Best Practice: Promoting Solar Energy

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CITY: BARCELONA **POLICY AREAS: CLIMATE CHANGE; ENERGY**

BEST PRACTICE

Barcelona is the first European city to have a **Solar Thermal Ordinance (STO)** making it compulsory to use solar energy to supply 60% of running hot water in all new buildings, renovated buildings, or buildings changing their use. This ordinance applies to both private and public buildings.

The Solar Thermal Ordinance is one of many accomplishments of Barcelona's overall strategy to encourage the installation and use of solar energy in the city. This report details the passing of the Ordinance in 1999 and its amendments in 2006, and highlights specific solar energy initiatives that have been introduced, including the conversion of municipal buildings to photo-voltaic (PV) energy and the development of self-sufficient solar-powered bus stops.

ISSUE

Dependence on fossil fuel with its mounting cost has a major impact on the economy and the environment. Sustainable solutions are vital. In the 1990's, there was a new commitment by the Barcelona city government to take action and forward programs to reduce energy consumption. As a result of increased political will, in 1999, Barcelona enacted legislation making itself the first European city mandating the use of solar thermal power.

With an average of 2,800 hours of sunshine every year, Barcelona was well-poised to take advantage of solar power.

GOALS AND OBJECTIVES

The Solar Thermal Ordinance has led to measurable energy efficiency, including:

- Saving over 70,000 MWh per year
- The energy produced is equal to the domestic hot water demand of a population of 171,000, or the needs of some 50 health care centers with 1,400 beds.
- Barcelona has increased, by over 50 times, the surface of solar thermal square meters in the city from 1.1m^2 per 1,000 inhabitants in 2000 to 59m^2 per 1,000 inhabitants in December 2010.
- Licenses requested for the installation of solar panels increased from 1,650m^2 in 2000 to 87,600m^2 in 2010.
- 20% of the total solar thermal capacity area approved for buildings has been installed and is operational.

As an outcome of this successful legislation, Barcelona quickly moved to establish initiatives with measurable energy objectives. With the approval of the Barcelona Energy Improvement Plan (PMEB), a ten-year energy plan (2000 to 2010), the City aimed to reverse trends and reduce energy consumption as well as greenhouse gas emissions. This pioneering plan has formed the general framework for the city's energy policy, providing a set of 55 local action measures ranging from normative actions to education programs.

IMPLEMENTATION

1999-2000 Passing of the Solar Thermal Ordinance
Barcelona is the first large European city to have a Solar Thermal Ordinance making it compulsory to use solar energy to supply 60% of running hot water in all new buildings, renovated buildings, or buildings changing their use. Barcelona drafted the ordinance in 1998 and it was approved by the City Council in 1999. Following a one-year moratorium to allow for adjustments, the ordinance took effect in August 2000.

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The ordinance was prepared and approved thanks to the political will of the local administration to promote solar thermal energy in Barcelona. This initiative came about through the active participation of various actors and groups which contributed their experience and knowledge. Among them, the following are:

- Asociación Española de Empresas de Energía Solar y Alternativas [Spanish Association of Solar and Alternative Energy Firms] (ASENSA).
- Asociación de Promotores Constructores de España [Spanish Association of Construction Promoters] (APCE).
- Asociación de Promotores de Energías Renovables de Cataluña [Association of Renewable Energy Promoters of Catalonia] (APERCA).
- Asociación para la Promoción de las Energías Renovables y el Ahorro Energético Association for the Promotion of Renewable Energy and Energy Savings] (BARNAMIL).
- Colegio de Administradores de Fincas de Barcelona y Lérida. [Association of Property Managers of Barcelona and Lerida]
- Colegio de Aparejadores y Arquitectos Técnicos de Barcelona. [Barcelona Association of Master Builders and Technical Architects]
- Colegio de Arquitectos de Cataluña. [Catalonia Architects Association]
- Colegio de Ingenieros Industriales de Cataluña. [Catalonia Industrial Engineers Association]
- Federación Catalana de Gremios de Instaladores [Catalan Federation of Installers Unions] (FERCA).
- Organización de Consumidores y Usuarios de Cataluña. [Catalan Organisation of Consumers and Users] (OCUC)
- State Administration: Institute for Energy Diversification and Saving (IDAE), Ministry of the Environment, Ministry of Housing.
- Catalonia Regional Government: Departament of Industry and Employment, Department of the Environment and Housing, Catalan Energy Institute (ICAEN).
- Barcelona City Council Departments: Urban Planning, Urban Services and the Environment, Municipal Institute of Urban Landscape and Quality of Life, Municipal Institution of Housing.
- The Barcelona Advisory Council for the Environment and Sustainability's Energy Group,

The ordinance first required that new buildings and those undergoing major refurbishment using more than 0.8 MW per day for hot water production, meet at least 60% of their demand with solar thermal collectors. All commercial buildings and residential buildings with more than 16 apartments were subject to the regulation.

