STRATEGY FOR PROMOTING PHOTOVOLTAICS IN URBAN AREAS: LESSONS FROM THE FIRST GRID CONNECTED RESIDENTIAL HOUSE IN UK

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ABSTRACT

The building of the first integrated photovoltaic roof on a house in Britain, the Oxford Solar House (OSH) has had a significant impact on the perception of the viability of PVs on homes in the UK. It also provided many lessons on the possible barriers that may be encountered in the development of an internal domestic PV industry These include technical, institutional, management and marketing barriers, which are discussed in this paper.

INTRODUCTION

Interest in renewable energy has surged world-wide in the 1990's, despite continuing low international energy prices. The primary reasons for this enhancement of interest include impressive technical advances; environmental pressures, particularly climate change and broader sustainability concerns; loss of faith in nuclear power; and possible benefits to other sectors. Many and varied national, regional and global projections now indicate that renewable energy could make a substantial contribution to energy supplies. However, many renewable energy sources still require further technical and/or industrial development and are not yet economically competitive in current bulk energy market. Many of the most significant benefits are not reflected in current market structures, and it may take decades to realize big contributions to the energy balance. All these factors make supporting renewable energy an issue of strategic public policy.

Photovoltaic solar energy is broadly recognized as one of the most important sources of renewable energy in Europe and it promises to be one of the key fuels of the future.

The prospects of developing a PV industry depend on the ability to overcome institutional and technical barriers . The institutional barriers include:

- government expenditure and legal frameworks;
- lack of awareness of the potential and possibilities;
- levels of PV industry investment;
- private investment;
- utility support programs;
- poor training;

It is also important to define the technical barriers in realizing reliable, low-cost and efficient PV plants. They are:

- invertor efficiency,
- systems performance,
- load patterns,
- systems interrelation with the local electricity grids;

The construction in 1995 of the first UK roof integrated photovoltaic house provides an excellent tool for the evaluation of the barriers mentioned above to the wider uptake of PVs in the UK.

THE OXFORD SOLAR HOUSE

In 1994 the feasibility study undertaken by the Department of Trade and Industry recommended that the UK should gain practical experience of PV in the built environment through the means of building a demonstration PV house in Oxford designed to ensure that the issues surrounding the use of this technology could be tested and addressed. The objective of the project was:

- To build an energy efficient home with the aim of it being substantially independent of the utility mains supply
- To examine the barriers against ready implementation by a private individual and to :

1. Determine the reaction of Institutional bodies such as the Local Authority and Electricity Company and of neighboring households
2. Investigate sources of advice, design, supply and implementation; the problems in dealing with a new vocabulary; and of Contract and Day to Day Site Management

The Site

Blandford Avenue Oxford. This is a city location with the road oriented roughly east west, ensuring that the house has south facing rear elevation. The trees in adjacent gardens may have an effect in later years.

Design Strategy

It was very important for the OSH to function as an ordinary single-family standard house. But in the case of the OSH, an effort was made in the design process so the house would use as little energy as possible. It is quite clear that strategies for reduction and conservation of energy are a pre-requisite in the design and key requirements were determined to be :

- Super Insulation with high thermal mass and stability for low solar heat gain in summer (no cooling) and low heat loss in winter (minimal heating)
- Passively Heated air mass in a south facing glass conservatory mixed with fresh air and circulated around the house
- Background heat from a wood burning stove
- Solar Thermal Collectors to pre-heat hot water
- PV system to provide ac power coupled with careful choice and use of low energy appliances and import or export energy according to need

The House

The design of the house and solutions chosen to satisfy the insulation and heating requirements are in Ref. 1. Significant characteristics of the house are:

- Heated volume: 468 m^3
- Heated floor area: 233 m^2
- Conservatory floor area: 12.6 m^2
- Thermal characteristic: the heat loss from occupied zones is 0.84 W/m^2C
- A built cost of £800/m^2

The Solar Roof

The roof is the obvious place for pv and solar thermal collectors. A roof is normally built to be a flat tilted surface, ideal for solar collectors, so putting the two together should be easy. In the case of the Oxford Solar House no tiles were used on the south facing roof. The whole surface was made up from 48 pv modules covering 30 m^2, 4 solar thermal collectors occupying 5m^2 and 2 "Velux" windows all arranged together with a small number of glazed infill panels to give the appearance of a single glazed surface. The finished roof is excellent and integrates well with the glass roof of the conservatory.

In the case of the Oxford House, a supporting sub-frame was used to mount the pv modules and solar collectors to the roof structure. This enabled a truly flat surface to be created from the nominally flat surface as built and created an airspace behind the modules for ventilation. In future systems, it would be desirable for the built surface to be prepared such that the pv modules and solar thermal collectors can be mounted directly to it. The south facing roof slopes at an angle of 50 degrees so that the PV and solar collectors face more directly to the sun in order to maximize their output. The north facing roof slopes at 20 degrees.

The PV modules produce about 4kWatts of dc energy in full sunlight and this is converted by a high efficiency 5kW inverter into ac energy suitable for direct connection to the house wiring system. The connection of the PV system to the utility supply required the negotiation of 'Parallel Running' and 'Tariff Agreements' with the local electricity company. This did not prove to be a significant problem, but did require a degree of familiarity and persistence. Proof of safe operation of the inverter had to be demonstrated before connection to the utility was permitted.

