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Heiselberg, Per Kvols

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ZEB and public spaces *energyplus.*
Architectural and urban integration of active energy systems: criteria and guidelines

Fabiana Cambiaso

Architect and Civil and Environmental Engineer
PhD in Environmental Design
Planning, Design and Architectural Technology Department, Sapienza University
Via Flaminia 70, 00196 Roma (Italy)

fabiana.cambiaso@me.com;

fabiana.cambiaso@uniroma1.it

Abstract

Our massive dependence on fossil fuels has upset the very climatic system that made human evolution possible. Energy efficient and low-carbon technologies will play a crucial role in the energy revolution needed to make this change happen. Biomass, hydropower, wind energy, solar thermal collectors, photovoltaics systems, centralized solar thermal power plants, solar architecture and geothermal energy and a number of experimental technologies are raring to go. A second basic requirement of such a fully renewable energy supply structure is the intelligent interchange of energy between regions. This interchange can be managed by the power grid, gas networks (using solar generated hydrogen) or by transporting biomass. As energy use is strongly linked to building age, there is enormous energy and CO2 savings potential in upgrading building envelopes and heating and cooling systems to modern standards. Recognising the importance of energy efficiency improvements in the buildings sector, the EU introduced the EPBD in 2002. In 2010, the EPBD was revised with tougher requirements for buildings, including the requirement for member states to ensure that all new buildings will be nearly zero-energy buildings (ZEBs) by the end of 2018 for buildings owned by public authorities and by the end of 2020 for all other new buildings. The transition to zero energy district will have positive benefits for other sectors, most notably the power sector, and will translate into avoided electrical capacity additions, as well as reduced distribution and transmission network expansion, with potentially huge savings for utilities.

The goal of this research is to promote the use of active energy systems into high quality architecture and urban designs. To achieve this goal I defined architectural integration criteria per technology, highlighting on one hand the need of improving designers knowledge, and on the other hand the need of enhancing the building and urban integrability of the products available on the market. I have been focusing on the tools and methods available for the dimensioning and positioning of active

energy systems in buildings and urban public spaces, showing that new, architects friendly, tools are urgently needed. Finally, I provided a wide selection of well documented case studies, demonstrating that energy efficient strategies on renewable sources can be the basis for inspiring high quality architectures (in new constructions and in building renovations and on experiments or prototypes or visions).
Further the purpose of the research is the development of a open source database established to address these issues by presenting, on one hand, the active energy systems and innovative products available in the market today and, on the other hand, the information you need to optimally integrate them in the architecture of a building and built environment. By choosing a specific technology and an integration type (roof, façade, balcony...) the user gets access to a selection of appropriate products, presented in the form of synthetic A4 sheets. These sheets include architect oriented information, contact details and pictures, both on the product alone and situation examples in buildings.

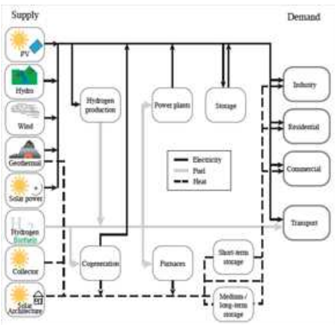
Keywords - Integration; Active Energy Systems; Renewable Energy; Energy Technology

1. Introduction

Today's world economy does not use the Earth's resources in a sustainable way. Humanity is rapidly coming closer to the exhaustion of conventional and nuclear finite energy reserve. Now it is widely accepted that the mid-depletion point of oil reserves has already been passed in non-OPEC countries, and will be passed in the OPEC countries within the next decades (according to EWG, 2008a), peak oil, i.e. global maximum oil production capacity, was passed in 2006. Additionally EWG studies on global coal and uranium resources showed that these will also become scarce in the near future. Last but not least, the environment faces increasing threats, ranging from the well-known problem of human-caused climate change to the erosion of fertile soil, water pollution and the various effects of manmade toxins and nuclear waste.