2002 Establishment of the Barcelona Energy Agency and the first Energy Improvement Plan

The Barcelona Energy Agency was established in May 2002 with the aim of implementing, managing and monitoring Barcelona's Energy Improvement Plan. Among the other objectives, the plan aims to maximize the use of solar energy in Barcelona. It was awarded the European Climate Star in 2002.

The PMEB is a set of 55 local action measures, assessed from the energy-related, environmental and economic standpoints. These projects envisage various levels of action, ranging from regulations or financial aid for facilities to training and education programs.

In this plan the City Council has taken a bold step in exploiting thermal solar energy by making a strong commitment to installing solar panels. The plan presented the following energy contribution from solar energy:

- 58,000 GJ per year of electricity using solar photovoltaic technology, with a generating capacity of 14.14 MWp.
- 11.44 MWp in offices, 1.1 MWp in commercial, 0.25 MWp in schools and 1.35 MWp in a centralized plant on the 2004 Forum site.
- Installation of 96,300m2 of thermal solar panels with a heat generation capacity of 280,000 GJ per year. These installations would turn Barcelona into one of the cities making most use of solar energy and provide 679,800 GJ per year from renewable sources or 1.1% of the city's total energy consumption in 2010. This is consistent with the target set by the Spanish government's plan for fostering use of renewable energy sources for Catalonia autonomy.

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Building Solar Energy Plants in Public Spaces
A large pergola (structure with solar panels), which operates as a photovoltaic energy plant was installed in 2004 at the Universal Forum of Cultures, an exhibition co-sponsored by the Catalonia Regional Government, the Spanish Federal Government and United Nations Educational, Scientific and Cultural Organization (UNESCO). This structure is located in the Forum Esplanade and consists of a 10,500m2 surface that captures solar energy and delivers it to the electric public utility system. The great esplanade that dominates this new public space has been turned into the most powerful urban solar energy power plant in Spain. In 2007, the solar pergola produced almost 500,000 kilowatt hours of electricity.

How does it work?
A total of 1/3 megawatts of photovoltaic modules were installed on the site, corresponding to the yearly electricity needs of about 1,000 inhabitants of Barcelona. The system for capturing light energy uses 2,668 monocrystalline modules and is made up of tiny silicon wafers that convert sunlight into electricity. The pergola is 50m tall, and in order to maximize solar exposure throughout the year, the panel faces south; tilted at a 35° angle.

2006 Amending of the Solar Thermal Ordinance
In 2006, Barcelona upgraded the existing ordinance, eliminating the 0.8 MW per day minimum requirement. Consequently, the STO now applies to all new buildings and those undergoing renovation, regardless of their size or intended use. Also, to increase the scope of the ordinance it is considered that a building project, to promote several buildings with the same or different use, is a single project.

The buildings covered by the regulation are those intended for the following uses: residential, health, sports, commercial (in special cases), industrial, and in general any other use that entails the presence of dining rooms, kitchens or collective laundries.

2006 changes include:
Applicability when the use of the building implies the use of domestic hot water, heating of water to condition swimming pools, or use of hot water for industrial purposes.

The design and execution of a system to produce hot water with thermal energy must take the following minimum solar contribution into account:

- To heat domestic water: the values specified by the ordinance, according to the various demand levels (a minimum of 60%), for a reference temperature of 60°C – general if the auxiliary source of energy is heating oil, propane, natural gas or other gas (general gas), or the Joule effect if electricity is the auxiliary source.
- To heat water of covered swimming pools: 30%
- To heat water for industrial processes, from the temperature of the water network to 60°C: 20%.
- The heating of uncovered swimming pools will only be allowed with a system of solar energy collection.

2007 Installation of a solar cooling plant in a municipal building, based on thermally driven chiller with two hot storage tanks and two different temperature levels

Technical data

- Type of system: Solar heat driven chiller based system
- Chiller: Absorption - 35 kW (YAZAKI WFC-SC10)
- Collectors: Flat-plate - 81m^2 (WAGNER LBM 100 AR)
- Hot storage: Two tanks 3m^3 + 3m^3
- Cold storage: 1m^3
- Back-up (former system)
- Boiler : 508 kW
- Compression chiller: 323 kW

Performance data

- Source: Transient System Simulation (TRNSYS)

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- Solar contribution:
  - Cooling: 4 %
  - Heating: 20 %
  - Domestic Hot Water: 68 %
- Primary energy savings: 72 MWh/a

2009 "Solar Power Generation" conference convened in Barcelona as part of the "Green Power Conferences Solar Series"
Goals of this international conference included:

- Understanding the potential of concentrated solar thermal energy (CST), concentrating photovoltaic systems (CPV) and large scale photovoltaic (PV) energy in Europe and globally
- Networking with the leading players in large scale Solar Power Generation

2009 The Solar Bus Stop, the new icon in the urban design
The Barcelona Metropolitan Transportation Department (EMT) sponsored the development of solar-powered bus stops, in a public-private partnership with CAPMAR, S.L., a private design company and the Investigation and Education (I+ED) department of the Istituto Europeo di Design (IED) Barcelona.