Lessons Learned

- Methods and materials for building the house envelope to achieve low heat loss at reasonable cost are readily to hand and practicable and yield dwellings with a substantially low annual energy cost
- Techniques are readily available and practicable for implementing passive heating regimes in buildings and high efficiency wood burning stoves or similar are available and effective
- Low energy consuming appliances are becoming more widely available and affordable
- There appears to be no significant obstacle to the integration of PV and solar thermal systems into roof designs. However the integration of these two different technologies needs care at the detail design stage
- Unfamiliarity with PV in the building trade is a significant obstacle, and specialist training for builders in the technology would be essential
- Similarly for the electrical connections. The firm working on the house were not prepared to undertake the work without design drawings. But once these were available completion was not a problem
- Materials and equipment for pv systems are readily available in Europe including several outlets in the UK. However defining the specification is unlikely to be successful without recourse to expert advice
- There is limited availability of expert advice in the UK, but systems vendors will usually assist. This may not yield the preferred solution, but obtaining the whole system from one vendor has advantages , especially in terms of problem solving and warranty
- The Local authority for Oxfordshire were supportive and queries over planning and building regulations were resolved without major difficulty. This appears to have been reflected in other local authority areas
- Permission to connect the pv system to the local utility supply was not a major obstacle. Requests to connect in parallel have received a mixed reception by other utilities. Permission did require negotiation and a degree of familiarity and resourcefulness that may not be widely present among prospective users.
- The vocabulary proved to be difficult
- Users wanting to implement similar systems without using a specialist supplier/installer will need to have strong negotiating skills and be able to deal with the day-to-day site management. This proved to be the biggest obstacle and in particular defining scopes of supply and interfaces needs great care.

AN ACTION PLAN FOR DEVELOPING PV INDUSTRY

The promotion of the PV industry needs to be approached in a broad context, bearing in mind that clean solar energy is not just a quantitative matter but also depends upon the qualitative aspects related with the relation and integration with the environment. It is necessary to define the objectives of the action plan, the targeted groups and a plan of activities.

Objectives

The objective of a program should be

- enhance the architectural quality, the technical quality and the economic viability of PV systems in the built environment. It should contribute to the introduction of PV systems as an energy-significant option for electric utilities and other public and private users, through:
  1. the improvement of the architectural design and the implementation of PV in buildings
  2. the increase of technical quality, electrical performance, reliability and safety of PV integrated into buildings or other structures in the built environment
  3. the improvement of the economic viability of PV systems through cost reductions and added value of PV integrated into buildings or other structures in the built environment

- capacity building by training tradesmen and designers.
- launch a marketing campaign in the media targeting at particular interest groups. The campaign would be aimed at changing perceptions of the viability and the potential of PVs.

Target groups

The target groups in any program to develop the PV industry should include active environmentalist groups, urban planners, architects, building engineers and the general public. However, key target groups should be:

- Architectural student in their last year of University. With them one has a captive audience of people who will go out into practices taking this new concepts with them.
- Building owners/developers. The message for them should be set in terms of the market advantage of building "super buildings" with very low energy demand, solar energy and low environmental impact.

Focus

The focus of the program should be to present PVs as electricity sources in low energy buildings and how to optimize the efficiency of PVs in building integrated scenarios (roofing, cladding, roof mounted, as windows, solar shading, heat sources and as emergency lighting systems, fail safe energy supply, etc.) in terms of their physical design in relation to operational performance. Early demonstration projects such as the Oxford Solar House can be very useful in changing perceptions, providing the models and establishing protocols which can be reused in later projects.

Activities

Planned activities could include:

- An international design workshop based on
  1. Review and evaluation of design concepts of building integrated PV systems, development and discussion of improved design that may lead to an improved technical and architectural quality
  2. Review and development of design concepts for PV-systems integrated into non-building structures, such as noise barriers, parking areas and railways platforms
  3. Evaluation of characteristics, application and benefits of multipurpose elements such as see-through PV elements, PV-sunshades, PV-thermal insulation, etc.
- An international Zero Energy Building Competition in which PV will be the main feature.
  The outcome of this competition will be a set of demonstration buildings that will
  1. bring the results to the market by demonstrating new and existing integration designs and technologies,
  2. analyze energetically the performance of the demonstration projects,
  3. be the focus for a massive marketing campaign in the media.

CONCLUSIONS

Photovoltaics is a market ready technology waiting in the wings. The Oxford Solar house has demonstrated that with a wider exposure of the potential of PVs to the public combined with well planned capacity building programs for designers and builders, PV is a market waiting to take off. A strategically well designed program of training, barrier testing and publicity will optimize the potential of that market in its early stages.
These are a large number of new building integrated systems being built by Solar Pioneers around the world. The market for building integrated PV systems is being seen as increasingly promising. After all it is only a matter of time isn't it ? The sooner we build more systems, the sooner the system's prices will come down. As far as energy is concerned - the sooner the cleaner the better.

REFERENCES:

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