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ENERGY EFFICIENT BUILDINGS: MODELS, INNOVATION AND MARKET

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At the beginning of the 21st century, the built environment cluster is facing a major challenge: that of energy- and environment-efficient buildings. From two international benchmarks, three energy- and environment-efficient building models are defined: the Low Consumption model (LC model), the Energy and Environmental model (EE model) and the Energy Saving and Production model (ESP model). A socio-eco-technical evolutionist approach to innovation allows analysing how those models can meet the market. The driver is political, at three levels: continental, national, and local. Local authorities and private local actor cooperation is an active engine for the dissemination of energy- and environment-efficient buildings.

KEYWORDS: innovation, green buildings, energy, market.

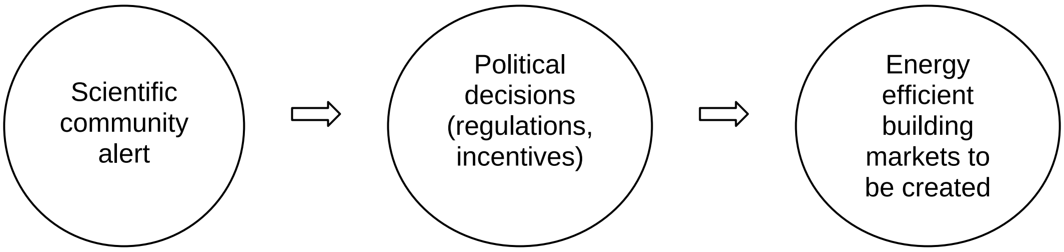
INTRODUCTION

At the beginning of the 21st century, the built environment cluster is facing a major challenge: that of energy- and environment-efficient buildings. The built environment cluster concept is wider than that of the building industry (Carassus, 2004). Based on the life cycle of buildings and infrastructures, the built environment cluster approach includes not only the site process non manufacturing industry (construction firms), but also service segments (developers, designers, material distributors, asset, property and facilities managers), manufacturing segments (construction material and equipment firms) and regulatory actors (public continental, national and local authorities, private industry and professional organisations) (Carassus et alii, 2006). The economic weight of the built environment cluster is twice the construction industry one (Sexton et alii, 2007).

Buildings represent roughly 40% of two major planetary challenges: that of climate change and energy supply. As the scientific community has demonstrated (IPCC, 2007, Stern, 2007), the main cause of climate change is human-origin CO_2 emissions. Buildings generate almost 40% of CO_2 emissions. Energy supply is a major strategic challenge. Buildings generate more than 40% of the final energy consumption, that is the total of industry and transportation energy consumptions.

An original three-step mechanism is currently in action: first, the scientific community alerts, second, political decisions (regulations, incentives) are made, not only to fight climate change but also to secure energy supply, third, energy buildings markets are to be created, with four main segments: those of new and refurbished residential buildings, and new and refurbished non residential buildings (see figure 1).

Figure 1 A three-step mechanism



Three energy- and environment-efficient building models will be identified through two international benchmarks. A socio-eco-technical approach of innovation will be defined through evolutionist analysis. The link between innovative models and market will be specified through the international benchmarks. The complexity of the innovative models meeting market will be summarized.

THREE ENERGY- AND ENVIRONMENT-EFFICIENT BUILDING MODELS

Several international benchmarks deal with the energy-efficient building topic. Two of them are used: the French government 2006-2007 Building and Energy International Benchmark (PREBAT, 2007) and the 2007-2009 World Business Council for Sustainable Development Energy Efficient Buildings Project (WBCSD, 2008).

The aim of the first one was to know the best practices to be transferred to the French context to meet the ambitious European objectives. Europe played an active role in the 1997 Kyoto agreement, which specifies a decrease of 8 % in greenhouse gas emissions between 1990 and 2010 in Europe. The March 2007 energy action plan, adopted by the State and government heads European council, defined three ambitious objectives for 2020, known as the “Three Twenty objectives”: a unilateral decrease of 20% in greenhouse gas emissions between 1990 and 2020, a decrease of 20% in energy consumption between 1990 and 2020 and a share of 20% of renewable energy in 2020.

