CONCEPTUAL DESIGN OF RENEWABLE-BASED ENERGY MIXES FOR SUSTAINABLE COMMUNITIES

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Abstract: The transition towards a new, sustainable and affordable energy pattern is defined in the European Union document known as SET Plan (The European Strategic Energy Technology Plan). As the built environment accounts for over 40% of the total energy consumption, special attention should be devoted to the development and implementation of renewable energy systems (RES), able to cover in a large extent the thermal and electrical energy needs. Thus, the concept of Nearly Zero Energy Building was not only formulated but is also part of EU Directive 2010/31, entering in force by 2018. A Nearly Zero Energy Building is actually a Low Energy Building (thus highly efficient) that covers the energy demand in a large extent (more than 50%) by using renewables. Plenty of work is devoted to identifying solutions both for increasing the building's efficiency and for implementing the renewables in the built environment; related to the latest, a common consensus was reached, outlining the need to design renewable-based energy mixes, making use of the available potential in the implemented location. In a step forward, the community should be analysed, as besides the buildings, a community has common utilities consumptions that should need also follow the sustainability concept. The paper proposes a design concept that allows community to become sustainable, by a careful selection of systems implemented at building's level and systems providing utilities at centralized level. This concept well matches the European Union trend, stating that large photovoltaics and wind facilities should be implemented at community level, while the thermal energy need should be (partially) covered by heat pumps, solar-thermal and/or biomass systems installed on or near the buildings or group of buildings.

Keywords: Sustainable Community, Nearly Zero Energy Building, Renewable-Based Energy Mix

1. INTRODUCTION

Energy still is the main problem of the humankind, and strongly influences the sustainable solutions for other problems: food, water and environment as defined by Nobel laureate Smalley in 2005 [1]. These problems will deepen with the expected growth of population, up to 10 billion till 2050, if appropriate measures are not taken to ensure a sustainable development. A general accepted definition of sustainable development was introduced in 1987 by the Brundtland Commission as "*the development that meets the needs of the present without compromising the ability of future generation to meet their own needs*" [2]. To apply this concept, one must "think global and act local" [2] with measures implemented to transform a community towards sustainability. Sustainable community may refer to campuses, neighbourhoods, cities, metropolitan areas, counties and regions, each with theirs specific needs and requirements. At each level, different methods are applied most often by governments and non-profit organizations involving community members, academics, decision makers, and creating networks for planning ways to create sustainable communities. These methods address the issues related to energy efficiency, waste reduction, climate friendly systems in the main energy demand sectors: the built environment, industry and transport.

Over 40% of the energy is currently used in EU buildings, out of which 80-90% represents the operating energy during buildings' life cycle [3]. At building level, sustainability can be reached combining the decrease of the energy demand for space heating, cooling, lighting and domestic hot water, with the use of RES, resulting in an important reduction of the greenhouse gases emissions. Optimizing RES is possible through the use of various types and larger systems (renewable-based energy mixes) working more efficient due to the balanced peak loads, the increased storing capacity of the energy, the compensation of the variability of some renewable sources of energy (solar, wind).

At European level, legal instruments were launched to support this strategy. The 2009/28 Directive sets for 2020 targets of 20% reduction of greenhouse gases, 20% reduction of energy demand through energy efficiency measures, 20% from energy demand to be cover by renewable energy and 10% by biofuels [4]. The 2010/31 Directive states that by 31 December 2020 all new buildings (31 December 2018 for new public buildings) should be Nearly Zero Energy Buildings (nZEB) with cost-optimal implemented solutions both in energy efficiency measures and in energy supply systems including renewable energy sources. This legal frame promotes an extended effort to develop low energy buildings (LEB), embedding solutions to cut the energy losses and decrease the total energy demand at 60-80 kWh/m^2/year. To reach the nZEB status, this energy demand should be covered from renewable sources of energy implemented on or nearby buildings [5]. Each European Member State should implement national plans for increasing the number of nZEBs, setting minimum values for the building energy efficiency and for the renewable energy share covering the energy demand. Nowadays, out from 28 European Member States, only 15 defined quantitative indicators for the specific energy demand of nZEB, and only five of them for the energy share to be covered from renewable sources of energy, Table 1:

Table 1. **European Member States with already established requirements for specific energy demand and renewable energy share for nearly zero energy buildings [6]**

European Member State	**Belgium**	**Cyprus**	**Denmark**	**Lithuania**	**Slovak Rep.**
Specific energy demand [kWh/m^2/year]	30…60	180	25	10	32
Renewable Energy Share	50…30%	25%	50%	50%	50%

The nZEB Directive refers to the new buildings [5]; however, new buildings have an annual growth rate of around 1%, decreasing in the recent years as result of the current financial crisis, [7]. Therefore, existing building stock should be also addressed, knowing that less than 2% are LEB [8]. In both cases (new or existing building), the technical, economic and environmental feasibility of RES shall be considered. At community level, this RES analysis may be carried out for groups of buildings in the same area, connected to centrailzed systems: fresh and waste water, power, heating and cooling.

