid Region by use in 2012

The total final energy consumption by fuel in the region was: oil 66,070 TWh (55.7%), electricity 26,121 TWh (22.0%), natural gas 23,539 TWh (19.9%) and thermic energy 2,407 TWh (2%) (*Figure 2*). This increased between 2000 and 2012 from 11,536 TWh (about 10.8%), even though the maximum was reached in 2009 and from then it has started to decrease.
The consumption per inhabitant is around 18,259 kWh, less than 20,585 kWh during 2000

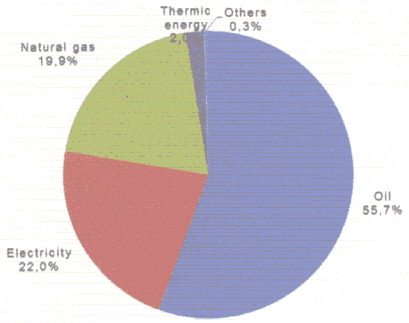


Figure 2 – Total energy consumption by fuel in Madrid Region in 2012

The electricity consumption has increased in the last 12 years by 4,356 TWh (about 20%) with a compounded annual growth rate of 1.53%.

The total GHG emissions from all sectors combined were 23,501 $ktCO_2eq$ in 2011, while in 2005 the emissions had reached the highest value ever of 27,700 $ktCO_2eq$. (*Figure 3*).

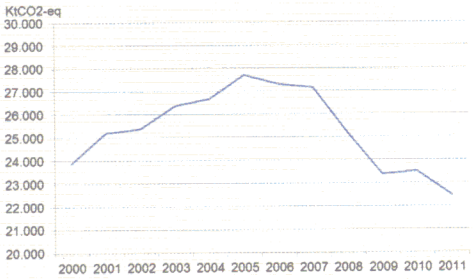


Figure 3 – History of CO_2 – eq emissions in Madrid Region from 2000 to 2011. (www.magrama.gob.es)

The production of energy in the Region was 2,212 GWh in 2012, which amounts to 1.87% of the total final consumption and 4.22% considering cogeneration; however, regional energy production has grown by 54.3% since 2000. It can be broken down into: biomass 1442,120 GWh (65.2%); waste treatment 264,001 GWh (11.9%); hydraulic 70,943 GWh (6.3%); solid urban waste 183,754 GWh (8.3 %); solar thermal 169,798 GWh (7.7%) and PV 80,247 GWh (3.6%) (*Figure 4*).

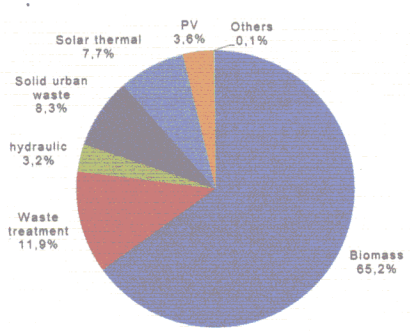


Figure 4 – Energy production by fuel in Madrid Region in 2012

The electric energy generated was 2,221 GWh, 8.5% of the total electric consumption. The share of energy sources for electricity production was: waste and biomass 1,104.85 GWh (49.6%); cogeneration 965.290 GWh (43.7%); hydraulic 69.78 GWh (3.2%); and photovoltaic 81.41 GWh (3.6%).

The region is totally energy dependent on the rest of the country. The high population density, the high concentration of service companies and a lack of sources for intensive energy production explain the high demand of electric energy from the service sector with 11,885 TWh (43.5%), the domestic sector with 8,548 TWh (32.7%), industry with 3,547 TWh (13.6%), and transport with only 1,884 TWh (7.2%). Total demand for electricity is 26.12 TWh (2012).

2. CURRENT SITUATION: TARGETS ELATED TO ENERGY POLICY

Due to the dependency on imported energy and according to the Regional Strategic Action Plan, the Autonomic Community of Madrid aims to improve the efficiency of use of the energy products, to promote savings and to reduce the intensity of energy consumption. In the Strategy for Air Quality and Climate Change (2006 – 2012) – the Blue Plan – the target was to gradually reduce the demand for total energy consumption by 10% as well as to double the annual energy production from renewable sources, and to reduce CO_2 emissions by 15% by 2016 and by 20% by 2020.

A new Air Quality Strategy and Climate Change of the Community of Madrid (2013 – 2020) is currently under development.

