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POSITIVE NET BUILDINGS: SIMULATIONS AND OPTIMIZATION

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For a positive net building (PNEB), the paper presents its need, and tools to achieve its design. The PNEB should provide the maximum thermal comfort with a minimum of energy, primary energy, and exergy consumption, and a minimum of CO_2 emission. Then, the paper presents the software for a energy simulation and optimization of PNEB. After that, the paper describes the two examples connected to the PNEB. The first example is a simulation of a residential PNEB, and the second the optimization of the photovoltaics in the residential PNEB.

Pentru o clădire cu bilanţ energetic net pozitiv (PNEB) lucrarea prezintă cerinţele şi instrumentele necesare proiectării ei. Clădirea PNEB trebuie să ofere confort termic maxim, cu un consum minim de energie, energie primară şi exergy, şi cu emisii minime de CO_2. Apoi, lucrarea prezintă software-ul necesar simulării energetice şi optimizării clădirii PNEB.

Lucrarea descrie în continuare două exemple legate de clădirea PNEB. Primul exemplu este o simulare a unui imobil rezidenţial PNEB iar al doilea este o optimizare a sistemului fotovoltaic ce echipează un imobil rezidenţial PNEB.

1. Introduction

Daniel M. Kammen, Director of the Renewable and Appropriate Energy Laboratory, University of California, Berkeley wrote the following in Nature[1]. "By 2020. humankind needs to be solidly on to the path of a low-carbon society — one dominated by efficient and clean energy technologies. Several renewable technologies are ready for explosive growth. Energy-efficiency targets could help to reduce demand by encouraging innovations such as PNEBs and electric vehicles. Research into solar energy — in particular how to store and distribute it efficiently— can address needs in rich and poor communities alike. Deployed widely, these kinds of solutions and the development of a smart grid would mean that by 2020 the world would be on the way to an energy system in which solar, wind, nuclear, geothermal and hydroelectric power will supply more than 80% of electricity." Globally, the drive for PNEB is necessity and urgency to decrease carbon emission, and relive energy shortage.

Several worldwide targets are established. First, the Energy Performance of Buildings Directive of EU states that all buildings built after 31 December 2018 will have to produce their own energy onsite [2]. Second, from beginning of 2020 in USA, all new Federal buildings will be designed to consume zero-net-energy and be zero-net-energy buildings (ZNEBs) by 2030 [3]. Third, to progress with the development and adoption of high performance buildings in USA, there is the Net Zero Energy Commercial Building Initiative. The initiative aims to achieve marketable net-zero energy buildings by 2025 through public and private partnerships [4]. Finally, UK Government sets out improvements to energy requirements in Building Regulations to include that all new homes has to be 'zero carbon' by 2016[5].To reach ZNEB target, it is advisable to go for PNEB.