The development of a sustainable community, from the energy point of view, shall start from the evaluation of the community energy demand, identifying measures to decrease it, followed by the assessment of the renewable energy potential and by the implementing renewable-based energy mixes [9].

In the first step, the energy demand of the community should be evaluated for the main energy intensive sectors: built environment, industry and transport. In the built environment, the main contributors in EU are: residential buildings (75%), followed by the wholesale & retail (7%), offices (5.75%) and educational buildings (4.25%) [7]. The energy demand of these types of buildings should be evaluated at community level, based on theirs characteristics and implementation site. The building's characteristics of interest are: building geometry and orientation towards the cardinal points, envelope components (thermal and optical properties), building's type (household, office, industrial building etc.), and number of building users. For existing buildings, the evaluation could be completed with measured data from energy meters if implemented. The implementation site shall be characterized at least by monthly average values of the meteorological parameters: outdoor air temperature, relative humidity, rainfall, ground temperature, solar irradiance, wind speed and direction. The industry sector has specific energy demand upon the companies' profiles. To evaluate the energy demand, the industrial processes and their equipment should be characterized (nominal power). Each industrial process has a precise schedule for each equipment, with working times and installed capacity, resulting the peak and non-peak periods, allowing to calculate the energy demand. The transport sector contributes to the energy demand of the community mainly through the passenger transport (public and individual) followed by freight transportation of goods inside the community. The size of the energy demand in transport sector depends on the infrastructure, distances, fuel type and on the efficiency of the transport means. Also the energy demand to cover the losses on the district heating and cooling grid should be estimated along with energy need for public utilities like fresh and waste water facilities, street lighting systems, waste disposal etc.

Once the energy demand is evaluated for each sector, actions to decrease it should be investigated. According to the specific features, the main actions to be taken in the built environment are: (a) improving the thermal characteristics of the building's envelope; (b) optimizing the ratio between the opaque and transparent elements in this envelope; (c) using efficient heating, cooling and lighting systems for the building; (d) reducing unnecessary use of energy; (e) implementing Building Energy Management System (BEMS) etc. In the industry sector, measures to decrease the energy demand primarily seek to reduce the energy use on a permanent basis through energy efficient technologies and recovery systems for the waste energy, followed by shifting the peak load away from high cost, peak demand periods. In the transport sector, the decrease in the energy demand should focus both, on the transport infrastructure and the transport means. A well designed and operated infrastructure can decrease the energy demand by avoiding traffic jams and shortening the travel time. In the case of transport means, the energy efficient and low pollutant engines, improved fuel efficiency and transport modes are compulsory both for freight and passengers transport.

The site renewable energy potential must be evaluated for the available renewable sources from: a) the outdoor meteorological data, infield measurement for at least one year (ideal); b) data generated by dedicated software, mainly relying on the geographical coordinates (latitude, longitude, altitude etc.) or c) mathematical models applied for the site location. It is important to avoid under- or over- estimation of the renewable energy potential due to the negative consequences on the final energy output and costs.

Optimal *renewable energy mix should be implemented in a LEB* towards the nZEB status based on an algorithm [10], aiming at covering a large percentage of the building energy demand by using RES-based energy mixes (at least 50% renewables) [11].

The paper presents the first steps of the conceptual design of the renewable-based energy mixes for sustainable communities, starting whit the evaluation of the surfaces available for RES implementation at buildings and community levels, followed by the investigation of the maximum capacity of RES which can be installed on these surfaces, by the evaluation of the renewable energy yield in these conditions and by an integrated design algorithm applied to find optimal renewable – based energy mixes based on the available on-site renewable potential and on affordable renewable technologies [12]. A case study is presented: the R&D Institute of the Transilvania University of Brasov, Romania where, for its low energy buildings developed in respect with solar passive design methodology, the energy demand of this community is covered with a renewable-based energy mix composed by solar thermal, geothermal, photovoltaic and small wind turbine systems installed on the buildings' rooftops or nearby buildings.

2. METHODOLOGY

At community level, the use of renewable-based energy mixes is supported by an averaging of the thermal and the electrical energy peak loads of the different consumers, with various schedules (residential, commercial, industrial etc.), and by the possibilities to counteract the strong variability of the renewable energies potential, under the climatic conditions of the implementation location. For rooftops and facades implementation, the following RES are the best candidates:

(a) Thermal energy: solar thermal collectors (flat plate or evacuated tube), heat pumps (with ground or air as energy source/sink), and biomass systems (if allowed);

(b) Electrical energy: photovoltaic systems and micro- or small wind turbines (on-grid or off-grid). At community level, there are less spatial limitation thus centralized (district) RES could be implemented for:

(a) Thermal energy: arrays of flat plate solar thermal collector, ground source heat pumps (large horizontal heat exchanger);

(b) Electrical energy: photovoltaic parks (grid connected), average or large wind farms, micro-hydro systems (c) Combined heat and power plants: arrays of concentrated solar-thermal collectors, biomass burners, or high enthalpy geothermal sources (e.g. hot springs, hot rocks).

