Ali Sayigh *Editor*

Renewable Energy in the Service of Mankind Vol II

Selected Topics from the World Renewable Energy Congress WREC 2014

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Selected Topics from the World Renewable Energy Congress WREC 2014

- Editors
- (view affiliations)

- Ali Sayigh

Book

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About this book

Introduction

· Details the research advances being made in pivotal renewable energy technologies from waste-to-energy and offshore wind, to energy forecasting and bio-hydrogen

· Includes case studies and detailed examples to demonstrate how leading-edge research is applied in practice

· Covers economic and policy issues from regional perspectives around the globe

This book provides insights on a broad spectrum of renewable and sustainable energy technologies from the world's leading experts. It highlights the latest achievements in policy, research and applications, keeping readers up-to-date on progress in this rapidly advancing field. Detailed studies of technological breakthroughs and optimizations are contextualized with in-depth examinations of experimental and industrial installations, connecting lab innovations to success in the field. The volume contains selected papers presented at technical and plenary sessions at the World Renewable Energy Congress, the world's premier conference on renewable energy and sustainable development. Held every two years, the Congress provides an international forum that attracts hundreds of delegates from more than 60 countries.

Keywords

Biomass and Biofuels Energy Meteorology Geothermal Power Green Energy Hydrogen Fuel Cells Marine Energy Renewable Energy Renewable Energy Policy Waste-to-energy Wind Energy

Editors and affiliations

- Ali Sayigh (1)

1. Chairman, World Renewable Energy Congress, Brighton, United Kingdom

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Photovoltaic-Integrated Buildings in Florence and Lucca, Italy: Case Studies

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- Lucia Ceccherini Nelli (1) Email author (lucia.ceccherininelli@unifi.it)

1. DIDA Department, ABITA, University of Florence, Florence, Italy

Chapter
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Abstract

When using the integrated approach, solar systems become part of the general building design. In fact, they often become regular building elements. This is due to the fact that integrating solar systems into the building envelope is often a necessity if the systems are to be economically feasible. The solar elements cannot be separate elements that are added after the building, or at least the architectural design of it, is complete. Rather, they must replace other building elements, thereby serving dual functions and reducing total costs.

The following case studies depict a coming-of-age of building-integrated photovoltaics (PVs).

These PV elements are specially designed for glass shading devices. The PVs will serve as shading elements for areas protected by the new system.

The overhanging shading roof provides adequate shade in the summer and allows for useful solar heat gain in the winter. These factors combined should help to keep the building’s running costs to a minimum. In conclusion, the simulations and testing at the design stage show that the overall environmental strategy will reduce the building’s running costs while optimizing visual and thermal comfort.

Integrating PVs into the architectural design offers more than cost benefits; it allows the creation of an environmentally friendly energy-efficient building.

The systems consist of crystalline PV modules integrated with a semi-transparent module. We also present an example of PV modules in thin films.

Keywords

Retrofitting buildings Building-integrated photovoltaics Photovoltaic products Replicability

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Personalised recommendations

34 PV integrated Buildings in Florence and Lucca, Italy: case studies

Lucia Ceccherini Nelli
DIDA Dept, ABITA, University of Florence
Via S.Niccolò 93 50125 Firenze
Tel 39 055 2755322 e mail: lucia.ceccherininelli@unifi.it

Topic 1 photovoltaic technology

Abstract

When using the integrated approach, the solar systems become part of the general building design, In fact they are also often become regular building elements. This is due to the fact that integrating the solar systems in the building envelope often is a necessity if the systems are to be economically feasible. The solar elements cannot be separate elements that are added after the building, or at least the architectural design of it, is completed. They must rather replace other building elements, thereby serving dual functions and reducing total costs.

Case studies represents a coming of age of building-integrated photovoltaics.
The PV elements are specially designed for glass shading devices. The photovoltaics will serve as shading elements and use an area protected by the new system.
The overhanging shading roof provides adequate shade in the summer and allows for useful solar heat gain in the winter. These factors combined should help to keep the building's running costs to a minimum. In conclusion, the simulations and testing at the design stage show that the overall environmental strategy will reduce the building's running costs while optimizing visual and thermal comfort.
The PV integration into architectural design offers more than cost benefits, it allows to create environmentally design and energy efficient buildings.

