URBAN ENERGY COMMUNITY BETWEEN RECOMMENDATION AND PERSPECTIVE

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ABSTRACT

This paper approaches the impact of the new provisions of the new energy market directive on passive consumers and their transformation into active consumers. They can participate in demand response or energy efficiency schemes provided that these activities do not constitute their primary commercial or professional activity. These active consumers benefit from transparent network tariffs, in a non-discriminatory manner and reflecting the costs, separately calculated for the energy inserted into the network and for the energy used from the network. Moreover, these are also the key element of local energy communities. The local energy communities, according to IEM Recast, are entitled to own, establish or lease community networks and to autonomously manage them, benefit from a non-discriminatory treatment regarding their activities, rights and obligations as final customers, generators, distribution system operators or aggregators.

This impact is achieved through a case study analyzing the extent to which it is technically possible and justified from an economic point of view to accomplish at each block level and ultimately for the lodger's association of a local energy community promoted by this directive and energy community's implications on the energy distributor.

INTRODUCTION

The European Union's long-term vision for the energy sector is to "move towards competitive, sustainable and secure energy throughout Europe". In order to reach the Europe 2020 Strategy, the policy actions were based on these three fundamental pillars:

- A single highly competitive internal energy market for both gas and electricity;
- Sustainable development to reduce the greenhouse emissions with 20% by shifting to low-carbon energy in order to maintain EU's global leader position in renewable energy sources and obtain 20% of the total energy from renewable energy sources;
- Security of supply through a 20% increase in energy efficiency in order to reduce EU's dependency on energy imports, energy cut-offs and possible energy crisis.

In order to adapt to the binding policy targets that are to be implemented following 2020, the legal framework will have to be adapted as well. And indeed, this process has already started to happen. The internal energy market [IEM] and renewable energy sources [RES] Directives [1,2] have already been recast at the end of 2016. The energy efficiency Directive [EED] shall be recast in the near future.

Of consumer point view, the liberalization of the electricity market promoted by Directive 2009/72/EC allowed the free choice of electricity supplier (similarly to choosing the supplier in the telecom market), non-discriminatory and transparent access to energy networks for both consumers and energy suppliers, it has clearly legally separated the activities of production, distribution and supply of energy with the aim of creating independent operators.

The liberalization of the energy market and the change of the organizational structure of the electricity system promoted by the IEM Directive have thus led to two evolutions:

•entry of several actors on the energy market due to the liberalization of the energy sector;

•the production of energy from renewable energy sources instead of fossil fuels, as an effort to mitigate climate changes.

These two evolutions combined have facilitated the introduction of decentralized energy production in which consumers are starting to generate energy for their own use and are selling the excess energy to the supplier, transforming themselves from regular final energy consumers to prosumers. In Romanian legislation [3] "producers holding low-efficiency cogeneration units or micro-cogeneration units are entitled to apply simplified procedures for connecting to the electricity grid.

NEW ACTORS IN ENERGY MARKET

Starting from the premise of [4] "all customer groups (industrial, commercial and households) should have access to the energy markets to trade their flexibility and self-generated electricity." the recast IEM Directive introduces new actors on the energy market such as:

- *'local energy community'*[5] means: an association, a cooperative, a partnership, a non-profit organization or other legal entity which is effectively controlled by local shareholders or members, generally value rather than profit-driven, involved in distributed generation and in performing activities of a distribution system operator, supplier or aggregator at local level, including across borders”. It has the right to own, create or lease Community networks and manage them autonomously (Article 16 1 (a)) have access to all organized markets Article 16 1 (b), enjoy non-discriminatory treatment in terms of their activities, rights and obligations as end customers, producers, distribution operators or aggregators;

- *‘active customer’* [5] means a customer or a group of jointly acting customers who consume, store or sell electricity generated on their premises, including through aggregators, or participate in demand response or energy efficiency schemes provided that these activities do not constitute their primary commercial or professional activity” These [6] are subject to cost reflective, transparent and non-discriminatory network charges, accounting separately for the electricity fed into the grid and the electricity consumed from the grid”.

CASE STUDY ON CREATING A LOCAL ENERGY COMMUNITY

In the urban area, with reference to the city of Galati, most of the blocks of flats are GF + 4 and the tenants are organized in owners' associations. These condominiums are currently connected to the DSO's centralized power supply system and tenants have individual contracts with the energy provider. The case study analyzes the extent to which it is technically and economically justifiable to achieve the local energy community promoted by this directive and the implications of the energy community on the energy distributor at the level of each block and finally at the association level. The analysis starts from the available surface of the roof of each block to mount on-grid photovoltaic panels, the renewable energy source available in the urban environment being solar energy. The physical and architectural limitation is given by the methodology of the International Energy Agency Photovoltaic Power Systems Program and can be synthesized with a simple rule of thumb: for every m^2 of building area ground floor, there is on average 0.4 m^2 of rooftop area and 0.15 m^2 of façade area with good solar potential

Technical analysis of the system

The photovoltaic system sizing methodology requires:

- Choosing the type of photovoltaic panel
- Determination of panel configuration on a flat-roofed building with Lsxls = 20x12=240m^2, the number of panels and installed power
- Assessment of average daily energy production
- Chosing the inverter and correlating the voltage of the photovoltaic panels with the inverter input
- Connection diagram, cable selection and voltage drop check

Choosing the type of photovoltaic panel

The chosen photovoltaic panels are polycrystalline, and they are used for economic reasons with the specifications given in [7] and the external characteristic and Pp = 300W at G = 1000W /m^2 are shown in figure 1.