The conceptual design of the renewable-based energy mix for a sustainable community starts from two sets of input data: (1) the energy demand of the community (quantitatively and qualitatively defined, both for thermal and electrical energy) and (2) the renewable energy potential of the community site.

In the embodiment design the renewable-based energy mix, following intermediate steps must be followed: a) identify the areas available for the implementation of the renewable energy systems, on the buildings' rooftop, facades, or on the ground: near the building or on the community's sites, b) evaluate the maximum capacity of the RES which can be implemented on the available areas, c) evaluate the yearly energy yield corresponding to the available installing area and renewable energy systems' maximum capacity d) evaluate the optimal renewable-based energy mix.

a) **When evaluating the available space for RES implementation**, firstly areas related to buildings (roofs, facades) should be considered, followed by nearby ground areas. The built environment brings several constraints in the implementation of RES (shadowing, wind shielding etc.) which should be evaluated to avoid under- or over- estimation of the renewable energy potential, with negative consequences on the final energy output and costs. Also the competition between RES and food production (when the ground installation is planned) should be avoided to not negatively affect the community development.

The best candidates in installing RES for *solar energy conversion* are the buildings' roofs and rooftops. Among the roofs, those with an optimal tilt and azimuth, have the maximum output followed by rooftops where there of a structure to install the solar thermal collectors or photovoltaic modules is needed. The tilt angle of a surface represents the angle between the surface and the horizontal plane. The azimuthal angle represents the angle between the south direction and the horizontal projection of the normal to surface.

Ground coupled heat pumps require very large volumes of soil to extract the geothermal energy without affecting the process efficiency at the end of the heating/cooling season by overcooling/overheating the ground. These large volume can be obtained by large surfaces having shallow depths (up to 2 meters) or by small ones with great depths (up to 100 metres). For new buildings, even the ground below the building can be used (only for vertical ground heat exchanger and for combined systems used both for heating and cooling to regenerate the energy into the ground). Also, the use of building's deep foundations reduces the cost of drilling, posing and sealing the boreholes. When nearby buildings ground surfaces are used for geothermal energy extraction, they should not be covered with water-tight materials like asphalt, concrete, etc. that limit water penetration into the ground and hinder the regeneration of the ground temperature after a heating season; the land above can be used for playground, parks, agriculture etc.

For *wind energy*, the built environment could shield or amplify the wind and therefore detailed studies of the building emplacement must be conducted. The best option for installing wind turbines are the rooftops of the high tower, benefiting from higher wind speeds at higher altitudes and lack turbulence caused by other neighbouring buildings.

Biomass systems, if allowed to be installed by the city's authorities, need large storage capacity for biomass and for the resulting ash. Usually, such systems are installed in remote communities' areas to provide district heating and domestic hot water through the public utilities grid. The energy losses and the energy to circulate the fluids on these grids should also be evaluated and subjected to efficiency measures.

b) **The evaluation of the maximum capacity of the RES** which can be implemented on the available areas on/nearby buildings is required in the fourth step when the energy mix is optimised by selecting the different shares of RES and their extreme values of variation.

For solar energy convertors (solar thermal collectors and photovoltaic systems), the maximum capacity (Fig. 1) depends on the available surfaces and on the RES efficiencies. Due to the lower efficiencies of photovoltaic modules (between 10 and 20%) than the efficiencies of solar thermal collectors (between 60 and 80%) the maximum installed capacity for the same available surface is very different: installing 200 m^2 of solar thermal collectors with an efficiency of 70% results a maximum capacity of 140 kW (thermal), much larger than 30 kW (electrical) obtained in the case of 200 m^2 of photovoltaic modules with an efficiency of 15%. The solar energy received on these surfaces, and therefore the RES energy output (thermal or electrical) depends on their orientation and will be evaluated in the next step. Spatial limitations are related to the geometrical shape of the available surface: for not rectangular shapes, the RES installed surface will be smaller than the available surfaces. For example, in Fig. 2a, the trapezoidal shape of the roof cannot accommodate the same area of rectangular photovoltaic modules (PV) or solar thermal collectors (STC). To give use of a larger share of the available surface, new shapes of trapezoidal PV or STC allow a better coverage, also improving the RES aspect and acceptance (Fig. 2b) [13].

