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Innovative alternative solar thermal solutions for housing in conservation-area sites listed as national heritage assets

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ABSTRACT

In a privatized global marketplace, innovation is a key driver of sustainable development and national competitiveness. Here we report on an innovative new fully building-integrated thermal solar panel concept that is patented and currently being readied for commercialization. The paper outlines the French regulatory landscape governing the deployment of thermal solar panels in France, and thus the need for countries like France to develop new building-integrated solar power meeting "building-envelope" integration requirements for protected areas. We go on to introduce the new as-developed system, its physical modelling via a finite element analysis model constructed using an electric circuit analogy, and the results achieved on a detached home retrofitted with this system and trialled for a 12-month period. This paper leads out of COST – European Cooperation Science and Technology – framework action TU 1205 "Building Integration of Solar Thermal Systems".

1. Introduction

Building-sector energy demand is rising fast in many countries. In France, 30 million homes use around 50% of the energy budget and produce 25% of national greenhouse gas emissions. In Europe, the building sector accounts for around 40% of total energy demand, which makes improving building energy performances crucial in order to meet EU energy efficiency targets and combat global climate change – and create a platform towards domestic energy security. In 2002, the EU introduced the Energy Performance of Buildings Directive (EPBD) giving EU States an integrative methodology-based approach designed to foster efficient energy use across the building sector. The EC then recognized that there was non-negligible potential for profitable energy savings still going unexploited, which is why in November 2008 it proposed a recast of the EPBD designed to enable energy savings amounting to a further 60–80 million tonnes of oil equivalent per year to 2020, i.e. a further 5–6% reduction in total EU energy consumption, over and above the previous maximum achievable if the recast directive was integrally implemented across the board. Based on these proposals, in April 2009 the European Parliament passed a legislative motion calling for even tougher more ambitious legislation. The EU Council now needs to reach a position on this strand of proposals.

In the meantime, the tertiary and housing sector remains the leading energy consumer in France, at 69.04 Mtoe. Percent of market demand is stable at 43%, but the absolute figures jumped +25% between 1973 and 2008 [1].

Every day, an average EU citizen uses around 35 L of domestic hot water heated to 60 °C, and the trend is an upward curve, as the energy needed to produce domestic hot water has crept up over the years as people have progressively got used to greater indoor comfort. Heating (at 50%) and water heating (25%) are clearly the biggest subsectors in terms of energy consumption (Fig. 1). For low-energy buildings, water heating and space heating account for 50% and 30% of energy consumption, respectively, with the remaining 20% down to electrical home appliances [2].

Using renewable energies can both improve energy efficiency and reduce fuel or electricity consumption. The chosen solution must be able to fit new or recent housing and, more importantly still, to retrofit old housing stock, which the biggest energy consumer.

Solar collectors are a particularly well adapted option for use in this sector. A solar power system can efficiently cover up to 80% of household domestic hot water needs – and all with the added advantages of less fuel used, minimal pollution and little maintenance effort. The thermal solar market is booming, with 2008 figures pointing to a 51.5% jump on 2007 and over 4.5 Mm^2 installed

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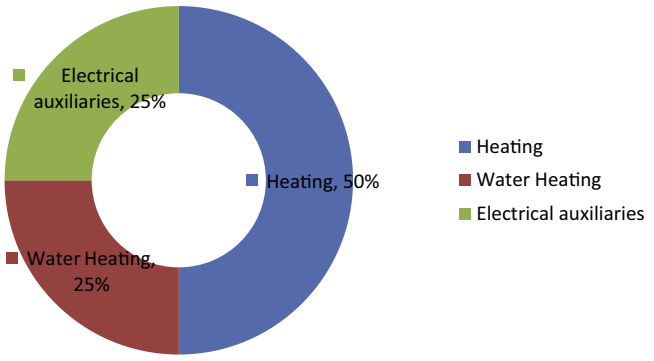

Fig. 1. Breakdown of housing-sector energy consumption in France.

(3172 MWth) [3]. There has been a fresh surge in research into thermal solar, which is explained by a combination of factors:

- Increased energy use tied to producing domestic hot water.
- Development of sustainable new solutions for cutting building energy use.
- A booming thermal solar market.

Introducing innovative and environmentally friendly solutions is a vital task made complicated by the number of bottlenecks involved – some financial, others technical, psychological, and even legislative (building code). The solutions proposed need to be seamlessly building-integratable and minimize eyesore (psychological bottleneck). They also need to be easily installed onto new building and old housing stock (technical bottleneck), not too expensive (financial bottleneck), and environmentally friendly. Our basic idea, in a nutshell, is to 'activize' passive components of a build.