Other Regional targets, barriers and drivers

The Regional Government with the support of the FENERCOM (Energy Foundation of Madrid Community) is providing incentives and information campaigns to drive the issues regarding energy in all sectors, encouraging local and regional energy suppliers to multiply efforts towards renewable energy systems (see, at references, FENERCOM 2004 – 2013). Large sector focused information campaigns have been launched since 2005 including:

- Madrid Solar' is a campaign organised by the Directorate General of Industry, Energy and Mines with the collaboration of the nine major energy companies to encourage the use of thermal and photovoltaic solar energy;
- 'Madrid Label Energy Saving' is a campaign directed at industry, the commercial sector and end-users to promote A class energy level appliances (€38 million funding);
- 'Madrid Welcomes Energy Saving' aimed at the tourism sector, which has a great potential for energy savings;
- 'Madrid Factory Energy Saving Programme' is directed at the regional industry which is responsible for 12% of total energy consumption;
- 'Madrid Education Energy Saving Programme' is a campaign directed at the educational institutions and their students;
- 'Madrid Manages Energy Savings Programme' is directed at public sector managers and workers of the region to allow effective implementation and active collaboration on energy issues.

All these campaigns are supported with technical guides such as the Guide of Energy Refurbishment for Residential Buildings, the Guide of Energetic Auditory in Supermarkets, etc., publications, meetings and other disseminations at all stakeholder levels.

The main objectives and strategies for each of the sectors studied are:

- industrial sector – reduction of emissions through the application of best available technology and the promotion of innovation and technological development in the industries of the region. In addition, encouragement of pollution prevention through the intensification of inspections and periodic on-site audits;
- residential and Public sector – promotion of sustainable urban development. It will therefore be necessary to incorporate specific environmental criteria into planning instruments; to promote energy efficiency in buildings, both existing and newly built, considering an average of 400g of CO_2 emission per KWh;
- transport sector – delivery of a strategy action plan to reduce traffic congestion in the regional area, modifying the mobility behaviour of citizens. Encouragement of the development of alternative ways of mobility, using new eco-friendly fuels, improving the technical performance of vehicles and promoting public transport.

Despite the level of campaigning, programmes and other activities, after the Regional Community of Madrid Strategic Action Plan (2004 – 2012) and the Strategy for Air Quality and Climate Change (2006 – 2012), there is a lack of new holistic and pragmatic plans with clear strategic targets.

3. CASE STUDY: LOCAL STRATEGIES FOR IMPROVING THE ENERGETIC CERTIFICATION IN MADRID REGION BUILDINGS

This case study investigates how energy certification could be used to improve residential buildings in the Madrid Region. A recent refurbishment of dwellings in San Cristobal de Los Angeles will serve as a working example.

The accomplishment of European Regulation is fundamental in every Spanish region in terms of energy efficiency in buildings. The need for an Energy Performance Certificate (EPC) for a building arises from the partial transposition of the European Directive 2010/31/EU of 2010. In Spain the Royal Decree 47/2007 incorporated the basic procedure for certification of energy efficiency of existing buildings.

The Royal Decree 235/2013, of 5 April 2013, approved the basic procedure for the certification of the energy-efficiency of buildings. The application of the Decree was voluntary until June 2013. After this date

the implementation of this legislation was transferred at regional level. Thus each different region has the capability to set the parameters for the Energy Performance Certificate (EPC) of buildings within its territory.

An EPC is required when constructing a new building and when renting or selling an existing building.

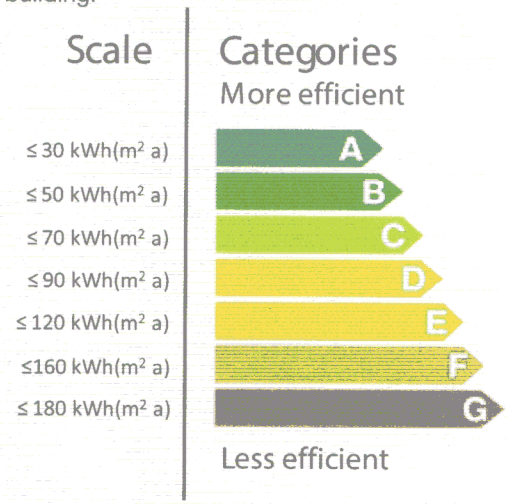


Figure 5 – Energy efficiency Categories

The EPC classifies the performance of a property, providing a score of energy efficiency and CO_2 emissions of a building on a scale from A to G, where A is very efficient and G is very inefficient.