The two main methodological aspects of the French international benchmark were a socio-eco-technical approach and a wide international partnership.

To analyse the foreign initiatives or innovations, the project used a socio-eco-technical methodology in 6 steps (1) national and local background, origin of the initiative or the innovation, (2) content of the initiative or innovation, type of building concerned, new construction, refurbishment, techniques used, (3) implementation, dynamics of the actors involved, funding, incentives, investment and operation costs, (4) evaluation, real performances, real costs, users’ view, impact of the initiative or innovation, (5) critical reflection, strengths, weaknesses, opportunities and threats, (6) transposition conditions in France.

The international partnership mobilised 55 engineers, economists and sociologists from 12 different countries (among them the Massachusetts Institute of Technology, the Building Research Establishment, the Stuttgart Fraunhofer für Bau Physik, the University of Genève, the Danish University of Technology and the University of Technology of Catalunya).

Three fields were investigated: national and local initiatives, technological innovations, and R&D programmes. Best practices especially from Germany, Switzerland, Spain, Denmark, Austria, Finland, the Netherlands, the United States, Japan and Australia were analysed.

The aim of the World Business Council for Sustainable Development Energy Efficient Buildings Project is different. It is a business oriented project monitored by an American and a French firm (United Technologies Corporation and Lafarge) mobilizing several multinational private companies from Europe, the United States, Japan and India.

The aim is to promote new and refurbished zero net energy buildings in six main potential markets: North America, Europe, Japan, China, India and Brazil.

In 2007 the project team published its first report (Energy Efficiency in Buildings: Business Realities and Opportunities), which will be followed by the 2008 Scenarios Report and the 2009 Call for Action Report. The project includes lobbying action through international meetings, mobilizing public and private stakeholders, held in Beijing, Brussels, New Delhi, Paris, Washington DC, Sao Paulo and Tokyo.

The French benchmark highlighted three main energy- and environment-efficient building models (Carassus, 2007 a)[1]. The first one is the “Low Consumption” model (LC model). The emphasis is placed on low energy consumption in over-insulated buildings. The German version (*Passivhaus*) is more demanding than the Swiss version (*Minergie*®). The *Building America* Project is another example of this model, with less ambitious energy targets.

The second one is the “Energy and Environment” model (EE model). Energy is articulated to other environmental objectives (integration into the site, comfort, materials, waste, etc.). The American *LEED*™ label and, in a certain way, the British *BREEAM* label, the Japanese *CASBEE* label and the French *HQE*® label are examples of this model.

In the third model, the “Energy Saving and Production” one (ESP model), the buildings save energy and also produce energy, especially through solar photovoltaic panels. The American *Zero Energy Homes* are more insulated and less industrialized than the Japanese photovoltaic houses. The Spanish experience highlights the use of thermal solar energy for hot water.

The Low Consumption Model (LC model)

The emblematic example of the LC model is the *Passivhaus* label (Fraunhofer Institut für Bauphysik, 2006). The Germans (who are branching out into Austria, Switzerland, Belgium and France) know how to construct new buildings with practically no heating in the German climate, with an investment of 5 to 12% more than usual.

[1] We were the head of the French Building and Energy International Benchmark project.

A house bearing the *Passivhaus* label must have a heat consumption of 15 KWh/m²/year of final energy, a total primary energy consumption of less than 120 KWh/m²/year, a maximum airtightness of 0.6 volume/hour.

The five most common characteristics of these houses are: over-insulation from the outside with triple-glazed windows, double-flow ventilation with heat recovery, passive solar gains, low-consumption household appliances and the use of renewable energies. Six thousand *Passivhaus* houses have been built.

