Building for the future

Launch of an innovative building system which achieves excellent efficiencies from advanced renewable energy systems.

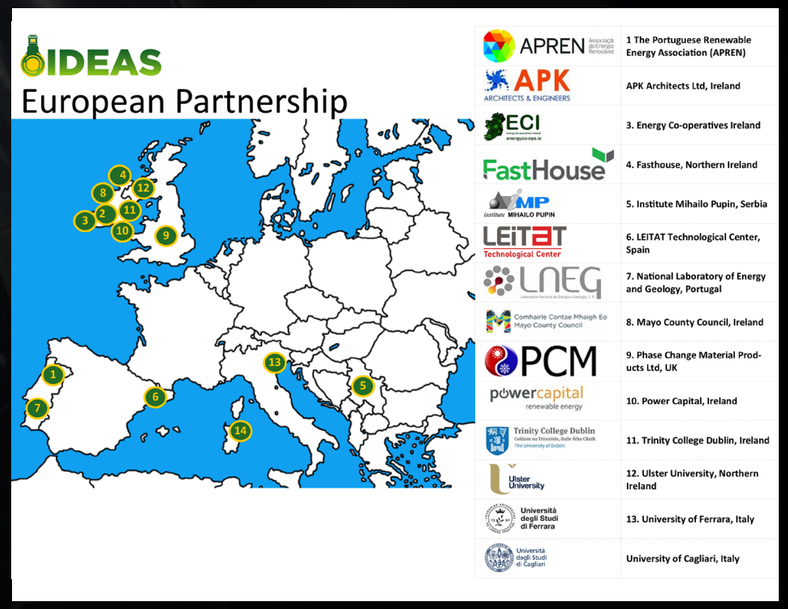
A community centre in County Mayo, Ireland, showcases international scientific co-operation and citizen participation creating a more sustainable built environment.

The efficiency of the centre's heating and cooling system is improved with IDEAS state-of-the-art solar photovoltaic-thermal panels combined with novel HP technology and the latest in heating control systems.

Background

Buildings play a significant role in the global energy balance. Typically, they account for 20–30 per cent of the total primary energy requirement of industrialised countries and 40 per cent in the EU. Global buildings sector energy intensity fell by 1.3 per cent per year between 2010 and 2014, thanks to the continued adoption and enforcement of building energy codes and efficiency standards. Yet progress has not been fast enough to offset growth in the floor area (3 per cent per year globally) and increasing energy demand. Applying the proposed integrated renewable energy system (RES) to buildings is an important application for wider integration and deployment of renewable energy and to achieving our binding EU targets of at least a 40 per cent reduction in greenhouse gas emissions (GHG) by 2030.

RESs often require more space than is practicable in the urban setting. Apartment blocks and offices have restricted roof space and surrounding building footprints, meaning that traditional solar and geothermal technologies' space requirements are insufficient to meet the buildings' energy needs. IDEAS brings together a number of efficiency and scale improvements to solar photovoltaic (PV), thermal and geothermal RESs that will enable more energy efficiencies can be achieved using a smaller area. This will mean that buildings in urban settings can have more of their energy needs met by sustainable sources.

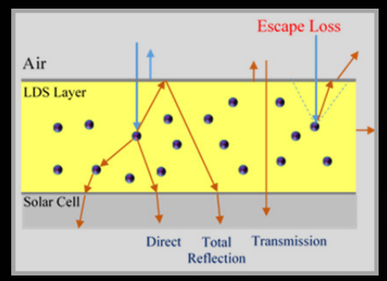


What is IDEAS?

Developed by an association of research teams, the hybrid solar PVT panel was developed in the project's first phase and trialled in the prototype installation at the University of Ferrara. The hybrid PVT panel consists of:

Downshifting layer (LDS)

An array of newly developed PV cells using downshifting layer (LDS) to increase solar energy collection and transference to electrical energy. The LDS uses specially formulated dyes which increase the amount of energy captured from the Sun compared to traditional cell coatings.