An EPC is produced using standard calculation methods with standard assumptions about energy use so that the performance of a building can easily be compared with another building of the same typology. This allows prospective buyers, tenants, owners and occupiers to see and compare information on the energy efficiency and CO_2 emissions of a building. In this way, they can consider energy savings and fuel costs as part of their investment decision. An EPC will include a list of recommendations on cost effectiveness and other measurements, such as low and zero carbon rating systems in order to improve the energy rating of the building. The EPC also contains information about the rating that could be theoretically achieved if all recommendations are implemented.
In Spain, the control on the application of the EPC is done by different regional governmental agencies. Different regions have applied their own regulations, which have taken form into Decrees at different times. Thus currently all regions (called Communities) have their own instruction for EPC control. Some examples are:

Figure 6 – Spanish Regions for the EPC considerations

- Andalucia: Order 25 June 2008;
- Galicia: Decree 42/2009;
- Canarias: Decree 26/2009;
- Extremadura. Decree 136/2008;
- Valencian Community: Decree 112/2009;
- Cataluña: new Decree 235/2013;

The final objective of monitoring energy consumption in buildings is the reduction of demand. Apart from environmental benefits of decreased energy consumption, it has been shown, on average, that higher energy ratings result in substantially higher sale values or rental values of buildings (about 8% and 4.4% in Austria and 3.2% and 2.3% in Belgium, respectively).

The acquisition of an EPC has been compulsory in Madrid region since June 2013. At the end of August 2013, more than 100,000 spanish houses had obtained an EPC. 85% of these are located in the Madrid region or Cataluña, due to the high population densities in Madrid and Barcelona. In addition, the register for the EPC is being delivered very quicly in these regions, thanks to computerised system for the registration of buildings.

The "Dirección General de Industria, Energía y Minas de la Comunidad de Madrid" (General Direction for Industry, Energy and Mines of the Madrid Community) indicates the percentage of building types that have achieved energy certification: flats: 77.5%; detached houses: 13.6%; offices: 4.5%; commercial 1.3%; others: 3.1% (*Figure 7*).

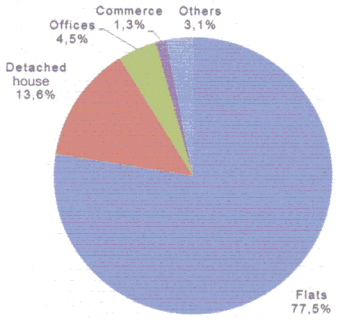


Figure 7 – Distribution of building typologies in the Madrid Region that have achieved the EPC

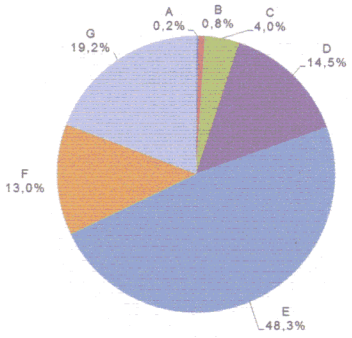


Figure 8 – illustrates the step changes for achieving an EPC

Figure 8 illustrates that most buildings assessed to date have achieved an E or F score. As E and F are "bad" scores, thus the efficiency in these buildings can be deeply improved.

Objectives and methods

San Cristobal de Los Angeles is a neighbourhood in the city of Madrid and it can be described as a typical example of the whole region. San Cristobal de Los Angeles has 18,000 inhabitants – 40% have recently immigrated to Spain and unemployment is at nearly 50%. A high proportion of the population arrived in Madrid from the South of Spain during the 1950's, as a result a large proportion of the population are over 65 years old. This combination of population groups creates significant social problems.

Environmental and technical measures

In order to improve the overall efficiency of the area, which includes 28 shared properties, new buildings were constructed at the same time as existing ones were refurbished. The main challenge was dealing with the high energy consumption of existing buildings, due to poor orientation and certain conditions of the façades. Two residential blocks that have been refurbished in San Cristobal de Madrid are presented in detail:

- area of intervention: 2,240 m^2 and 3,370 m^2;
- client: "Empresa Municipal de Vivienda y Suelo" and "Ayuntamiento De Madrid" (Madrid Municipality);
- architects: Margarita de Luxán and Gloria Gómez Muñoz.

Both energy demand and supply opportunities were considered before redesigning the building together with climatic conditions for the definition of strategies for passive heting/cooling. A study of the possibilities considered: solar gains based on the urban layout; dominant winds for ventilation; and improvement of the building envelope.

Remedial action undertaken on existing buildings included: orientation optimisation, envelope improvement and better accessibility.

New buildings were designed using bio-climatic principles. Natural chimneys were used to avoid the need of conventional cooling services such as air-conditioners.

Figure 9 – New building. Natural chimney

Of particular note is the improvement of accessibility to the refurbished apartments, where low power elevators and new staircases have been incorporated. No established form of evaluation is available to assess social benefits for elderly people using elevators instead of stairs.