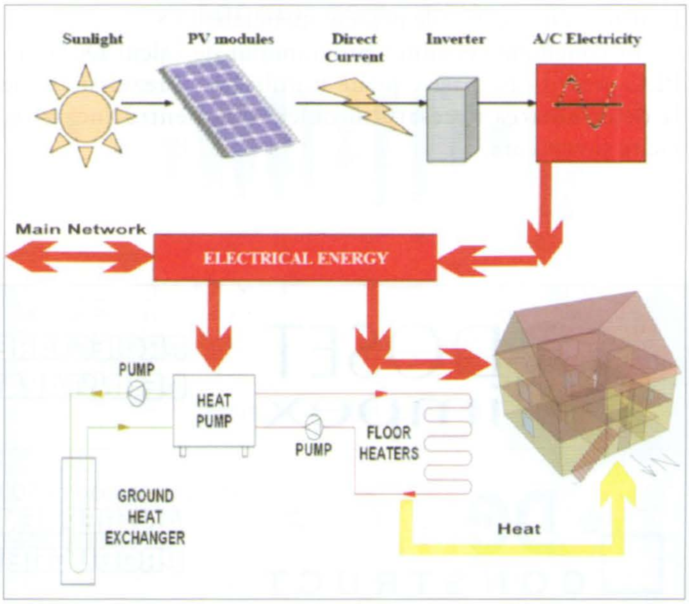
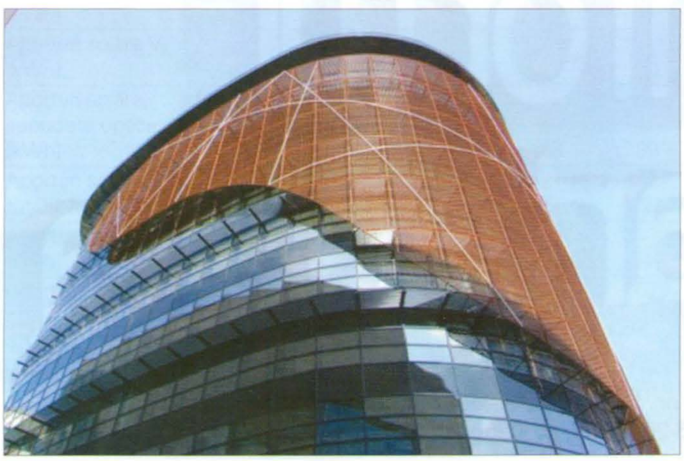


Fig.1 Schematic of a PNEB



The objective of this paper is to introduce definitions, show software for their design and give two examples of their application.

2. Definitions

The building may have a positive-net energy status regarding the site energy & exergy, the source energy &

exergy, the energy costs, the energy-induced emissions, and the embodied energy [6].

2.1. Positive-net site energy (exergy)

PNEB generates more energy (exrergy) than it consumes. It usually produces electrical energy through PV modules and is connected to the grid. The building may either consume electrical energy from the PV modules or from the grid. The generated electrical energy may either feed the building or the grid. The electric energy supplies the grid when there is the electrical energy surplus. When there is electrical energy shortage the grid supplies electrical energy to the building. The "positive-net" concept means that yearly the excess electrical energy (exergy) sent to the grid is larger than the amount received from the grid. The PNEB uses the power grid as an electrical storage battery. The schematic of a PNEB is shown in Fig.1.

2.2. Positive-net source energy (exergy)

A building that produces and exports more energy (exrergy) as the total energy it imports and uses in a year, when accounted for at the source. "Source energy" refers to the primary energy required to generate and deliver the energy to the site. To calculate a building's total source energy, imported and exported energy is multiplied by the appropriate site-to-source conversion multipliers.

2.3. Positive-net energy emissions

A building that produces and exports more emissions-free renewable energy as it imports and uses from emission-producing energy sources annually. Carbon dioxide, nitrogen oxides, and sulfur oxides are common emissions that PNEBs offset.

2.4. Positive-net energy costs

A building where the amount of money a utility pays the building's owner for the renewable energy the building exports to the grid is larger than that the owner pays the utility for the energy services and energy used over the year.

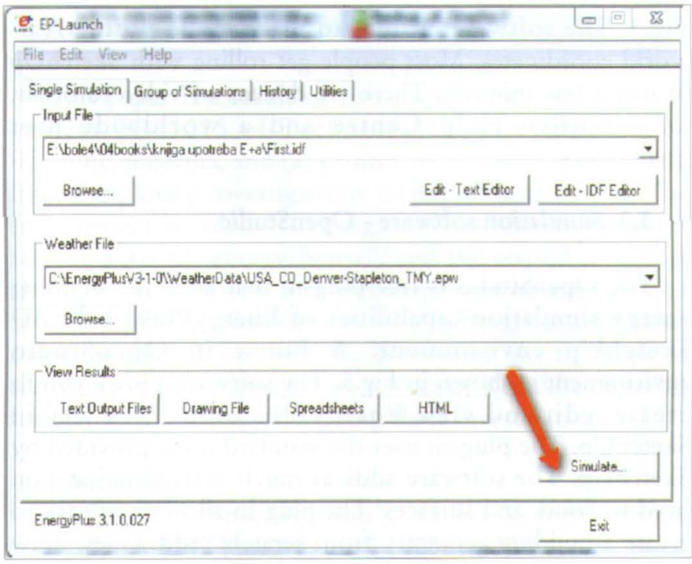
2.5. Positive-net life-cycle energy

Positive-net life-cycle energy building is defined that during entire life it produces more energy than it spends for the embodied energy of building components and its energy use [7].

