Technical Brochure No.67

CADDET renewable energy

IEA OECD

Building-integrated Photovoltaic System in the UK

Summary

A refurbishment project at the University of Northumbria in Newcastle upon Tyne, United Kingdom, provided the opportunity to install one of the largest building-integrated photovoltaic systems in Northern Europe. Photovoltaic panels have been incorporated into the new overcladding of the University's Northumberland Building and the electricity produced contributes to meeting the building's needs for lighting, heating, computers and other appliances. Any surplus electricity can be fed into the University's internal distribution system to supply other buildings on the campus.

Highlights

- **Integrated into conventional rain-screen overcladding**
- **Installed using normal building industry practices**
- **High system reliability**

Photovoltaic panels integrated into the cladding of the Northumberland Building.

Project Background

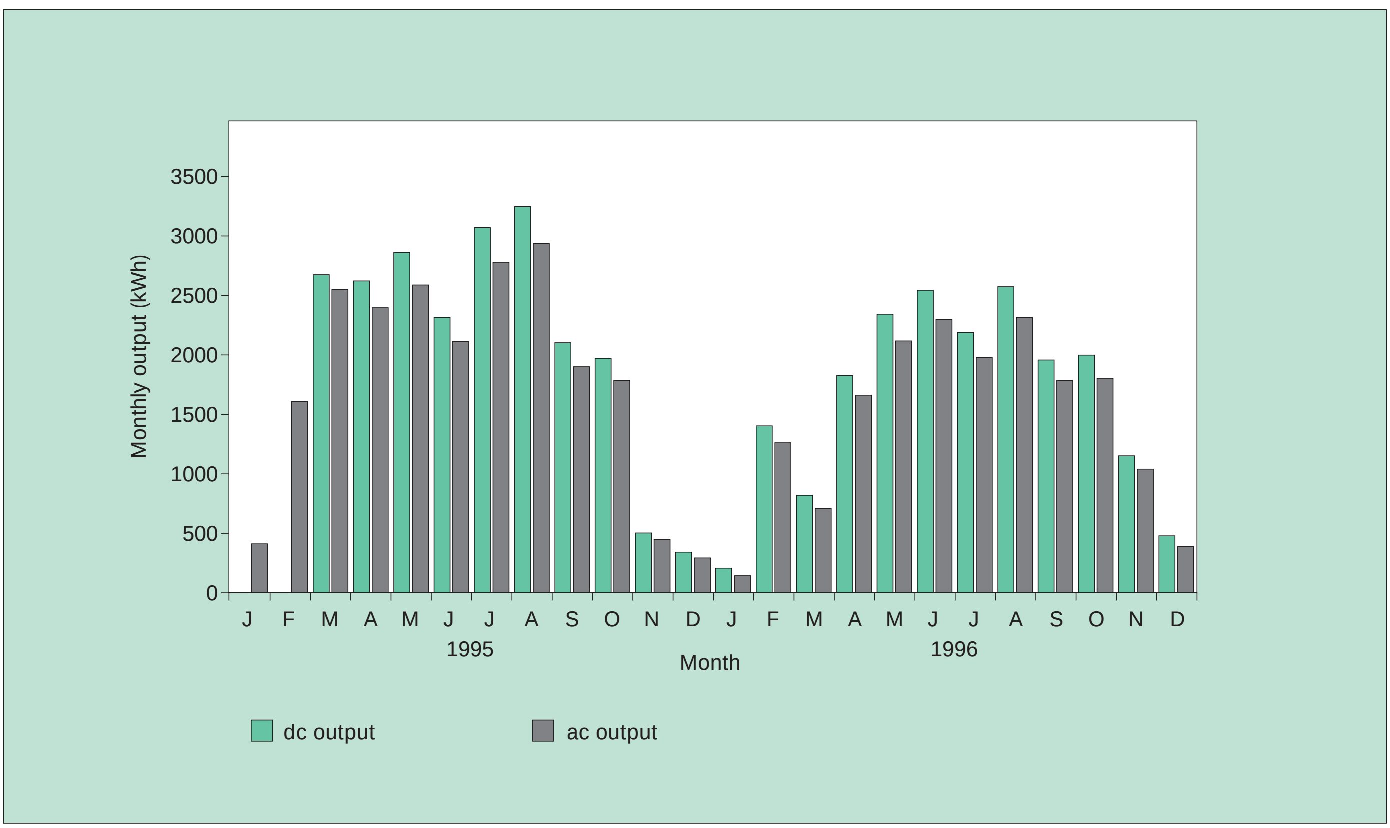
In 1991, the Newcastle Photovoltaics Applications Centre based at the University carried out a study to estimate the potential UK generating capacity from building-integrated photovoltaics. This study, funded by the UK government, suggested that the total theoretical resource is vast – up to 360 TWh/year (compared with the UK's annual electricity consumption at the time of 270 TWh/year). To demonstrate the technology and to gain information on system performance in a UK climate, the University, Ove Arup & Partners, BP Solar and IT Power Ltd formed a consortium to develop a scheme for recladding the Northumberland Building. The building is a typical 1960s design and required refurbishment due to the poor condition of the original cladding.