The systems will be realized with crystalline photovoltaic modules integrated with a semitransparent module and there is also an example with PV modules in thin films.

Keywords:
Retrofitting buildings, Building integrated with photovoltaic, photovoltaic products, replicability.

The PV integrated case studies described in this work are: Atrium of the Pediatric Meyer hospital in Florence (1), University Library and classrooms building (2) and Physics laboratory building in Sesto Fiorentino (3), Virtual Competence Centre ITC in Lucca (4) and University residential student building in Florence (5).


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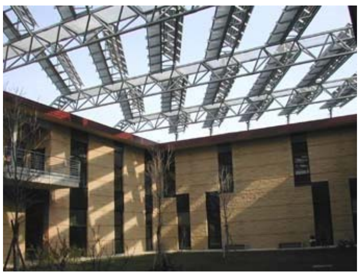
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1. Objectives and Scientific innovation and relevance

The integration of photovoltaics in buildings has huge development potential regarding both the market for BIPV systems and the contribution to renewable electricity production. PV installation integrated in building roofs and facades allow the possibility of combining energy production with other functions of the building envelope, such as shading, weather shielding and heat production.
Cost savings through these combined functions can be substantial, e.g. in expensive façade systems where cladding costs may equal the costs of the PV modules. Additionally, no high – value land is required and no separate support structure is necessary. Electricity is generated at the point of use. This avoids transmission and distribution losses and reduces the utility company's capital and maintenance costs. 'Multiple integration' is perhaps the appropriate expression. Building integration does not just mean the mounting of PV modules on roofs or facades. Real integration can involve much more, it includes all the steps incorporated in the process of new construction or in retrofitting building, starting from planning the production of the construction materials through to operation and recycling. Multiple integration does not produce multiple costs. However, if it is done in the right way, it results in multiple savings. Savings of landscape, cladding materials, engineering effort and so on have often been mentioned in the literature. The further steps of integration have not yet been studied in detail, but it is obvious that integration into the existing manufacturing process of cladding materials should lead to further cost reductions. Integration starts at the beginning of the planning process of a building construction or renovation and continues until the building is finished.
However, the integration of PV into the architectural design offers more than cost benefits. It also allows designer to create environmentally design and energy efficient buildings without sacrificing comfort, aesthetics or economy.

2. Case studies

Will follows some examples of PV integrated systems realized in public buildings in Tuscany during the last few years, designed and monitored by the researchers of the ABITA Interuniversity Centre of the University of Florence.

1. <u>Meyer Pediatric Hospital in Florence</u>

Fig1.,2 Main Atrium with glass-glass PV panels

The system created consists of 181 photovoltaic modules made with glazing of different sizes, the total output is 32,000 Wp. The modules have been integrated in the photovoltaic facade of the greenhouse of the main entrance of the building. The most of the PV panels have size 2,20x0,938 m with a power of 201 Wp. Group of conversion can transform direct current into alternating current and it is laid on the roof the greenhouse, the control panel and interface with the network is located in the center of the greenhouse inside a wooden structure.
The system is composed of three PV fields, east, west and central lots, each field feeds each of the three phases of the electrical network of the hospital. In order to optimize conversion efficiency of the modules connected to each inverter they have the same tolerance.

1. East lot
• 55 modules of 201 Wp (B1)
• 12 modules of 88 Wp (B1 / 2)
• 5 inverters SMA SB2500
2. Central pool
• 35 modules of 188 Wp (B2)
• 12 modules of 88 Wp (B2 / 2)
• 1 + 1 inverter SMA SB3000 inverters SMA SB3300
3. West lot
• 55 modules of 201 Wp (B1)
• 12 modules 88Wp (B1 / second)
• 5 inverters SMA SB2500

Four are the types of the PV modules (B1, B2, B1 / 2, B2 / 2) and can be grouped essentially in two types, modules of a length of 2 meters with a power of 200W and modules 1 meter long with 88W power. The SE project has achieved electrically compatible modules in order to avoid mismatching of current in the strings. The modules are certified and both sides are tempered glass HST (guaranteed 20 years).