A sustainable energy supply has to be fully based (100 per cent) on renewable energies and must use available resources most efficiently. Today, at the advent of the industrial solar age, there are eight basic technologies in the market (biomass, hydropower, wind energy, solar thermal collectors, photovoltaics systems, centralized solar thermal power plants, solar architecture and geothermal energy) and a number of experimental technologies are raring to go. These technologies tap renewable energy resources in a magnitude that exceeds current global energy consumption by many times, and can provide energy for millions of years.

A solar energy system to supply energy reliably throughout the year includes the consistent use of local renewable energy sources wherever possible. A second basic requirement of such a fully renewable energy supply structure is the intelligent interchange of energy between regions. This interchange can be managed by the power grid, gas networks (using solar generated hydrogen) or by transporting biomass. This approach helps balance the fluctuations in energy provision that can occur with some renewable energy technologies (such as wind and photovoltaics). If, for example, the wind stops blowing in one region, power can directly be supplied by surpluses in other regions or, if this not suffice, other regional sources, such as local biomass power plants, or even plants in other regions can deliver the required power.



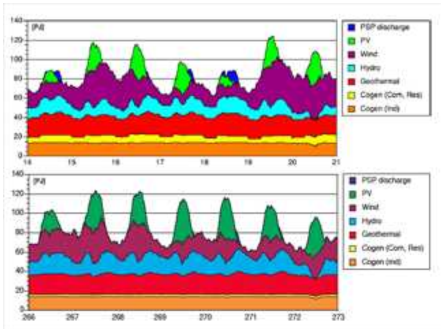
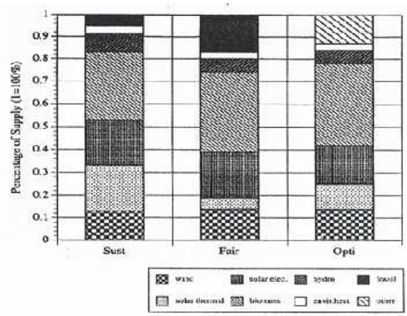


Fig. 1,2 The structure of a renewable energy system (Source: ERJ, 2003; on the left).

The twenty-first century is shaping up to be a transitional era for the way humanity dwells on this earth. Much of the stress we impose on the earth is manifested in the way we design, construct, and use our built environments; that means buildings and cities must play a vital role in shaping our sustainable future.

Net zero energy buildings (Nzeb) are tools in shaping this future.

Two key concepts make up this definition of nze. First, *net* means that nonrenewable energy sources (fossil fuels and nuclear) may be used; but over the course of a year, enough renewable energy must be generated so that the project can offset or exceed the use of nonrenewable energy. The concept *zero energy* does not mean that the building uses no energy; rather, it refers to reaching a net zero energy position for buildings that have full program demands. Nze is an operational goal. Operation means that the performance results in actual, quantifiable benefits – real carbon emission reductions and real cost savings.



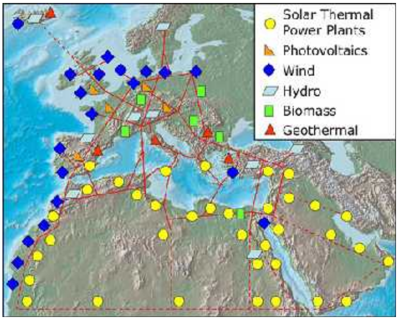


Fig. 3,4 Share of energy sources providing energy for Europe in 2050 in three different scenarios (Source:LTI,1998, on the left); The expanded super-grid (Source: DESERTEC in EV-MENA, on the right).

The National Renewable Energy Laboratory (NREL) has defined four ways of measuring and defining net zero energy for buildings: *net zero site energy*, *net zero source energy*, *net zero energy emissions* and *net zero energy cost*.