The Istituto Europeo di Design of Barcelona operates in the education and investigation field in the disciplines of the design, fashion, visual arts and communication. The school belongs to an international network with campuses in Italy, Spain and Brazil, that bets for the practical and didactic initiative related to the business reality through the culture of the project and of its department of I+ED (Investigation + Education). CAPMAR, S.L. is a company consolidated of a second generation with many years of experience and a solid base, but projecting towards the future in offering the best product, design, production and services in locksmith, carpentry, and urban furniture.

The design of the solar bus stop is based on a structure of two tubular columns of iron and a square section of 8x8cm, with a height of 3.5m and 67cm wide. The upper section has photovoltaic panel 67x72cm. The system consumes only 72 watts a day and can run for up to 5 days without solar radiation. The bus stops have a panel with bus schedules updated every 30 seconds, a panel with information and a button for nocturnal illumination. Its design allows for modifications to provide extra services such as a second informative screen on bus routes, local publicity and accessories like seats and magazine racks.

The solar bus stop is a modular installation, easy to set up, since it does not need to be connected to an electric network—all necessary energy is supplied by the solar panels. It is a light, innovative and functional design that has the maximum benefits, optimizing the use of materials, resources and space. The contemporary stylized lines turn the new solar bus stop into a special element of the Barcelona metropolitan aesthetic.

The initial phase was to install 100 solar bus stops in 2009 in the 18 cities of the Barcelona metropolitan area, followed by the replacement of 2,000 already existing bus stops with the new solar model.

2011 Approval of the Photovoltaic Ordinance under the new Barcelona Environmental Ordinance.
In February 2011, the new Barcelona Environmental Ordinance was approved, which includes an energy section, with the solar thermal ordinance approved in 2006, as well as the new photovoltaic ordinance. This new ordinance makes photovoltaic systems mandatory in news buildings, mainly in commercial and service sector.

2011 Establishment of the Energy, Climate Change and Air Quality Plan for Barcelona 2011 – 2020.
In March 2011, the City Council approved its second energy plan, the Barcelona Energy, Climate Change and Air Quality Plan for the period 2011 – 2020.

The main targets of the plan are to reduce energy consumption and greenhouse gas emissions and to improve air quality as well as energy supply systems.

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This plan allows the city define its strategies and its energy policies for the next ten years.
The plan contains 108 projects that are related to energy demand management, both in terms of technology improvements and awareness raising measures. Air quality improvement projects, as well as mobility, and distributed energy generation obtained from renewable energies and efficient technologies are also an important part of the document.

COST

The financing of photovoltaic installations has been assumed mainly by the Barcelona City Council with, in some specific installations, some support of co-financing by other public administrations.

RESULTS AND EVALUATION

Monitoring of the Solar Energy By-Law
The Solar Thermal Ordinance is managed by the Barcelona Energy Agency, part of the Environment Department of the City Council. This body grants design and construction approval. Building inspectors are then responsible for ensuring that construction meets the stipulated criteria.

Summary 2002-2010:

- 87,651m^2 of total solar thermal installed
- 58,58m^2 per 1.000 inhabitants;
- 70,121MWh/year; 12,329 tons CO2 per year reduced.

Concerning solar photovoltaic energy, by the end of 2008, 39 municipal installations had been carried out in public buildings across all city districts, with a total installed photovoltaic power of 1.69 MWp:

- Barcelona City Council and districts buildings: 5 projects, 99 kWp.
- Social and cultural centers: 11 projects, 131 kWp.
- Primary and Secondary schools: 13 projects, 110 kWp.
- Public libraries: 6 projects, 65 kWp.
- Pergolas in public areas: 3 projects, 1198 kWp.
- Others (parks, markets, urban waste disposal plant): 3 projects, 90 kWp

The total surface area of solar panels approved by the Barcelona City Council in December 2010 (87,621m²) represents an energy saving of over 70.000 MWh per year, and will save over 4,300 tons of CO2 equivalent emissions. The per-capita area of solar panels increased nearly 50 times, form 1.1m² per 1,000 inhabitants in 2000 to 58m² per 1,000 inhabitants in December 2010.

The solar energy produced is equal to the domestic hot water demand of a population of 171,000. By the end of 2010, 20% of the total solar thermal capacity area approved for the buildings covered by the ordinance had been installed and was operational. This figure is consistent with the lapse of time between the revision of the construction's basic project and granting the building permit, and the time when the building is actually occupied and the solar installation enters into use.