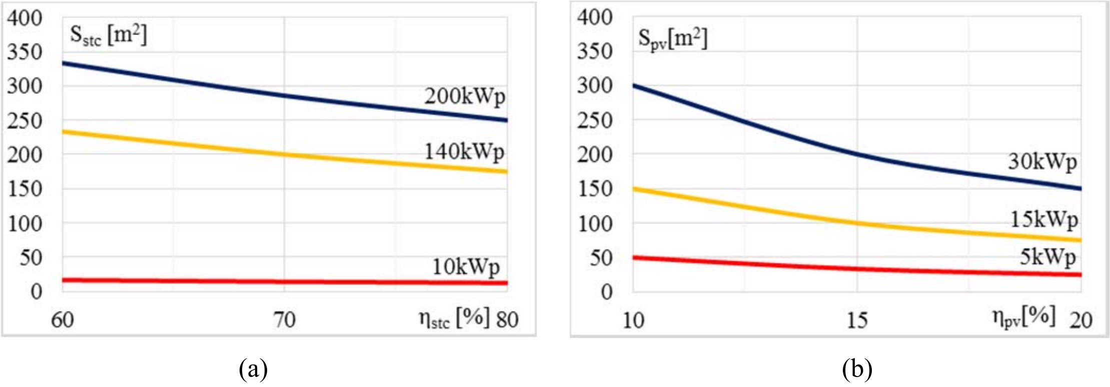


Fig. 1. The maximum nominal power output of: (a) of the Solar Thermal Collectors and (b) of the Photovoltaic Modules as a function of theirs efficiency and installed surfaces.

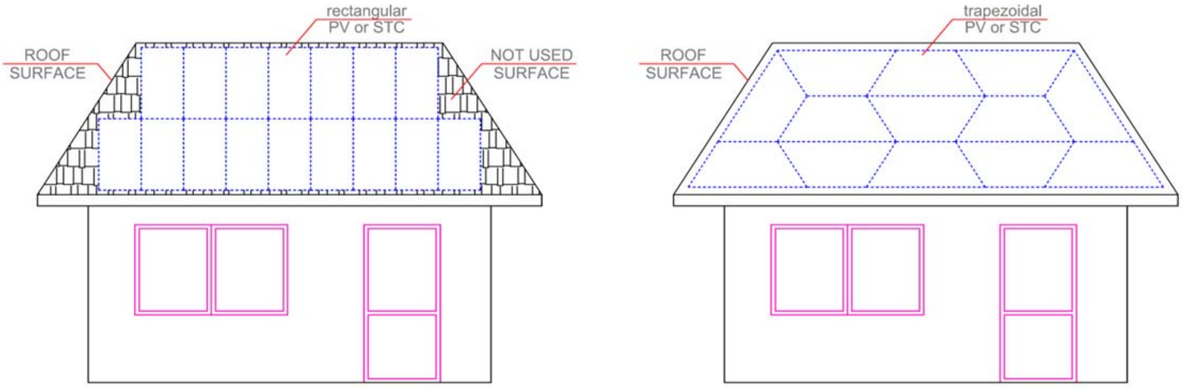


Fig. 2. Trapezoidal roof covered with a) rectangular or b) trapezoidal photovoltaic modules or solar thermal collectors.

Further limitation in the case of horizontal surfaces (rooftops or ground mounted systems) are imposed by the ratio (q) between the available surface lengths on E-W and N-S directions, Fig. 3, and the orientation of the surface relative to cardinal points. The limits of the q ratio are detailed in Fig. 3: in fig. 3a – the worst case, when the length of the available surface on the N-S direction (L_{NS}) is much higher than its length on E-W direction (L_{EW}) resulting the minimum value of the ratio q (q_{min}), and the best case, when the length of the available surface on the E-W direction (L_{EW}) is much higher than its length on N-S direction (L_{NS}) resulting the maximum value of the ratio q (q_{max}).

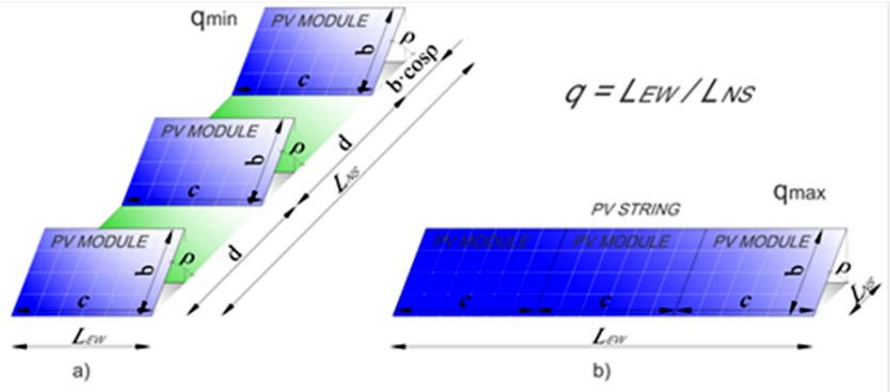
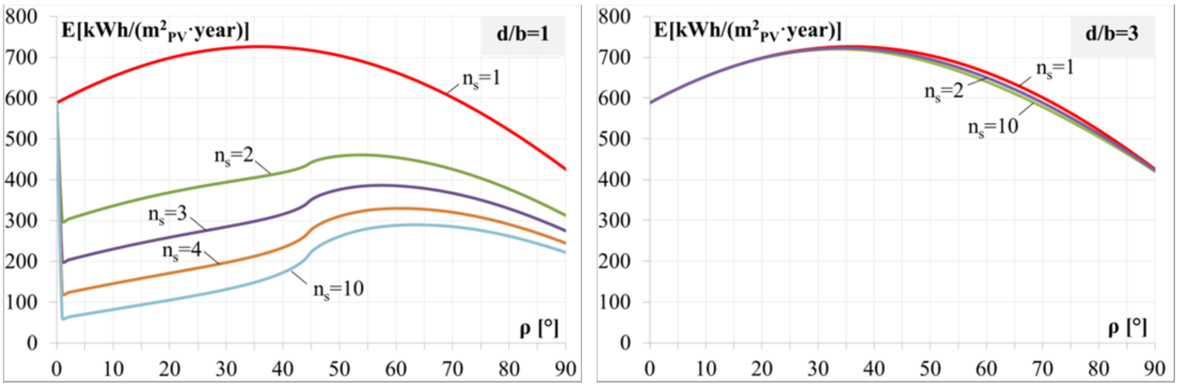