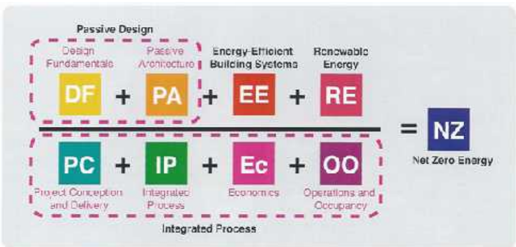


Fig. 5,6 Nze concept as an Equation (on the left); Nzeb Definitions (on the right).

1. Method

Integrated design for nzeb is part of an evolving design approach that has industry professionals rethinking the methods and purpose of design. Through this new approach, based on innovation, they seek to derive value and purpose-driven outcomes in response to research and data-driven inputs. Energy and architecture have always been intertwined. Architecture has always been formed by energy; it has been used to both mediate and harness the energy of the world. Nzeb represent exemplary energy use , they should also be considered whole, or complete, green buildings; that means pursuing a holistic approach to sustainable design. Holistic design works to optimize the three main priorities of sustainability, often defined as the *triple bottom line*: environmental, economic, and social concerns. Holistic design works to create buildings that eliminate negative impacts on the environment.

The design of energy-efficiency building systems or the active systems for a nze project is completed in concert with the passive design strategies and climate-responsive architecture. The passive strategies serve as the foundation for heating, cooling, ventilation, and lighting for a project. Active systems are also integrated with the design of on-site renewable energy systems. There are many options for renewable energy integration for a nzeb.

We refer to the main renewable energy systems: solar power (photovoltaics), solar thermal, wind, hydro, geothermal, biomass, hydrogen and fuel cells. Solar power derived through the use of photovoltaic (PV) technologies is the workhorse of the distributed, on-site renewable energy sector. It is the most common renewable energy resources for nzeb due to its versatility, cost-effectiveness, and capability for integration into projects at different scales.

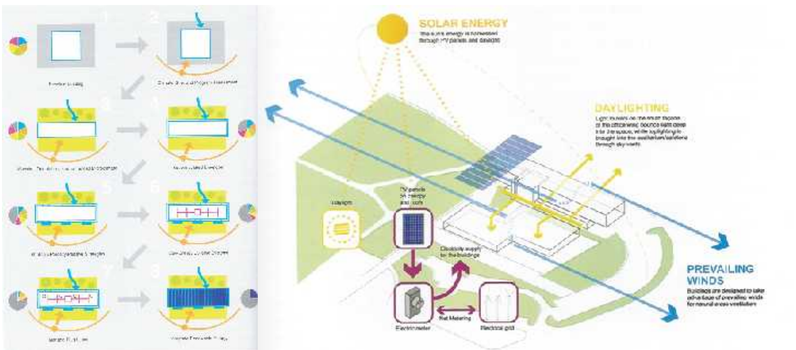


Fig. 7,8 Basic steps in optimizing a building for passive strategies, low-e integration and nze (on the left); Energy System Diagram for a nze (Image courtesy of RNL, on the right).

The goal of this research about Nzeb is to promote the use of active energy systems into high quality architecture designs. To achieve this goal I defined architectural integration criteria per technology, highlighting on one hand the need of improving designers knowledge, and on the other hand the need of enhancing the building integrability of the products available on the market.

Active systems are also integrated with the design of on-site renewable energy systems. There are many options for renewable energy integration for a nzeb. Which application or combination of applications is correct for any building is a complex question, one that involves variables such as available renewable energy resources, energy economics, and energy requirements, as well as building and site constraints. Planning for renewable energy systems for a nzeb can have a dramatic impacts early in the project; as such, it should be part of the goal- setting, programming, and early concept phases, and be fully developed through to delivery of the project. Evaluating a diversity of renewable energy systems can be a smart approach when matching available resources with energy needs, both thermal and electrical. Solving our energy future and addressing climate change will require a broad and diverse approach to renewable energy solutions. Nzeb and communities are just one part of solution, as they advance the objective of distributed renewable energy systems. But utility-scale energy also needs to be part of the solution, with a continual increase of the renewable energy proportion on the grid.