2. Thermal solar collectors and the governing French legal landscape

From the outset, installations harnessing solar energy have been tarnished by a reputation for creating an eyesore, which has turned many potential users away. On the aesthetics front, photovoltaic systems already offer households and designer large room for manoeuvre, as the cells are small and modular and the electrical cabling is far more flexible to work with than regular pipework, which substantially increases their potential integratability [4,5].

Outside of the sociological dimension – which remains a complex focus of study – there are legislative roadblocks based on heritage asset conservation policy, typically:

- Heritage protection perimeters surrounding a historic-interest monument;
- Conservation-area districts;
- ZPPAUP – conservation areas for 'Protected Urban, Architectural and Landscape Heritage'. Article 28 of French act no. 2010-788 dated 12 July 2010 was reformed to replace ZPPAUP with AVAP – areas of heritage value;
- Listed or scheduled heritage sites.

An AVAP project is purposed with the development and enhancement of built-environment heritage and historic spaces, as an extension of committed sustainable development policy. Any construction or development project inside these areas must first apply for planning permission from the STAP – the local-region buildings, monuments and heritage assets authority. An ABF – *Architecte des Bâtiments de France*, the appointed advisor charged with supervising that any new build or development work bordering onto protected monuments will not create an eyesore – then issues their local authority with a straight consent, development consent needed or full consent procedure [6]. Unfortunately, solar power facilities do not qualify as "showcasing heritage value".

Furthermore, the ABF also have an influence that stretches beyond AVAPs, as their scope of authority extends to:

- The surroundings in the vicinity of historic monuments and listed heritage sites: a protected-area perimeter spanning the 500 m radius around any historic monument [7,8]. This authority was enacted by the French Planning Act of 1943, which stipulates that "any home located in line of sight of a historic monument may not be extended, demolished, cleared of trees or altered in any way that might affect its character" [7];
- Scheduled sites: sites governed by the French Ministry for Sustainable Development, which missions the ABF out to the ground [8];
- Conservation-area districts: the ABF supervises that any first-fix (building envelope) or second-fix (structural interior) remodelling is compliant with the preservation and rehabilitation area map (Malraux Act of 1962 safeguarding historic-interest town centres);
- AVAPs: the ABF coordinates the study then checks the projects are code-and-regulations-compliant.

Taken together, these areas add up to represent huge potential for working thermal solar energy. As of 31 December 2012, France counted 43,180 monuments, i.e. 14,367 'listed' and 28,813 'scheduled', registered as holding historic interest [9], and the list is getting longer every year, plus the hundred-odd conservation-area districts that cover an average surface area of 6600 ha each [9].

That said, there are signs the legislature is loosening up:

- Under round 1 of the multi-party 'Grenelle Environment' reform, the French Senate and National Assembly, initially divided on the bill, finally agreed to a measure voted in Thursday 23 July 2009, passed by a special joint government – senate committee. Under this measure, ABFs saw their powers clipped back, as the duty to secure 'permitted development' consent was replaced by a straightforward 'consultative' ruling in the vast majority of cases. Today, the decision taken essentially follows local zoning code, called PLU – *Plan Local d'Urbanisme*. In practice, to determine the impact of this kind of measure, it would be necessary to pore through every single 'PLU' zoning map of France, as each one is defined at local council level (or, in rare cases, at cross-local-council level);
- The French Act no. 2010-788 dated 12 July 2010, dubbed 'Grenelle Environment Round 2', amended the French Urban Planning Code by ushering in article L.111-6-2, under which paragraph 1 reads: "despite any town planning provisions to the contrary, planning permission may no longer oppose the installation of equipment that produces renewable energy to cover the household energy needs of the occupants of all or part of the building".

Table 1 pools and recaps the various administrative procedures governing project sites according to area location.

This short analysis highlights how the stiff French homes and housing legislation privileges aesthetics over energy performance. Although there are signs the legislation is softening up, the conditions imposed are still strict and, in tandem with the financial grants and incentive schemes available, tend to support a policy of maximal integration of energy supply components. Indeed, government directives further anchor this policy priority given to building-integrated solar technologies to foster more landscape/architecture-conscious aesthetics and to position home solar trades and industries on a higher-value-added subsector [11]. Solar energy is coming to town and shaking up the old building