Fig. 3. The extreme situations for the ratio between the length of the available surface on the north-south direction (L_{NS}) and on east-west direction (L_{EW}).



a) b)

Fig. 4. The yearly solar energy yield by a string (E^*) as a function of the strings elevation (ρ^*) for discrete vales of the strings numbers (n_s) and d/b ratio.

The first case (q_{min}) is the worst one due to the distance (d) required between two consecutive modules for avoiding reciprocal shadowing. This distance increases the required surface to install a given capacity of photovoltaic modules or, when the available surface is limited, decrease the capacity of the photovoltaic system that can be installed. In the second case (q_{max}) the available surface is used at its maximum potential.

The influence of the distance (d) between two consecutive strings of photovoltaic modules or solar thermal collectors is presented on fig. 4, were the yearly solar energy yield by a string (E^*) is plotted as a function of the strings elevation (ρ^*) for discrete values of the strings numbers (n_s) and different ratios between the distance d and the width b of each string. To avoid the reciprocal shading between strings and herefor the decerease of the energy yield as presented in Fig. 4a, the ratio d/b must be increased at values above 3, when each string receives an identical amount of solar energy.

For ground coupled heat pump systems, the spatial limitations refers to the available surface of the ground wherefrom the geothermal energy is tapped. A ground heat exchanger is used for transferring the heat from the ground to the evaporator of the heat pump. The size of the ground heat exchanger mainly depends on its type (horizontal or vertical) and on the type of the soil (expressed through the ground heat extraction rate. The ground heat exchange rate express how much thermal power can be extracted with a square meter of horizontal ground heat exchanger or from a depth of one meter in the case of vertical ground heat exchanger. The maximum thermal output of the heat pump results as a function of the ground heat extraction rate, the surface of the ground heat exchanger and the heat pump coefficient of performance, COP (the ratio between the thermal output of a heat pump and the electrical energy needed to drive it, with usual values between 4 and 6).

The horizontal ground heat exchanger consists of closed loops of pipes buried in the soil, usually at a depth of 1.5 – 2 meters, parallel with the building, at a safety distance of 1 meter from the building or other facilities existing into the ground. Usual values for the ground heat exchange rate (q) for horizontal ground heat exchangers range from 10 W/m^2 (for dry sandy soil) to 35 W/m^2 (for aquifer soils). In Fig. 5a is presented a nomogram, plotted for ground heat extraction rates between 35 W/m^2 and 15 W/m^2 for heat pumps with COP=5. Thus, for an available surface of 1000 m^2, and a wet-clay soil with a heat extraction capacity of 20 W/m^2 results a maximum heating capacity of 25 kW for the heat pump. If the heating load of the building is higher than this capacity of the available surface, vertical ground heat exchanger should be implemented. Also, the nomogram can be used for evaluating the surface of the horizontal ground heat exchanger needed for a given thermal load of the heat pump and a type of soil, thus, if a thermal load of 50 kW is needed, in the same ground conditions (wet-clay) a surface of 2000 m^2 results. The third possibility to use the nomogram is when the output thermal power of the heat pump is known and similar areas are available for the implementation, resulting the recommended ground quality. This evaluation is highly sensitive to the COP value, therefore a feasibility study is compulsory to balance the cost of the heat pump (more expensive for higher COP) with the cost of ground heat exchanger affected mainly by the price/availability of the ground but also by the cost of the pipes and pumping system (low COP increase the surface of the horizontal ground heat exchanger, the length of the pipes and the power and energy demand of the circulation pump).

The vertical ground heat exchanger consists in vertical boreholes containing single U-tubes, double U-tubes or coaxial tubes in which circulates a heat transfer medium (antifreeze mixture). With coaxial borehole heat exchangers, the return pipe runs inside the descending pipe. Double U-tube borehole heat exchangers represent the most common form. Depending on the system design, borehole heat exchangers usually range from 50 to 100 metres in depth. They also are ideal for cooling. In combination with a solar energy system, their efficiency can be increased by feeding surplus solar thermal heat into the ground during the summer months in order to regenerate the ground and later use of this stored energy in winter. Their main advantage is the smaller occupied area, the distance between two boreholes is recommended to be between 4 and 6 meters; for a distance of 5 metres resulting a surface of 25m^2 for each borehole. Other advantages of vertical ground heat exchanger are: the space above the borehole can be used without restrictions and the ground temperature is not affected by seasonal outdoor air temperature variations.