The principles of the Swiss *Minergie®* label are the same with less demanding objectives (Haefeli et alii, 2006). More than 8000 buildings and houses are certified *Minergie®*. The French *Effinergie©* label is a version of the Swiss label adapted to the French context.

The LC model is well adapted to rigorous climates.

The Energy and Environment Model (EE model)

In 2000, the US Green Building Council (USGBC) launched its *Leadership in Energy and Environmental Design LEED™* evaluation and rating program, with six action fields: Sustainable Site, Water Efficiency, Energy and Atmosphere, Materials and Resources, Indoor Environmental Quality, Innovation and Design Process (Norford, 2006).

The label specifies four performance levels: certified, silver, gold, platinum. *LEED™* currently has four programs: New commercial constructions, Existing building operations, Commercial interiors projects, Core and Shell projects. Energy performance is 30% on average, compared to normal rules. Approximately 800 buildings are labelled, and 5500 applications are in progress.

The Building Research Establishment Environmental Assessment Model *(BREEAM)* was launched in the UK in 1990. It uses, for residential buildings, seven criteria: Energy, Water, Pollution, Materials, Transport, Ecology and Land Use, and Health and Well-Being. It is employed for seven types of buildings: dwellings (EcoHomes), industry, offices, retail, schools, courts and prisons.

It specifies four performance levels: “Pass” with 25 points, “Good” with 40 points, “Very Good” with 55 points, and “Excellent” with 70 points. More than 65,000 buildings have received *BREEAM* certification.

The *“Haute Qualité Environnementale” HQE®* method was created in France in 1997. It specifies fourteen criteria in four fields: Site (integration, materials, site process); Management (energy, water, waste, maintenance); Comfort (hydrometrics, vision, acoustics, olfactory); Health (quality of air, water, space).

“NF maisons individuelles démarche HQE®” certification for individual homes and *“NF bâtiments tertiaires démarche HQE®”* for non residential buildings were launched in 2005 and 2006. A seven-criteria version *“Habitat et Environment©”* is used for dwellings, condominiums and social housing units. Energy performance is only from 10 to 20% in comparison with normal rules.

The EE model is well adapted to investors, for whom energy is only one objective among others, in an environmental approach of the buildings.

The Energy Saving and Production model (ESP model)

An American *“Zero Energy Home”* is a wood-framed house with a thicker structural frame, a damp-proof membrane on the outside, well-insulated attic space, low-emission double-glazed windows, mechanical ventilation, a high-efficiency boiler and short networks, compact fluorescent lamps, thermal solar energy and a photovoltaic system (Norford, 2006).

A typical low-consumption Japanese house is a prefabricated house, in which everything is electric, with reinforced insulation, double-glazed windows, mechanical ventilation, heat pump, and local production through photovoltaic system integrated into the prefabricated house. 120,000 Japanese houses use photovoltaic.

In Spain, departing from an experience in Barcelona, according to municipal orders, thermal solar energy must cover 60% of the demand for domestic hot water in all important buildings, new or renovated.

The ESP model is well adapted for countries which plan to decrease peaks of electricity consumption. It also opens the perspective of Zero Energy or Positive Energy buildings, which will produce more energy than they will use.

A SOCIO-ECO-TECHNICAL APPROACH TO INNOVATION

How can those models meet the market? The evolutionist framework will be used. Founded by Joseph Schumpeter, for whom innovation was the engine of evolution (Schumpeter, 1959), this economics school for a long time highlighted essentially technological innovation.

In the two first editions of the “Oslo manual” defining guidelines for collecting and interpreting innovation data, from an experience based on the manufacturing industry, OECD uses in 1992, and still in 1997, a narrow definition of innovation, limiting it to technological product and technological process innovation.

Such innovation definition is not adapted to the complex building process produced by the built environment cluster, which includes not only the manufacturing industry (construction material and equipment firms), but mainly services firms (developers, designers, asset, property and facilities managers) and the site process non manufacturing industry (construction firms).