The resistance of the cables on the DC side is minimized by the size of the cables:
1. The string section in each of the conductors is 6 mm2
2. Inverters in the framework of the interface section of the conductor is 16 mm2
3. Framework of the interface to the general framework, the conductor cross-section is 25 mm2.
The connections were made with compression terminals and sometimes by soft soldering.

The monitoring system is a DG 700 display, it displays the values that characterize the photovoltaic system and its operation, degree of protection IP41. 700x500x45 mm / 6 kg
The proper functioning of the PV generator is controlled by a checking power energy production.

2. Virtual Competence building ICT Lucca

The building has installed 3 PV integrated systems. The photovoltaic façade system will consist of 84 PV modules. In each of the front panel (2.92 x 1.48 m) will be arrange 3 PV modules horizontally.
The photovoltaic facade is classified as an "integrated and intelligent system", has a power of 15.96 kW and an estimated production of 12.840,59 kWh of energy per year, resulting from 84 modules occupying an area of 120.71 sqm.

The PV array is divided into 6 sub-two strings, each connected to an inverter to be installed outside in a sheltered from direct sunlight and accessible for visual inspection and maintenance activities. Each string will be equipped with an insulated and blocking diode.
Number of surfaces available 28
Total Available 120.71 m² extension
Total extension used 120.71 m²
Total area 120.71 m² modules
Inclination of the modules (Tilt) 90 °
Orientation of the modules (azimuth) 7th
Annual solar radiation on the surface of the modules 1 074,01 kWh / m²
Technical Data
Total power 15.96 kW
Total number of modules 84
Number inverter 6
Total annual energy 12 kWh 840.59
- Model SANYO HIP , - Model ITALY SMA SB 3300TL HC
Strings x 7 x 2 Modules

The photovoltaic glass roo of the greenhouse has a power of 5.76 kW and an estimated production of 6615.98 kWh of energy annually, resulting in 24 transparent glass-glass photovoltaic panels (system glass room), size of 3,020 x 1,620 m, arranged in parallel rows of 12 panels each, occupying an area of 117.5 sqm. In the upper part of the structure, which form proper coverage, panels 24 will be arranged in two rows, to get a total power of 5.76 kW. Each panel has a peak power of 240 W, produced for 96 cells. The PV array is divided into 6 sub-1 string, each connected to an

inverter. The inverters are to be installed outside in a sheltered from direct sunlight and accessible for visual inspection and maintenance activities.
The framework of protection will be provided with the interface device that will provide surveillance of the phase voltages and network protection for minimum or maximum voltage and frequency protection and minimum and maximum frequency.

For the sizing of the system are considered two different inclinations of panels: 16 ° and 13 °.

Technical details of the section with panels at an angle of 16 °.
Number of surfaces available 1
Extending the total available 58,70 m²
Total extension used 58,70 m²
Total surface area 58,70 m² modules
Inclination of the modules (Tilt) 16 °
Orientation of the modules (azimuth) 7th
Annual solar radiation on the surface of the modules 1 541.21 kWh / m²

Technical Data
Total power 2.88 kW
Total number of modules 12
Total number of inverters 3
energy performance 3327.69 kWh total annual energy
form Module Module with 96 solar cells with a power of 240 W
inverter Brand - Model SMA ITALY - SB 1100 Modules strings x 1 x 4

Another part of the roof is covered with PV laminated, it cover the greenhouse and is built with pv a glass-glass (6 +6) modules with elements of tempered glass that meets the technical and performance audits conducted in accordance with the main terms and conditions of the site: atmospheric characteristics, thermal and mechanical properties.