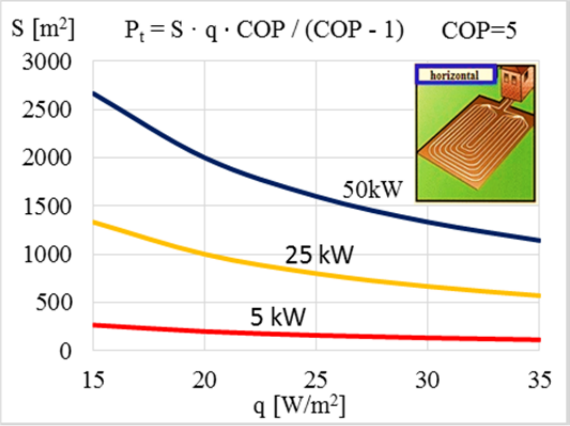


Fig. 5. The evaluation of the maximum thermal power of the heat pump for the available ground surface to install a) horizontal.

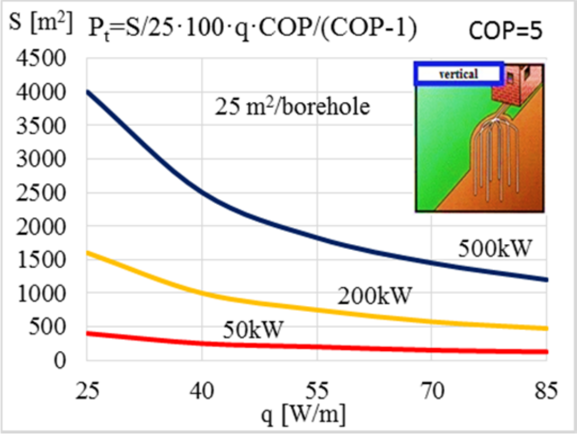


Fig. 5. The evaluation of the maximum thermal power of the heat pump for the available ground surface to install b) vertical ground heat exchangers.

Usual values for the ground heat exchange rate in the case of vertical ground heat exchangers range from 25 W/m (for dry sandy soil) to 100 W/m (for aquifer soils). In Fig. 5b a nomogram is presented, plotted for ground heat extraction rates from 25 W/m^2 to 85 W/m^2 for heat pumps with COP=5. Thus, for an available surface of 1000 m^2, and a wet-clay soil with a heat extraction capacity of 40 W/m results a maximum heating capacity of 200 kW for the heat pump (eight times bigger than for the same surface with an horizontal ground heat exchanger). If the heating load of the building is higher than this capacity of the available surface, the depth of the boreholes can be increased but the cost will increase significantly. Also, the nomogram can be used for evaluating the surface needed for the vertical ground heat exchanger for a given thermal load of the heat pump and a type of soil, thus, if a thermal load of 500 kW is needed, in the same ground conditions (wet-clay) a surface of 2500 m^2 results.

c) **The yearly energy yield** is evaluated based on the available installing area and on the RES maximum capacity. For heat pump systems, the output energy depends on the heat pump capacity and on the number of functioning hours, because the geothermal energy can be considered almost constant during the heating/cooling season. For solar energy converting systems, the energy output is very much influenced by the orientation of the convertor.

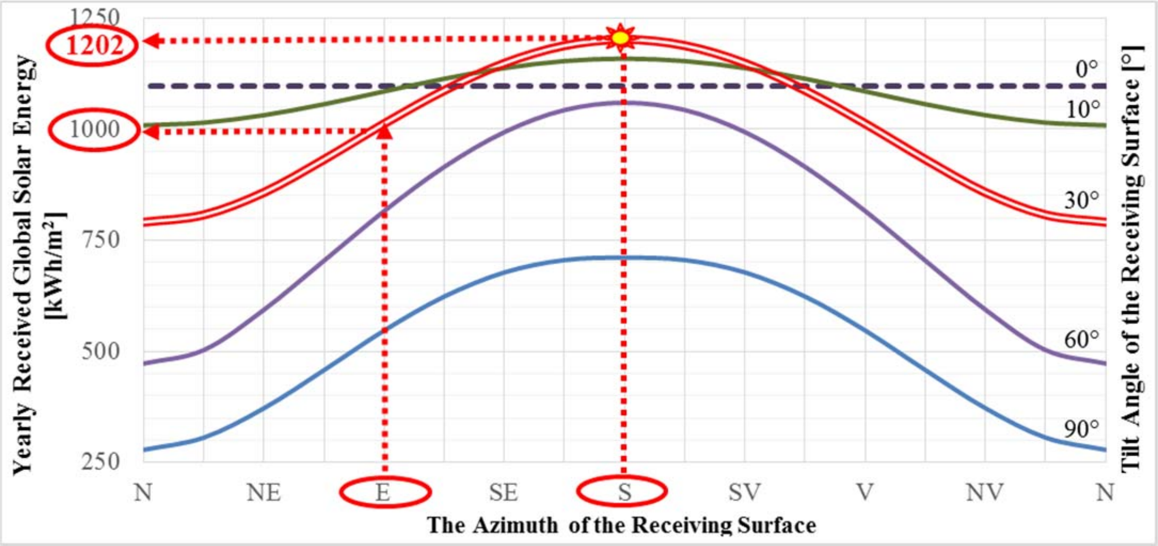


Fig. 6. The yearly received global solar energy as a function of the receiving surface's tilt and azimuth.