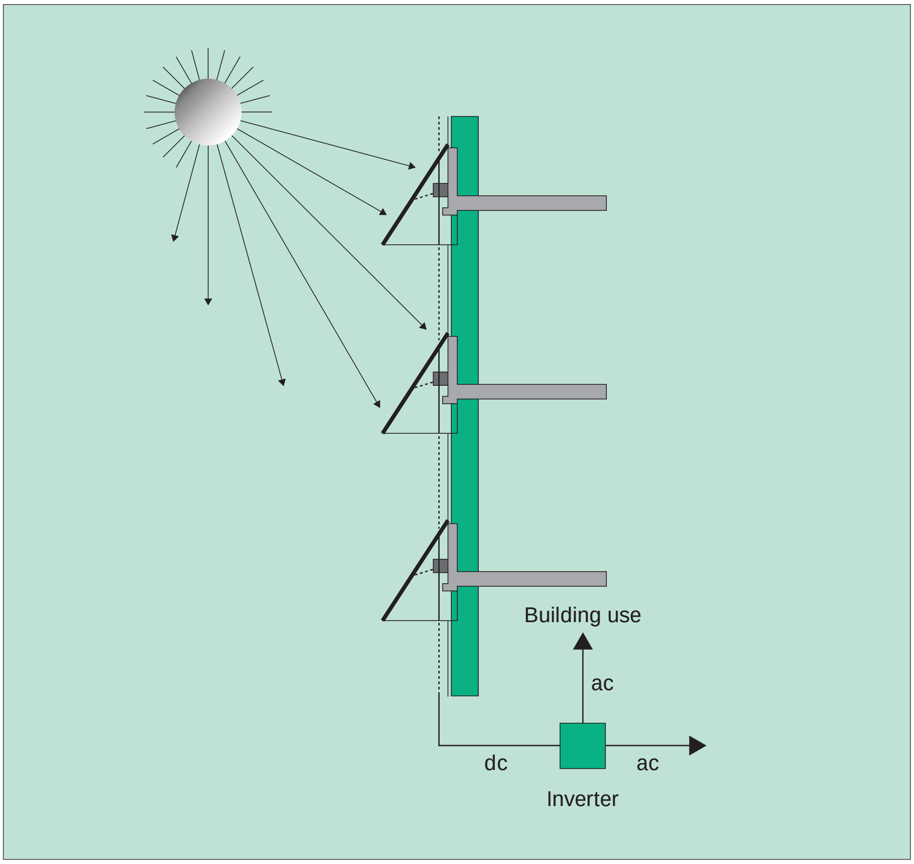
The Project

The project involved the installation of a new rain-screen overcladding system on both the north and south facades of the five-storey building. The photovoltaic system, comprising 465 high-efficiency, crystalline silicon photovoltaic modules manufactured by BP Solar, has been incorporated in the cladding of the south facade. This south-facing cladding is inclined at 25˚ to the vertical, to enhance the winter performance, to give some summer shading to the windows below and to provide an improved appearance by the introduction of a surface feature. The electricity generated is fed, through cabling routed behind the cladding, to the ground-floor plant room and, after conversion to alternating current (ac), is fed into the main building supply system. The total system capacity is almost 40 kWp.

Each photovoltaic module is rated at 85 Wp and five such modules are combined to form a single architectural cladding unit. The electrical leads from each cladding unit are connected in series in sets of three, ie there are 31 15-module series strings making up the whole array. The electrical leads from the resulting 31 strings are connected in parallel through the direct current (dc) switch box before being fed into a line-commutated thyristor inverter. The thyristor is rated at 40 kW, with a dc input voltage of approximately 270 V and a 415 V, 3-phase ac output.

Graph of dc and ac outputs by month for the first two years of operation.





Schematic of the cladding design.

Performance

The system has performed with a high degree of reliability since its official opening in January 1995 and experienced less than 36 hours of downtime in its first two years of operation. The performance of the system is consistent with that expected, providing over 39,000 kWh during the same period. All the electricity produced has been used within the building.

The system efficiency is calculated by comparing the electrical output with the solar input, measured in an unshaded position on the roof, and has an annual average value of about 8%. This value would be around 10.5% if there were no shading from surrounding buildings on the university campus. The annual average performance ratio, an indicator of electrical system efficiency, is around 60% and this is reduced from a value of about 75% by the shading losses. The inverter has proved to be very reliable with average monthly efficiencies of about 90% for reasonable sunlight conditions.

The use of embedded thermocouples in five of the modules allows typical operating temperatures to be measured. The modules are mounted so as to allow natural ventilation between them and the wall. This together with the cool climate keeps operating temperatures close to those of ground-mounted systems with unrestricted airflow. Thus, average operating temperatures only exceed 25˚C during two to three months in the summer. The maximum operating temperature recorded to date is just under 60˚C for a hot August day.

Economics

The objective of the project was to demonstrate the possibilities for photovoltaic integration and to obtain performance data for a UK city centre location. As a demonstration project, the cost of the electricity generated by the system does not yet compete with conventionally generated power. In the case of the Northumberland Building, the additional cost of the photovoltaic cladding has been calculated to be around £800/m^2 (where £ is the UK pound) and this results in an electricity cost of £0.40-1.00/kWh depending on the discount rate and system lifetimes chosen. Clearly, this will have to be substantially reduced before widespread adoption of the technology on similar buildings. However, the cost/kWh is significantly reduced when the additional cost of the photovoltaic cladding is lower; for example, where it is selected instead of higher value cladding materials (eg marble).

The project team are confident that present costs could be reduced by about £100/m^2 due to the lessons learned in the design and installation of the system and that further reductions in cost will occur as the market increases. The project now aims to establish operation and maintenance requirements to aid future economic analysis of building-integrated photovoltaic systems.

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