3. Simulations and Optimizations

3.1. Simulation software - EnergyPlus

EnergyPlus is made available by the Lawrence Berkley Laboratory in USA [8]. EnergyPlus interface is shown in Fig.2. EnergyPlus development began in 1996 on the basis of two widely used programs: DOE-2 and BLAST. The software serves to simulate energy behavior of buildings and renewable energy use in buildings. The renewable energy capabilities include solar thermal and photovoltaic simulation. Other simulation features of EnergyPlus include: variable time steps, user-configurable modular systems, and user defined input and output data structures. The software has been tested using the IEA HVAC BESTEST E100-E200 series of tests. To model, the building and renewable energy systems in EnergyPlus environment, we used models of different components that are embedded in EnergyPlus such as that of PV-array, inverter, flat-plate solar collector, storage tank, tempering valve, and instantaneous water heater. Water in the storage tank was heated by solar energy and water in the instantaneous water heater by electricity.



Input File: E:\bole4\04books\knjiga upotreba E+a\First.idf

Weather File: C:\EnergyPlusV3-1-0\WeatherData\USA_CO_Denver-Stapleton_TMY.epw

Fig.2 EnergyPlus interface

3.2. 3D software - Google SketchUp

Google SketchUp is a free 3D software tool that combines a tool-set with an intelligent drawing system. Building in Google Sketch-up environment is shown in

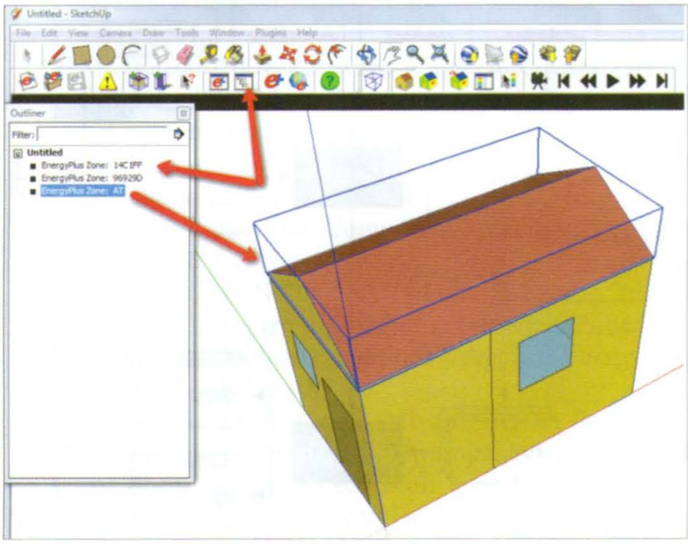


Fig.3 Building in the GoogleSketchUp and the OpenStudio environment

Fig.3. The software enables to place models using real-world coordinates. Most people get rolling with SketchUp in just a few minutes. There are dozens of video tutorials, an extensive Help Centre and a worldwide user community.

3.3. Simulation software - OpenStudio

The OpenStudio is free plug-in that adds the building energy simulation capabilities of EnergyPlus to the 3D SketchUp environment. A house in OpenStudio environment is shown in Fig.3. The software allows you to create, edit and view EnergyPlus input files within SketchUp. The plug-in uses the standard tools provided by SketchUp. The software adds as much extra detail as you need to zones and surfaces. The plug-in allows you easy to create a building geometry from scratch: add zones, draw heat transfer surfaces, draw windows and doors, draw shading surfaces, etc. You can save what you have drawn as an EnergyPlus input file. The plug-in also allows users to launch EnergyPlus simulations and view the results from within SketchUp.