In Figure 6 the yearly received global solar energy is plotted as a function of receiving surface's tilt and azimuth for a location situated at the latitude 45,65° in northern hemisphere. Between the evaluated tilt angles, the maximum yield of yearly global solar energy (1202 kWh/m^2) is received by a south oriented surface having a tilt angle of 30°. If a similar tilted surface is East oriented the amount of the yearly global solar energy decreases to 1000 kWh/m^2.

d) The optimal renewable-based energy mix should consider that the best output can be obtained based on the above characteristics used as input data in a previously developed algorithm [9].

3. CASE STUDY

The proposed methodology for the conceptual design of a renewable-based energy mix for a small sustainable community is further exemplified on the R&D Institute of the Transilvania University of Brasov, Romania. This small community is located in the outskirts of Brasov city, the administrative centre of Brasov County. The institute is the result of a structural founds project ("R&D Institute for High-Tech Products), being "in house" designed by university teams of specialists having a significant support from the university and was developed as a sustainable community. The R&D Institute has 11 new, low energy buildings which accommodate 29 research centres (16 with engineering topics and 13 on informatics, humanities, health, music, sports and law); it has its own fresh water source and waste water treatment facilities (Fig. 7). The institute is grid connected only to the power and gas public utilities. All the buildings are identical for cost efficiency reasons, incorporating state of the art materials and systems. Through results dissemination, the R&D Institute aims to promote the sustainable development concepts targeting individual beneficiaries and small communities.

Fig. 7. The R&D Institute of the Transilvania University of Brasov.

The energy demand of the institute consists of the specific need (thermal and electrical energy) of the 11 buildings and by the electrical energy demand of the water pumping and operation of the fresh and waste water treatment facilities. There are some research laboratories which can be assimilated with industry sector due to specific equipment (e. g. welding machines, CNC machines, robots etc.) but they are not operated on an everyday basis. The transport into the institute is pedestrian, the only aspect related to transport is the commuting from city to institute (about 5 km from the city centre) and back.

The energy demand of each building was calculated on a monthly basis [11] resulting 4244 kWh/year for DHW, 78027 kWh/year for heating and 7759 kWh/year for cooling. The yearly energy demand for lighting and other powered appliances (except the specific laboratory equipment) is 13224 kWh/year. Thus, the total energy demand of a building is 103254 kWh/year and therefore about 1135794 kWh/year for all the 11 buildings. The electrical energy need to drive the circulating pumps in DHW, heating and cooling systems is 2322 kWh/year for one building and therefore 25542 kWh/year for all 11 buildings. The electrical energy demand of the water source and of the fresh and waste water treatment facilities is 23126 kWh/year and for the exterior lighting systems is 9344 kWh/year. Thus, the total estimated energy demand of the Institute is: 990330 kWh/year for thermal energy and 219022 kWh/year for electrical energy.

The available surface for RES implementation, on each building is: 450 m^2 on the rooftop, 300 m^2 on the Southern facade and 150 m^2 on the Eastern or Western facades, 450 m^2 at the ground level (between buildings). In the close vicinity of the buildings, at the ground level, 7500 m^2 are available for geothermal heat exchangers and 25000 m^2 for a photovoltaic park.

A part of the energy demand of the R&D Institute is covered by already implemented RES (Fig. 8):

- 10 solar thermal systems for domestic hot water: seven with flat plate solar thermal collectors (fpSTC) 3.5 kW/system, two with evacuated tube solar thermal collectors (etSTC) 3.3 kW/system and one with concentrated trough solar thermal collectors (cptSTC) 6 kW/system;
- 2 geothermal heat pumps (22 kW) for heating and cooling of two buildings: one with a 1000 m^2 horizontal ground heat exchanger (HGHX) and another one with 4 vertical ground heat exchanger (VGHX), each one with a depth of 90 m;
- 7 photovoltaic systems grid connected for electrical energy: a 12 kW photovoltaic array of strings with monoaxial tracking system installed on the rooftop of building L11, a 5 kW photovoltaic systems with monoaxial and biaxial solar tracking systems on the rooftop of the building L7 and five 2 kW photovoltaic platforms with monoaxial and biaxial solar tracking systems on the ground;
- 2 wind turbine systems: one composed by three small (300W) wind turbines installed on the rooftop of the building L5 and the second one composed by three small (600W) wind turbines installed on the rooftop of the building L6.