Several evolutionist economists insisted on the service characteristics of the products (Saviotti, 1996) and on the specificity of innovation in the service economy (Gallouj, 2002).

And for the first time in 2005, OECD and the European Commission pointed out a socio-eco-technical approach to innovation by specifying that “innovation is the implementation of a new or significantly improved product (good or service), or process, a new marketing method, or a new organisational method in business practices, workplace organisation or external relations” (OECD, Eurostat, 2005).

OECD and the European Commission specify that “innovation activities are all scientific, technological, organisational, financial and commercial steps which actually, or are intended to, lead to the implementation of innovation.”

Four types of innovation are distinguished: product (good or service) innovations, (good or service) process innovations, marketing innovations and organisational innovations. Innovations can concern a novelty for the firm, for the market or for the world.

The two benchmarks dealing with energy-efficient buildings highlighted the importance of coordinated technical, service, organisational and marketing innovations, in a holistic view of building design, production and operation.

Highlighting only technical innovation is a failure factor, as was demonstrated by comparing the success of the Swiss *Minergie®* label and the failure of the French *5000 solar houses programme* (Carassus, 2007 b).

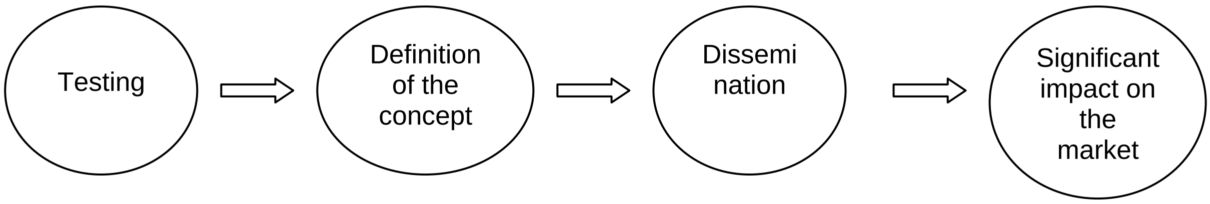
INNOVATION AND MARKET

The OECD and European Commission definition of a radical innovation is interesting to note: "A radical or disruptive innovation can be defined as an innovation with a significant impact on a market and the economic activity of firms in that market." The concept is focused on the impact of innovations as opposed to their novelty. The impact can, for example, "change the structure of the market, create new markets or render existing products obsolete."

This new approach of innovation meets our central question: how can energy-efficient building models meet the market?

The French benchmark specified four steps for the models' development: testing, definition of the concept, dissemination and significant impact on the market (see figure 2).

Figure 2. The four steps of energy-efficient building models development



The first step is testing. The first experiences allow testing a new design, new technologies, real performances, investment and operating costs, the users' view. When the learning from the first experiences is sufficient, the second step can be completed: the definition of the concept. Most of the time the concept takes the form of a label (*Passivhaus, Minergie®, LEED™*) specifying the performances of the building to be met.

This performance label form is crucial for the built environment cluster. Two characteristics of this cluster are: no actor is dominant, the production is very heterogeneous (houses, dwellings, offices, retail, schools, new construction, refurbishment…). The label can get the agreement of the different actors (developers, designers, construction firms…) and be used for many types of buildings.

When the concept is defined, it can be disseminated through several thousand buildings. This dissemination allows implementing the coordination of the different necessary innovations (technological, service, organisational, marketing), the new competencies of the actors, the legal conditions, the real performances of the model at large scale, the adaptation of the model to local conditions.

The fourth stage is the impact of the model on the market, when it has “a significant impact on a market and the economic activity of firms in that market” and can “change the structure of the market, create new markets or render existing products obsolete.”