3.4 Optimization software - GenOpt

GenOpt is an optimization program for the minimization of a cost function evaluated by an external simulation program [9]. Optimization and simulation data flow paths by using Genopt are shown in Fig. 4. GenOpt serves for optimization problems where the cost function is computationally expensive and its derivatives are not available or may not even exist. GenOpt can be coupled to any simulation program that reads its input from text files and writes its output to text files. The independent variables can be continuous variables (possibly with lower and upper bounds), discrete variables, or both, continuous and discrete variables. Constraints on dependent variables can be implemented using penalty or barrier functions. GenOpt is written in Java so that it is platform independent. GenOpt is applicable to a wide range of optimization problems. GenOpt has a library with adaptive Hooke-Jeeves algorithm, Discrete Armijo Gradient, particle swarm optimization etc.

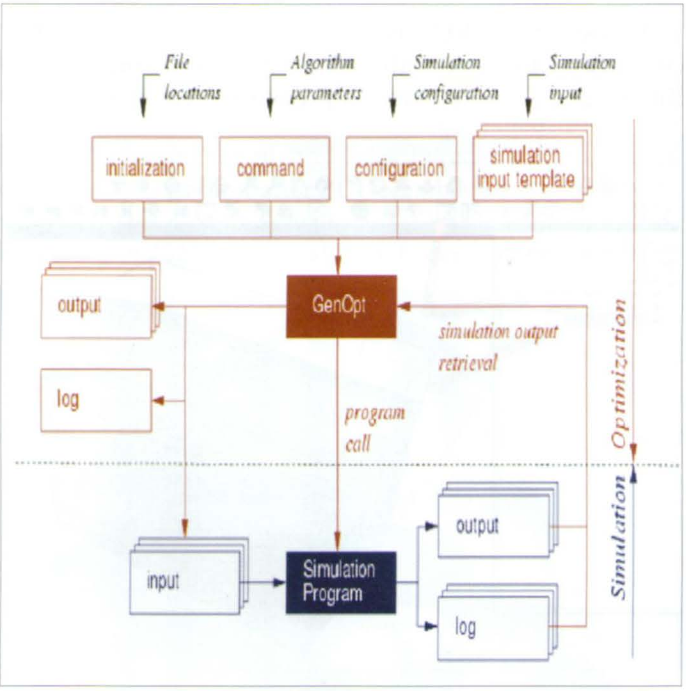


Fig.4 Optimization by using Genopt

4. Examples

4.1. Residential PNEB in Serbian conditions [11]

This article reports investigations of a residential building in Serbian conditions energized by electricity from photovoltaics (PVs), and the electricity grid. The building uses electricity to run its space heating system, lighting and appliances, and to heat domestic hot water (DHW). The space heating system comprises floor heaters, a water-to-water heat pump, and a ground heat exchanger. The schematic of this PNEB is shown in Fig.1. The PV system generates electricity that either may be consumed by the building or may be fed-in the electricity grid. The electricity grid is used as electricity storage. Three residential buildings are investigated. The first residential building has PVs that yearly produce smaller amount of electricity than the heating system requires. This is a negative-net energy building (NNEB). The second building has the PVs that produce the exact amount of electricity that the entire building annually needs. This is a zero-net energy building ZNEB. The third building has PVs that entirely cover the south-facing roof of the building. This is a PNEB. These buildings are presented by a mathematical model, partially in an EnergyPlus environment. For all buildings, simulations by using EnergyPlus software would give the generated, consumed, and purchased energy with time step, and monthly and yearly values. For sure, these buildings would decrease demand for electricity during summer, however they will increase this demand during winter when there is no sun and start of space heating is required. Depending on the size of PV array this building will be either NNEB, or ZNEB, or PNEB. However it is crucial for such a building to be connected to the electricity grid. The smaller payback for investment in the PV array is obtained for buildings

with larger size of PV array. The feed-in tariff for the generation of electricity in Serbia should be corrected to include small scale PV electricity producers for larger penetration of this technology in the Serbian market.