The PMEB sets the objective of attaining, by the year 2010, some 96,300m² of solar collectors installed in the city, for an estimated thermal generation of 778 GWh per year (280,000 GJ per year).

Since the solar regulation came into force, the fitting of solar thermal installations has increased by 5212.2%.

TIMELINE

1998	Barcelona City Council begins talks and drafting Solar Thermal Ordinance

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July 1999	STO approved
August 2000	STO goes into effect
2002	PMEB, the City's 10 year energy plan, is unveiled
2004	Installation of a pergola (solar energy plant) in Barcelona's Forum Esplanade
February 2006	Revision of the STO
February 2009	Barcelona hosts the "Solar Power Generation" conference as part of the "Green Power Conferences Solar Series"
2009	Solar-powered bus stops are designed and developed
October 2009	First solar bus stop unveiled
February 2011	Approval of the Photovoltaic Ordinance under the new Barcelona Environmental Ordinance
March 2011	Establishment of the Energy, Climate Change and Air Quality Plan for Barcelona for 2011-2020

LEGISLATION

The Solar Thermal Ordinance was approved July 1999, implemented August 2000 and revised February 2006. The purpose of this ordinance is to regulate the incorporation of solar thermal energy and its use for the production of hot tap water in the city's buildings. The STO affects new, restored and fully refurbished buildings and those seeking to implement a change of use. This regulation applies to buildings intended for residential, health-care, sports, commercial and industrial use and, generally, any activity involving the existence of kitchens, laundries or other circumstances that lead to a large consumption of hot water, regardless of whether they are public or privately owned.

In February 2011, the new Barcelona Environmental Ordinance was approved, which includes an energy section with the STO, as well as the new Solar Photovoltaic Ordinance (SPO). The purpose of the SPO, implemented in April 2011, is to regulate the incorporation of photovoltaic energy systems and its use for the production of electricity in the city's buildings. The Photovoltaic Ordinance affects new, restored and fully refurbished buildings from the tertiary sector.

At the national level, Barcelona's STO and SPO inspired a piece of national legislation requiring minimum levels of solar hot water and photovoltaic cells in new construction and renovation projects.

LESSONS LEARNED

The key challenges of this initiative have been ensuring that people are educated on the use and maintenance of their solar panels. Solar panels should be treated like elevators —they need regular maintenance and repairs. To deal with this issue the City Council has been running education campaigns to raise awareness. One example is the *Porta a porta* (Door to Door) campaign. Here the educators worked with the Neighborhood Association and building associations to ensure that tenants/public measure their energy savings and check to ensure that the solar installations are working. The Environment Department also has an information center open 6 days a week where people can get information on solar use and maintenance.

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In addition to increasing public awareness about the use and benefits of solar energy, the city developed an internal campaign for solar energy awareness. In 2003, the majority of the staff in municipal districts' Technical Services offices was unfamiliar with solar energy and some prejudice against this technology could be noticed amongst architects. For example, photovoltaic pergolas with a minimum tilt angle of 5° (recommended for the PV modules to be cleaned by rain water) were not accepted for aesthetic reasons.

This successful campaign is a result of close collaboration between the districts' Technical Services and the Barcelona Energy Agency. Besides regular meetings, visits to PV installations were held, so that the district's Technical Services could see for themselves the aesthetics of photovoltaic modules in different integration solutions (for the example mentioned above, no substantial difference exists between horizontal and 5° tilted surfaces). Not all districts had a positive view of solar energy in the initial stages, but the city-wide campaign generated enthusiasm. A positive result of this collaboration is that many new and renovated public buildings designed by districts' Technical Services have structures that can easily accommodate solar energy technology.

TRANSFERABILITY

Barcelona's promotion of solar energy has inspired municipalities in Spain and in other European countries. In each country, the legal framework is different. But the example of Barcelona showed that a solar obligation is politically feasible, supported by citizens and can boost the market.

Some Spanish cities including Seville, Madrid, Burgos and Pamplona have followed Barcelona's lead and instituted regulation more stringent than that imposed by the federal government. As the first regulation of this type to be adopted in a large European city, it has been presented to autonomous bodies, local administrations, networks of cities and international institutions to influence its polices taking this local initiative as another good local practice that contributes towards both local and global sustainability.

In 2003, the small (less than 15,000 inhabitants) Municipality of Carugate, Italy adopted a new building regulation which promotes energy efficiency in general. In particular, following the model of Barcelona's STO, the use of solar thermal systems to produce at least 50% of the domestic hot water demand was introduced as a mandatory measure for new buildings.

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Facts and figures in this report were provided by the highlighted city government to New York City Global Partners.