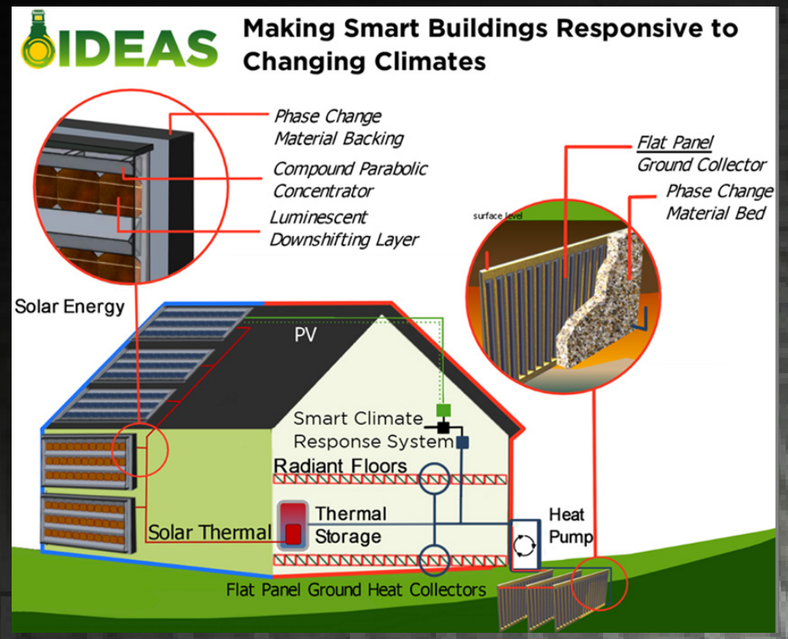
Compound parabolic concentrators (CPCs)

These are site specific arrays of reflective material which reflect the rays of the Sun to maximise the exposure of the PV array to the Sun's energy. Their design means that they can be installed on the façade of the building and still produce adequate thermal and electrical power. The CPC is part of the technology's applicability to deployments where space is limited: in built-up areas or on medium and high-rise urban buildings where the roof area to building volume area ratio makes building renewable energy self-sufficiency problematic. The CPC configuration varies according to the latitude of the installation –it was specifically designed for the low-Sun of North Mayo (53 degrees N) and also separately for the latitude of the other demonstration installation in Ferrara, Italy (44 degrees N).

Phase change material (PCM)

Enhanced heat collection PCM heat sink modules were configured to the PV cell array to increase the cells' efficiency by reducing overheating while at the same diverting excess heat to a heat storage which combines with the heat pump components below to maximise the rate of energy collection.

Image: PCM backing to PVT panels



Integrated innovations from leading specialists customise efficiency measures, making future buildings more sustainable and comfortable. The Mayo community centre demonstration deployment shows how the project's technologies enable new sustainability options for the urban setting.

Flat panel ground source heat exchangers (GSHX)

These were developed at the University of Ferrara and are the ideal complement to the high-density energy efficiency of the PVT panels. Unlike traditional ground source heat exchangers, they are concentrated in trenches and so require much less site area to achieve the same level of efficiency through exchanger surface area.

Radiant floors

The floor of the community hall in Mayo was upgraded with a heating loop connected to an air source heat exchanger. ThinICE™ PCMs supplied by PCM Products Ltd, UK, have been co-installed with the heating loop to increase the efficiency of the radiance in an application which was devised and tested by Ulster University.

Image: Deployment of ThinICE™ radiant floor in Mayo demonstration building.

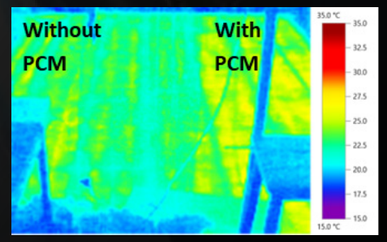
Smart building software system

The 'brains' of the entire system, this control system whose design was led by IMP, Serbia, co-ordinates the inputs of all of the renewable energy and energy efficiency components. The system is weather and climate tuned so that energy requirements, heating and cooling, can be determined in advance so that energy can be stored in the form required for the users of the building. While there is a user interface that facilitates user customisation, it is expected that most users will accept the benefits of an automatically tuned climate control for their building of a steady 19°C all year round.

Performance

PCM radiant floor

Ulster University's research into the effectiveness of incorporating ThinICE™ phase change material containing into the radiant floor shows that the PCM conserves heat for longer as well as diffusing it better to achieve a 37 per cent improvement in performance over the same radiant floor without PCMs. This radiant floor system has now been installed in the demonstration building in Mayo.