Figure 10 – New building – East façade

Figure 11 – New building – South façade

Figure 12 – New building – West façade

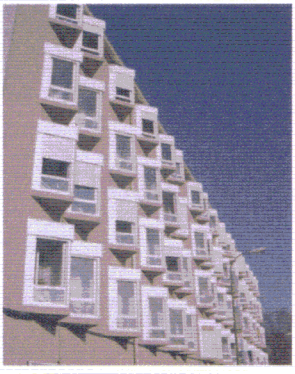


Figure 13 – Renovated building – East façade

Figure 14 – Rehabilitated building – North and East façades

Figure 15 – Rehabilitated building – West façades

Long term focus

The implementation of similar measures to all properties across the whole neighbourhood has been planned. The plan also included social issues, mobility, etc. By extending these "refurbished neighbourhoods" to all similar municipalities across the region would allow the improvement of the whole regional building stock.

Energy simulations have been undertaken using software, mainly 'Design Builder', and the potential to use software for urban scale modelling, such as EnviMet is currently being investigated (Vidmar, 2013).

Results

Passive measures have been used with the goal of achieving acceptable comfort conditions in the dwellings for of the time 80%, for both winter and summer. According to calculations, the specific energy consumption of buildings for air conditioning (heating and cooling) before the intervention was 54.44 kWh/m^2/yr (EPC class E). Thanks to the implemented measures, a consumption of 20.36 kWh/m^2/yr (EPC class C) was achieved, meaning a 62.6% reduction in energy demand.

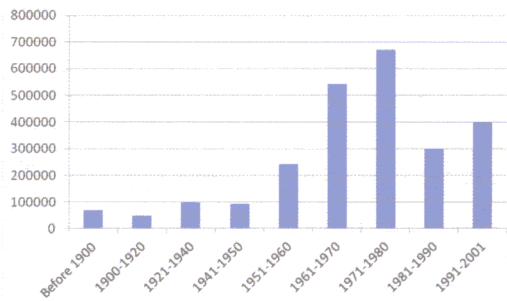
Outcomes

From a social and economic point of view, any public intervention that improves the quality of life whilst maintaining or saving energy costs is good for the neighbourhood. From an environmental and technical point of view, this project was awarded with an 'Isover Energy Efficiency' Award 2007. Unfortunately, with the current economic situation in Spain, a lack of investment is the most crucial barrier for the delivery of similar interventions.

4. CONCLUSIONS

A general analysis of energy consumption in the Madrid Region and implications in energy certification in buildings (EPC) are presented. As a particular case, the intervention in the neighbourhood of San Cristobal de Los Angeles is described. Reductions of energy consumption and CO_2 emissions are significant compared to initial performance. The case study demonstrates the potential of applying this refurbishment strategy to other buildings of the same typology in the region and outside the regional borders, in areas with similar climatic conditions.

In 2001 there were 508,882 residential buildings containing 2,478,145 dwellings across the whole region of "Comunidad de Madrid". These figures allow optimistism to enable more detailed projects (INEweb). Figure 16, indicates the number of dwellings that have been built during different time periods.



x – axis the period of construction,
y – axis the number of dwellings.

Figure 16 – Distribution of construction per year in Madrid Region

Regulation on thermal performance was established in 1980, which defines the scope of work, as buildings built before this time will require the most work. About 1,200,000 dwellings in the Madrid region were built during the period 1961– 1980 which require significant retrofitting. This work could benefit the region economically, providing employment in the construction sector.

A simple calculation illustrates the possibilities: a building improved from EPC class F (140 kWh/m^{2}yr) to C (60kWh/m^{2}yr) would result in

a saving of 80 kWh/m^2. Since each dwelling is about 50 m^2, 4,000 kWh/y and 200,000 buildings would result in savings of 80 GWh per year. As a result of the energetic mix in Spain, assumptions can be made that 453 g CO_2/kWh is from electric energy and 201 g CO_2/kWh from gas use. For the Madrid region, it could be assumed that 7 times more energy is required for heating than for cooling. Therefore, for each 800 kWh, 700 kWh will be obtained from gas and 100 kWh by electricity (Maña, 2003). This results in the following calculations:

- for gas, a reduction of 70 GWh (0.2 kgCO_2/kWh) will save 14 million of kg CO_2;
- for electricity, a reduction of 10 GWh (0.45 kg CO_2/kWh) will save 4.5 million of kg CO_2.The Spanish regions that received internal immigration at those times including Catalunya, Comunidad Valenciana, etc. are likely to be in similar population situation.

Since the use of EPC is compulsory in Spain and has to be adapted for each region, it is proposed by the authors to quantify energy and emissions improvement as the jump from a previous (worse) label to a new (better) label. As EPC is used in a lot of EU countries, this method could be exported and applied directly.

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