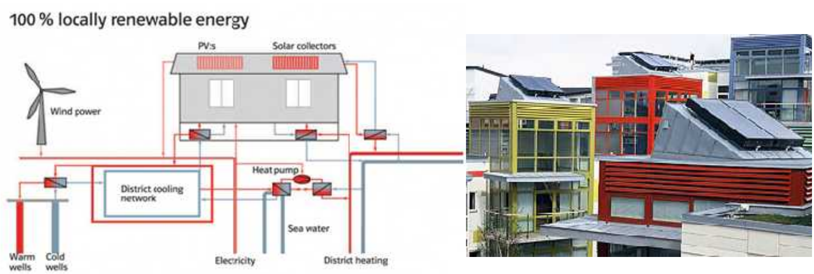


Fig. 9 BO01, Malmö, Energy system concept (Source: E-ON, 2009).

2. Discussion and Results

I have been focusing on the tools and methods available for the dimensioning and positioning of active energy systems in buildings, showing that new, architects friendly, tools are urgently needed.
Finally, I provided a wide selection of well documented case studies, demonstrating that energy efficient strategies on renewable sources can be the basis for inspiring high quality architectures (both in new constructions and in building renovations and, in addition, on experiments or prototypes or visions).

After a common section on general architectural integration issues and criteria, solar thermal and photovoltaic are treated separately, following a common structure:

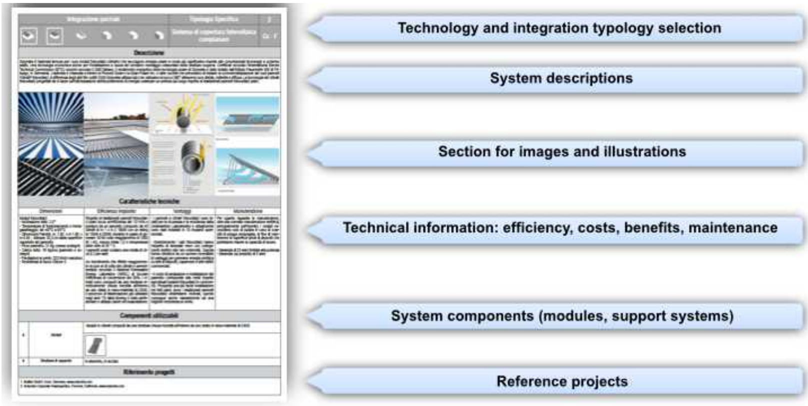
1. Main technical information (technology working principle / available subtechnologies/ related basic collector components / suitable energetic applications / energy yield /cost);
2. Constructive/functional integration possibilities in the envelope layers, supported by a collection of selected examples showing the different possible approaches;
3. System sizing and positioning criteria (to help integrate the system, taking into account all design criteria - area and solar radiation availability – targeted solar fractions - storage issues – system efficiency - advantages and disadvantages – maintenance);
4. Formal flexibility offered by standard products, and derived design freedom;
5. Available innovative products conceived for building integration (nearly one hundred products collected).

Case Studies and Products

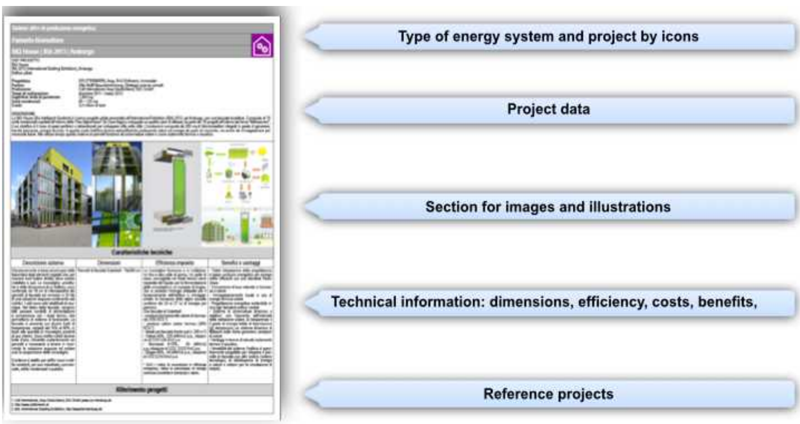
Fig. 10 Some of Examples of architecturally integrated energy systems.