4.2. Optimizing performances of photovoltaics in Reunion Island – tilt angle [12]

As in Reunion Island, France, around 61% of electricity is produced by using coal and fuel oil with high greenhouse emissions. It is beneficial to the environment to produce electricity from solar energy. Therefore, there is a large push to generate electricity from solar energy by use of photovoltaic (PV) arrays. However, it is important to have high efficiency of electricity generation, that is, to locate PV arrays in an optimal direction. The investigated PV systems may take 1, 2, 4, and 12 tilts per year. For the PV arrays facing the north–south direction, this paper reports investigations of their optimum tilts and the maximum amounts of generated electricity. The investigated PV arrays are located in the towns of Saint-Benoit, Les Avirons, Piton Saint-Leu, and Petite-France in Reunion Island. To obtain optimal tilt of the PV arrays for electricity production from solar energy, EnergyPlus software and GenOpt software are used with Hooke–Jeeves optimization routine. For the investigated PV arrays, the percentage gains in energy, exergy, avoided fossil energy, and the percentage decrease in CO2 emission are around 5% when compared with that of the PV array that takes only one optimum tilt per year.

5. Conclusions

The paper shows that PNEBs are in strong need worldwide. The most important fact is that throughout their life, the PNEBs should provide the maximum thermal comfort with the minimum of energy, primary energy, and exergy consumption, and the minimum of CO2 emission. The different definitions of the PNEBs are present. They can account for the site energy, source energy, CO2 emissions, costs, and embodied energy. The PNEBs may be designed by using software for energy simulation and optimization. The PNEBs would be successfully used for residence, however their behavior should be simulated and optimized before their application in practice.

Acknowledgment

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References

[1] "2020 visions, Opinion", Nature Vol. 463, 2010, pp.26-32 (7 January) doi:10.1038/463026a;

[2] J. Kammer, All new buildings to be zero energy from 2019, Press Service Directorate for the Media, European Parliament, 2009.

[3] White house, Federal leadership in environmental, energy, and economic performance (executive order), The white house office of the press secretary, October 5, 2009.

[4] US Department of Energy, NetZero Energy Commercial Building Initiative, Building Technologies Program Energy Efficiency and Renewable Energy.

[5] UK Green Building Council, Zero Carbon Task Group Report, WWF-UK, 2008

[6] P. Torcellini, S. Pless, M. Deru, and D. Crawley, Zero Energy Buildings: A Critical Look At The Definition, Preprint, Aceee Summer Study, Pacific Grove, California, August 14?18, 2006.

[7] P. Hernandez, and P. Kenny, "From net energy to zero energy buildings: De?ning life cycle zero energy buildings (LC-ZEB)", Energy and Buildings, 42, 2010, pp.815–821

[8] Lawrence Berkeley National Laboratory. EnergyPlus input output reference: the encyclopedic reference to EnergyPlus input and output. Berkely: LBL; 2001.

[9] M. Wetter 2004. GenOpt, Generic Optimization Program. User Manual, Lawrence Berkeley National Laboratory, Technical Report LBNL- 54199, p. 109.

[10] R. Hooke, and TA. Jeeves, "Direct search solution of numerical and statistical problems", Journal of the Association for Computing Machinery 1961; 8: pp.212–229.

[11] M. Bojic, N. Nikolic, D. Nikolic, J. Skerlic, and I. Miletic, "Toward a positive-net-energy residential building in Serbian conditions", Applied Energy 88, 2011, pp. 2407–2419.

[12] M. Bojic, D. Bigot, F. Miranville, A. Parvedy-Patou, and J. Radulovic, „Optimizing performances of photovoltaics in Reunion Island – tilt angle", Progress in Photovoltaics: Research and Applications, DOI: 10.1002/pip.1159 (2011) Online ISSN: 1099-159X.