What are the present characteristics of the development of different labels implementing the three energy-efficient building models? (see table 1)

Table 1: Present impact of LC, EE, ESP models on the market in three countries

Model	Label	Testing	Concept	Dissemination	Significant impact on the market
LC model	Swiss Minergie® new				In 2005, 17% of new Swiss residential buildings are labelled Minergie®
	Swiss Minergie® refurbishment				
	German Passivhaus new				
	German Passivhaus refurbishment				
EE model	American LEED™ new				
	American LEED™ refurbishment				
ESP model	American Zero Energy Homes new				

Source: PREBAT, 2007

According to our analysis, only one label (from the LC model) has a significant impact on the market in its country today, the Swiss *Minergie®* for new construction. The other ones are widely disseminated through several thousand buildings, but their impact on the market is for the moment marginal.

5. MEETING THE MARKET: A COMPLEX PHENOMENON

The two benchmarks showed that the driver for energy-efficient buildings development is not the market. The driver is political and three political levels have to be distinguished.

The first political level is the intercontinental and continental one. This political level specifies the quantitative objectives to be met (1997 Kyoto objectives, 2007 European objectives, post-Kyoto agreement expected objectives). The national level is the second political level. It defines the framework: regulations, taxes, incentives, funding. The regional/local level is the third one. It is the practical one, where energy-efficient buildings are made through active cooperation between regional/local authorities and private actors.

The regional/local level is the strategic one. The international benchmarks highlighted its importance. In Switzerland, the canton level; in Spain, the regional and municipality levels; in Scandinavian countries the municipal level; in Austria and Germany, the land level; in the United States, the state and municipality levels are the more important for the dissemination of energy- and environment-efficient buildings.

The main reason for such a characteristic is that the essential part of the built environment cluster actors is regional and local.

The building market is highly segmented. Roughly, nine segments can be distinguished: new residential buildings, new non-residential buildings, existing individual houses owned by households, existing condominiums owned by households, existing residential buildings owned by social housing and private companies, existing public non-residential buildings, existing private non-residential buildings.

To meet ambitious CO_2 2020 objectives, action must be concentrated on the existing stock. New construction will generate a negative impact by 2020: the main part of new construction will enlarge the stock, and a minor part will replace obsolete existing buildings.

For each segment, a demand/supply analysis has to be completed. On the demand side, public decisions (regulations, incentives, funding) will be the main engine of the market mechanisms. Market obsolescence will be a specific market instrument, especially for some segments like private non-residential buildings, energy and environmental efficiency “rendering existing products obsolete.”

The main challenge concerns the supply side. The two international benchmarks highlighted that simply adding an energy and environmental dimension to usual practices is a failure factor. Energy and environmental efficiency creates a new paradigm for the built environment cluster actors. Every actor of the value chain is concerned. New ways to finance energy- and environment-efficient buildings, using life cycle cost analysis, have to be invented. Performance briefing has to be the new norm. Holistic design has to replace sequential design: climate, shell and equipment have to be analysed and defined by architects and engineers, working together at the very beginning of the design.

The site process has to be renewed, especially to obtain very good air tightness. Quality process has to ensure a high level of commissioning, guaranteeing the continuity of energy and environmental performance from the production to the operation of the building. Eventually, the users have to adopt a new behaviour to meet the ambitious energy, water and waste consumption objectives.

New actors will appear, such as house energy renovators. The initial and continuous training of all the actors has to integrate this new view of the building process. It is one of the more difficult parts of the challenge.

CONCLUSION

The energy and environment efficiency of new and existing buildings is a major challenge for the built environment cluster. Three main energy- and environment-efficient building models can be identified: the Low Consumption model (LC model), the Energy and Environmental model (EE model) and the Energy Saving and Production model (ESP model). The driver is political. The objectives are specified at the intercontinental and continental level. The national level defines the regulations, taxes, incentives and funding framework. The strategic level is the regional/local one, where an active cooperation between regional/local authorities and local built environment cluster actors is a key factor of the dissemination of energy- and environment-efficient buildings. An in-depth analysis of each market segment is necessary to know in detail the specific barriers and drivers of the models' dissemination.

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