3. University classrooms and library in Sesto Fiorentino , Florence

The integrated photovoltaic system, totalling 20 kWp power occupying surface of 300 sqm. The system is composed by 160 PV glass/tedlar transparent modules with a power of 125 Wp/each, divided into five subsystem of 4000 Wp each.
Every subsystem has an inverter dedicated, completed with interconnection box
The photovoltaic system is composed by the following:

- **Principle structure** – 4 reticular beams of 22 m each positioned on the shortest side of the internal court.
- **Secondary structure** – 25 beams realised with 2 steel IPE supported by the principal beams

- **Modules structure** – modules are positioned for the longest side along beam direction, the photovoltaic modules, transparent glass/tedlar are supported by an aluminium tripod. Modules are then sustained and screw down to the aluminium easels realised with three L steel profiles.
- Footbridges – to guarantee maintenance operations and security grill footbridges have been realised (made of Alugril or Orsogril) these are positioned behind the PV modules on the principal and secondary beams. In the executive project we put many handrails, but during a function check we decided to keep the handrails off to improve photovoltaic efficiency in wintertime.

Photovoltaic modules are 35° tilted and south oriented. The electricity produced in DC current by PV modules will be fed, after conversion into alternate 400 V and 50Hz, into the building grid connected to the Medium Voltage Distribution National Grid. The energy produced will be measured trough a proper meter, installed by the grid manager and accounted under the directive n° 224/00 by the National Energy Authority.
On the base of sun values on floor and on the modules plane tilted 35°, and assuming an average energy 75%efficiency of the system in the different situations, system electricity production, agreed as electrical energy given to the ENEL grid is: about. 32.996 kWh/year.

Components description and general scheme of the system
The PV system is provided to produce energy in connection to the electrical grid of the building in low voltage and alternate current; the system will be connected electrically to the part of the network of the client. In the connection point the voltage is 400 Vac three-phase, 50 Hz frequency.
The energy produced will be fed into the grid, accordingly with the technical and economic conditions of the exchange service defined by Electrical and Gas Authority directive n. 224/2000.

The principal elements that constitutes the system are the following:
- 160 photovoltaic modules in polycrystalline silicon, 125 W peack each
- 5 inverter one phase power 3.3 kW DC, 4.2 kWp photovoltaic side
- interface panel for grid connection low tension, accordingly CEI 11.20 regulations

Group of conversion and electric energy delivery
Five inverters are dedicated to the 5 subsystems, for the energy conversion from DC to AC current. The inverters convert the energy of the PV generator in alternate 3-phase current, for energy distribution into the grid.
5 inverters installed: Firm manufacturing: Sun Power Solartechnik Model SP 3100-600

4. Physic University laboratories - Sesto Fiorentino 50kWp

This PV system is a retrofit installation in the building of the Department of Physics of the University of Florence.
The photovoltaic modules are placed in the field with the following values of the tilt and azimuth: 1/2/3 Subfields: TILT 30.0 ° - 32 ° azimuth.
The project involves the construction of three PV generators connected in parallel on the general framework QAC. The building is divided into several portions with two, three or four floors, arranged to form two quadrilaterals which enclose two interior courtyards. On the cover of one of the portions of the building is two and three storeys and steel structures with a height of one storey, with aesthetic function; portions of the four-storey building are arranged at the vertices of quadrilaterals as turrets.

The parties involved in the project of building are constituted by a cover portion (with metallic structure) and a facade on the side opposite to Via of Ideas.
Two of the generators will be installed on the front so as to achieve a sun screen, the third generator will instead be installed on the cover in part by exploiting the existing metal structure.
The three subfields are composed respectively of 60, 54 and 74 PV modules of variable strings divided by 9 to 12 modules.
The total number of panels, each divided by the PV field is equal to:
subfield 1 54 modules of 290Wp - 15.66 kWp
subfield 2 60 modules of 290Wp - 17.40 kWp
subfield 3 74 modules of 225Wp - 16.65 kWp
The total installed peak power is equal to: 49,71 kWp.
TOTAL ANNUAL PRODUCTION FIELD SOLAR: 51,766 kWh
The photovoltaic modules are of the type used at high peak power composed of 60 multicrystalline solar cells 156x156 mm.