The Products and Case Studies selected were drawn into two different layout of sheets.

A) **Innovative Layout Products Sheets** by different energy technologies systems (Solar energy in buildings/Solar thermal/ Photovoltaics/PV vs. Solar thermal/Wind turbines/Geothermal/…)



B) **Innovative Layout Products Sheets** by different case studies (projects, prototypes, visions,installations…)



C) Innovative Layout Products Sheets: example of open source database

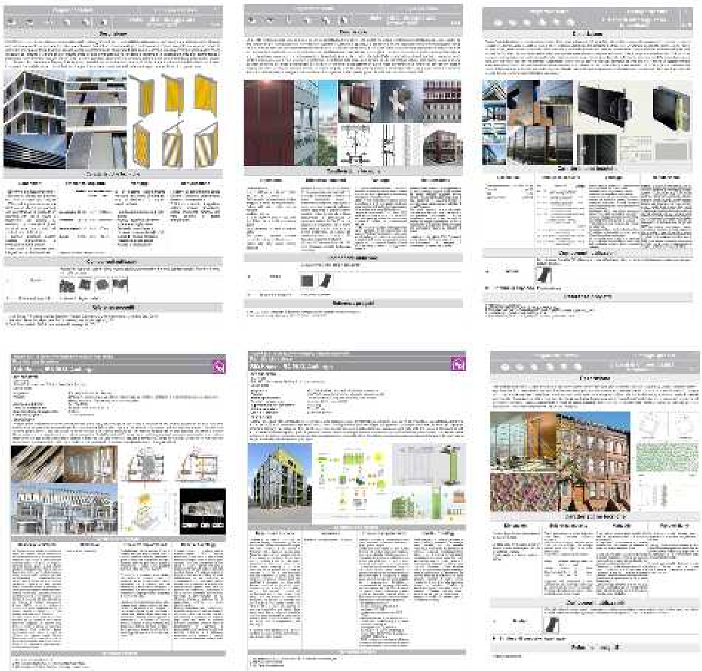


Fig. 11 Innovative products sheets.

4. Conclusion

To complete the information, the manual ends with a short section highlighted the differences and similarities between energy active systems. The difference in energy medium between active systems implies very different transportation, storage, and safety issues, as well as different formal and operating constraints, resulting in different integration possibilities in the building envelope. One of the main barriers is the low number of products conceived for building integration, and the related lack of knowledge among building professionals. Further the purpose of the research is the development of a *database and website* established to address these issues by presenting, on one hand, the active energy systems and innovative products available in the market today and, on the other hand, the information you need to optimally integrate them in the architecture of a building.

The site will be designed to be ergonomic and attractive to architects and their clients and it is structured around the main active energy technologies: photovoltaics, solar thermal, hybrid systems, geothermal, wind turbines, experimental prototypes. By choosing a specific technology and an integration type (roof, façade, balcony…) the user gets access to a selection of appropriate products, presented in the form of synthetic A4 sheets. These sheets include architect oriented information, contact details and pictures, both on the product alone and situation examples in buildings. The website is completed by a set of documents (extracts from other task almost fifty documents) on the specificities of the different technologies (Solar energy in buildings / Solar thermal / Photovoltaics / PV vs. Solar thermal / Wind turbines / Geothermal /...

Acknowledgment

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[1]The material of this paper is part of a research in progress at the PDTA Department (Dott. Arch. Ing. F. Cambiaso; Coordinator: Prof. Arch. E. Cangelli)