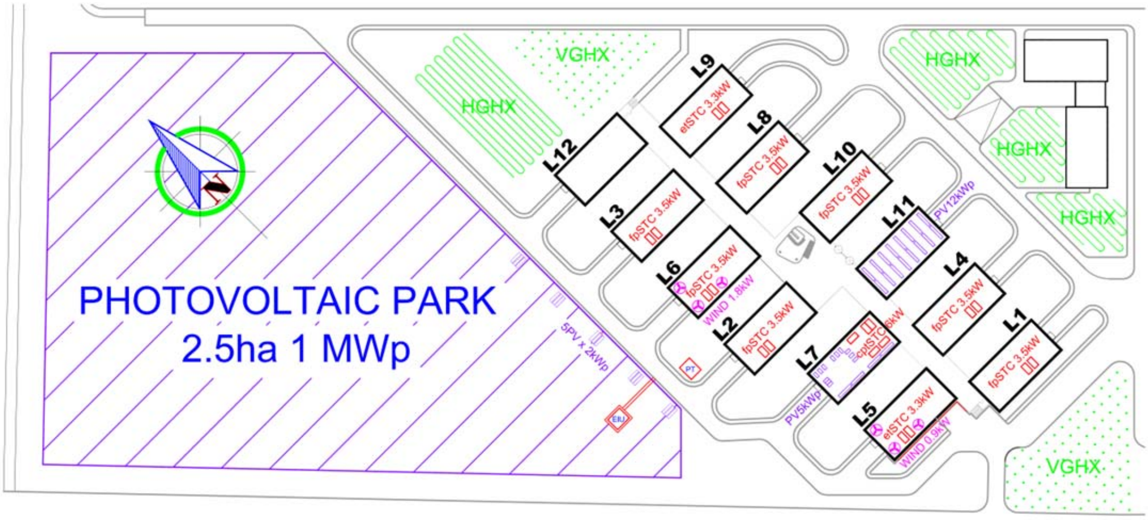


Fig. 8. The implemented RES on the R&D Institute of the Transilvania University of Brasov and available surfaces for further RES development.

4. CONCLUSIONS

The transition towards sustainable communities requires specific solutions that give value to the on-site renewable energy potential and maximise the green energy output.

The paper presents a step-wise methodology that identifies the maximum on-site potential, followed by evaluating the maximum output (considering various renewable energy systems) and this is a pre-requisite in identifying the optimal energy mix for nearly zero energy buildings and, in extension, for sustainable communities.

Correlation nomograms are presented for the mostly used renewable energy systems (solar-thermal, photovoltaic, heat-pumps), that can be further used for predictive scenarios that allow the selection of the most feasible solutions, for a given implantation location.

This methodology was extensively used when the R&D Institute of the Transilvania University of Brasov was designed and developed.

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PROIECTAREA CONCEPTUALĂ A MIXURILOR BAZATE PE ENERGII REGENERABILE PENTRU COMUNITĂȚI DURABILE

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Rezumat: Tranziția către un nou model energetic, durabil și acceptabil socio-economic, este definită prin documentul european SET-Plan (Planul Strategic European pentru Tehnologie și Energie). Deoarece mediul construit este responsabil de consumul a peste 40% din producția de energie, o atenție specială trebuie alocată dezvoltării și implementării de sisteme de conversie a surselor regenerabile de energie, capabile să acopere într-o mare măsură necesarul de energie termică și electrică din clădiri. În acest sens a fost formulat conceptul Nearly Zero Energy Building definit prin Directiva europeana 2010/31 cu intrare în vigoare din 2018. O astfel de clădire este în fapt o clădire cu consum redus de energie (cu eficiență energetică ridicată) în care necesarul energetic este asigurat în mare măsură (peste 50%) din surse regenerabile. Ca urmare, există un efort semnificativ la nivel european pentru identificarea de soluții atât pentru creșterea eficienței energetice a clădirilor cât și pentru implementarea sistemelor de energii regenerabile în mediul construit; pentru cea din urmă țintă, s-a ajuns la un consens de opinii, referitor la necesitatea proiectării de mixuri bazate pe energii regenerabile, capabile să valorifice potențialul locației de implementare. Un pas înainte trebuie făcut prin extinderea analizei la nivelul comunităților pentru tranziția lor către sustenabilitate, deoarece la acest nivel, pe lângă necesarul de energie specific clădirilor, se adaugă și cel de utilități la nivel comunitar care trebuie și de asemenea proiectat respectând conceptele dezvoltării durabile. Lucrarea propune un cadru de proiectare conceptuală care permite realizarea de comunități durabile, printr-o selecție atentă a sistemelor implementate la nivelul clădirilor și a celor implementate la nivel comunitar. Conceptul este conform cu tendințele europene care indică implementarea sistemelor cu capacități instalate mari (fotovoltaice și eoliene) pentru producerea de energie electrică și sisteme localizate pe sau în apropierea clădirilor pentru producerea de energie termică (pompe de căldură, sisteme solar termice și sisteme bazate pe biomasă.)

Cuvinte cheie: comunități durabile, nearly zero energy building, mixuri bazate pe energii regenerabile