Compound parabolic concentrators (CPCs)

There is a measured increased productivity from the solar cells using the CPC over the control PV panel in the Mayo demonstration building. The reflection of the Suns rays at the site at a latitude of 54°N onto the PV cells means that the deployment on the façade of the demonstration building is feasible. The research team at Trinity College Dublin have found an output three times higher than the reference cells (giving a concentration ratio of 3). Combined with efficiencies from the PCM heat sink and the LDS layer, the team expects to be able to report very strong results by the end of the project.

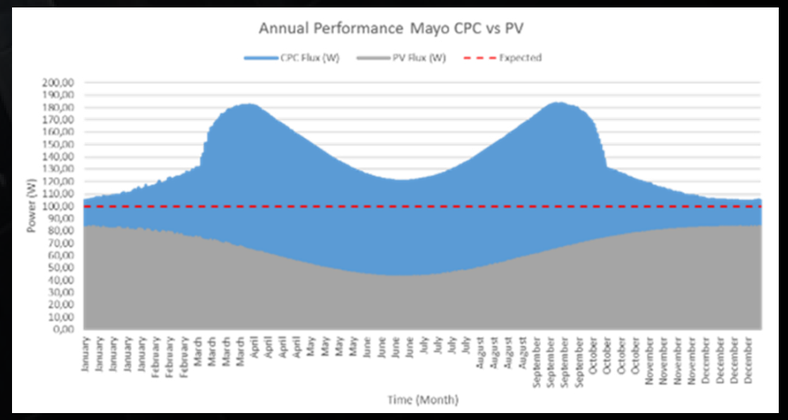


Image: Superior performance on CPC over control.

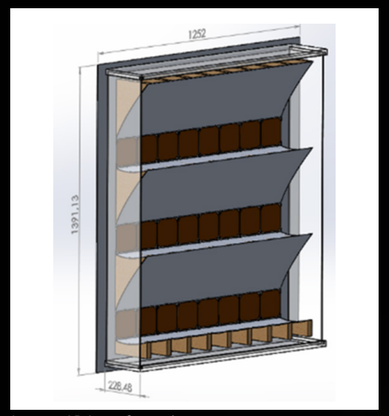


Image: CPC configuration.

Ground source loop

Ten novel flat panel horizontal geothermal heat exchangers, patented by the team in UNIFE, Italy, were installed in a 1.8m(D) trench. The HP installations have removed the need for the existing oil boiler making the building's heating system carbon neutral. ThinICE™ units of a salt-hydrate phase change material have been installed under the floor of the community hall. Underfloor heating circulates hot water from the HP around the PCM, which will absorb excess heat above 27°C, which is stored in the form of latent heat. Over the next six months, the performance of the system will be monitored by 24 thermocouples installed in the floor and walls.

Image: Installation of the flat panel GSHX.

Citizen engagement

Technology must be tailored to suit the needs and expectations of the user community. While IDEAS itself is complex with many parts, these have been developed with ease of use in mind, designed to provide a comfortable ambient temperature for the building without overstretching the user. The community group that makes use of the hall have been central to the deployment in Mayo and the project has already had strong engagement in sustainability, training, and education opportunities. The Trinity College School of Engineering is very grateful to the community group in Brackloon and Drummin and looks forward to a long-lasting relationship.

Image: The local community making great use of the new radiant floor.

Image: Local community group members with TCD team and Duncan Stewart of Irish National television Citizen Engagement.

PROJECT SUMMARY

The IDEAS project is an innovative building-integrated renewable energy system utilising solar energy, thermal storage and heat pump technologies to generate electricity, heating and cooling. This hybrid energy efficiency application will benefit multi-purpose public and commercial buildings across a range of urban and rural climatic conditions. This will enable families, communities, and businesses to contribute to creating a low-carbon, sustainable future.

PROJECT PARTNERS

The IDEAS project is led by the Department of Civil Structural and Environmental Engineering in Trinity College Dublin, utilising modern laboratory resources. Key IDEAS partners consist of universities, public and private organisations in Ireland, Italy, the UK, Portugal, Spain and Serbia with demonstration sites located in north and south Europe (Mayo, Ireland and Ferrara, Italy).

PROJECT LEAD PROFILE

The Civil, Structural and Environmental Department of Trinity College Dublin (TCD) comprises academic staff, experienced researchers and PhD students with its research internationally recognised and extensive expertise in energy efficiency in buildings, energy storage and low carbon technologies. Associate Professor Sarah McCormack, PhD with TCD staff leads and coordinates the IDEAS project.

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