Body made from anodized aluminum frame with high resistivity to corrosion, tempered glass solar low iron content, with maximum load equal to 550kg/mq. Presence of n ° 3 by-pass diodes to minimize the power loss for the eventual shading or damage.

DATA FIELD FRONT PANEL
Manufacturer SCHOTT SOLAR
Model POLY TM 290
Peak power of 290 Wp
Number of cells n. 80 connected in series
Module efficiency 13.7%

5. University home students Florence 20 kWp

The system is integrated into the type of coverage for the building used as a place in University residences because of Mezzetta in Florence.
The system is grid-connected and the connection mode is "three-phase low voltage." The power is 19.92 kWp, and the estimated production of 21.320 kWh of energy per year (minimum guarantee), 94 derived from amorphous silicon modules occupying an area of 220 M2CA and 34 monocrystalline silicon modules occupying an area of 44 m2 approx., power, respectively: - 12.784 kWp; - 7,14 kWp.

Modules in amorphous Si thin film
The photovoltaic panels are made of aluminum sheet 10/10, high corrosion resistance, having dimensions of 5700 mm x 467 mm, which supports the laminates, to be mounted parallel to the cover plates of the building.
The metal sheet cover must be able to adapt to the underlying curve through a system of extruded aluminum profiles and should not interfere with the disposal of water.
The profile of the sheet is integrated with a system of spacer elements and stiffening in extruded aluminum that are anchored through the cover to the support structure below.
The spacer elements are formed by two types of drawn aluminum extruded, one to omega-shaped profile, the other inverted T profile. The omega spacers are anchored at the rafters of the existing structure.
The T sections are positioned orthogonally to those omega and constitute both longitudinal strength of the panels and anchoring element.
Having to adapt to a curved structure both profiles (omega and T), as well as panels, must be supplied already calenderer with specific radius of curvature.

At the bottom of the cover will be arranged a row of PV modules in hybrid technology (monocrystalline silicon surrounded by ultra-thin amorphous silicon layers) parallel to the roof surface.
The modules will be placed side by side with each other and fixed to the cover by means of special aluminum profiles and in adherence of the existing roof covering exploiting the existing inclination (about 35 ° above the horizon).
This plant (consisting of No. 34 modules) of the rated power of 7.14 kWp, will complement the other system getting an implant "mixed" by a total of 19.92 kWp.
Generator (G1 + G2)

3. Conclusions

Public actions result necessary to stimulate PV systems integration, to encourage the firms to find new process and technical solutions, knowing that interesting borders amelioration exist, whether to costs level or to devices efficiency increase. A great activity of new products development - more suitable for the architectural applications - is to remark as effect of the support's mechanisms until now adopted by several countries.
The most recent typology of Photovoltaic technology applications is the one using buildings integrated systems: PV systems can be used as integrative source, a contribution - according to the dimension of the plant - to the building global electric budget. These applications introduce different advantages:

- energy produced near user has a greater value than energy furnished by the traditional electric power station;
- electric energy production during insulation times allows to reduce the demand to the net during the day, just when there is the greatest request. Hypothesising a high development of building integration of PV systems, it is possible to foresee a levelling of the daily peak request, usually corresponding to the more expensive kWh electrical cost. It is a more and more interesting alternative, particularly for the increasing use of the conditioning systems in the residential, commercial and public buildings;
- the PV installation cost could also be an avoided cost decreasing the global building cost, because the PV modules can be constructive elements replacing tiles or façades glasses;
- the adoption of these systems allows the diffusion, directly among the consumers, of a great “energetic conscience”, with positive increase of the use of electric energy produced and exchanged with the net.
  It is necessary to highlight the PV systems esthetical value: the silicon cell has a pleasant aspect and a particular effect, making it an interesting material for the contemporary architecture. It is possible to use different color cells, adapting them to the several contexts.

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