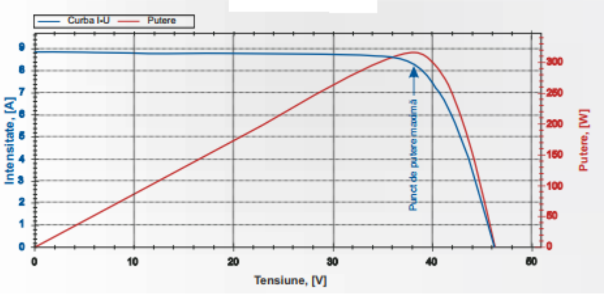

Figure1. PV Characteristics

Determining the distance between the panels

Taking into account the positioning of panels with a 35-degree inclination on the south side and an azimuthal angle of 21 degrees, the distance between the rows of panels, according to figure 2, with the equation:

$$d = l\cos 35^{o} + \frac{l\sin 35^{o}}{tg21^{o}} = 2.3$$

Where l=998mm

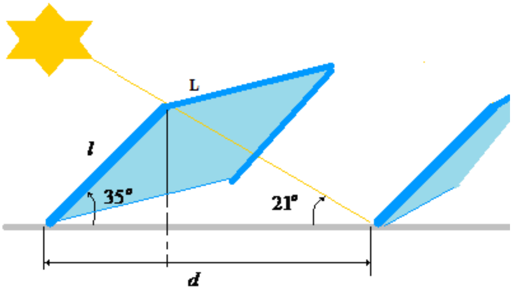

Figure2. PV panels configuration

The number of rows of photovoltaic panels is determined by the equation:

$$n_r \leq \frac{Ls}{d} = \frac{20}{2,3} \approx 8$$

The number of panels per row is determined by the equation:

$$n_{PVr} \leq \frac{ls}{L_p} = \frac{12}{1,98} \approx 6$$

The total number of panels is $n_{PV} = n_r \cdot n_{PVr} = 48$, the total installed power is $P_i = n_{PV} \cdot P_p = 14.4kW$ and the area covered by the panels represents 32.5% of the roof surface.

Assessment of average daily energy production

Average daily production E$_{PV}$[kWh/day] - represents the average output obtained by multiplying the installed PV system's installed capacity by the number of average annual solar hours of the Galati region:

$$E_{PV} = P_i \cdot d_s = 14.4 \cdot 3.98 = 57.3kWh\text{/day}$$

Where d$_s$=3.98 h/day

Inverter selection and correlation of voltages

The selection of the inverter and of its size is carried out according to the PV rated power it has to manage. The size of the inverter can be determined starting from efficiency of inverter with value 0.8 to 0.9 for the ratio between the active power put into the network and the rated power of the PV system resulting P_{inv}=16-18kW. From market[8] was chosenPV Grid-tied Inverter (Three phase) type SolarLake 17000TL.

As regards the voltage at the input of inverter , the extreme operating conditions of the PV generator shall be assessed in order to ensure a safe and productive operation of the inverter.These corelations of the voltage is shown in figure 3.

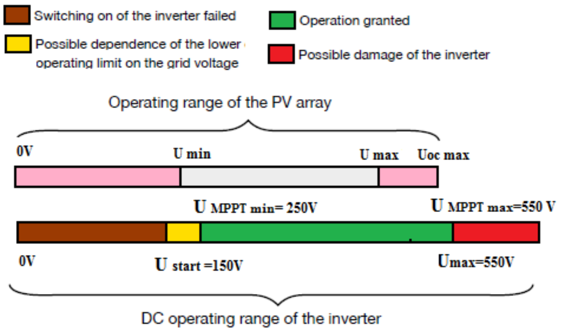

Figure3. PV and inverter voltage correlation

Select the nominal voltage U_{dc} =360 V and determine the number of photovoltaic panels connected in series with the equation:

$$n_{PVs} \geq \frac{U_{dc}}{U_{oc}} = \frac{360}{45,57} = 8$$

Check the variation of idle voltage in the intermediate circuit with the equations:

$$U_{ocT} = n_{PVs}(U_{oc} - \beta(T-25)) > U_{MPPTmin}$$

$$U_{ocT} = n_{PVs}(U_{oc} - \beta(T-25)) < U_{max}$$

The values obtained must be within the variation of the input voltage of the inverter.

Verification of voltage variation in the intermediate circuit at extreme temperatures of +70 ° C and -10 ° C, is done with the equation:

Minimum voltage

U_{ocT}=8(45.57-0.3166(70-25))=250,6V >150V

Maximum voltage

U_{ocT}=8(45.57-0.3166(-10-25))=453.2V<550V

The connection diagram

The connection diagram to the DSO network is shown in the figure 3. The local energy community may conclude an agreement with a distribution system operator to which their network is connected on the operation of the local energy community's network.

In the connection scheme, a three-phase central inverter for the entire PV network was preferred. This type of PV network configuration (Figure 4) is used in small installations and modules of the same type with the same sun exposure. The inverter regulates the operation of the PV network at the maximum power point (MPPT), considering the average parameters of the rows connected to the inverter.

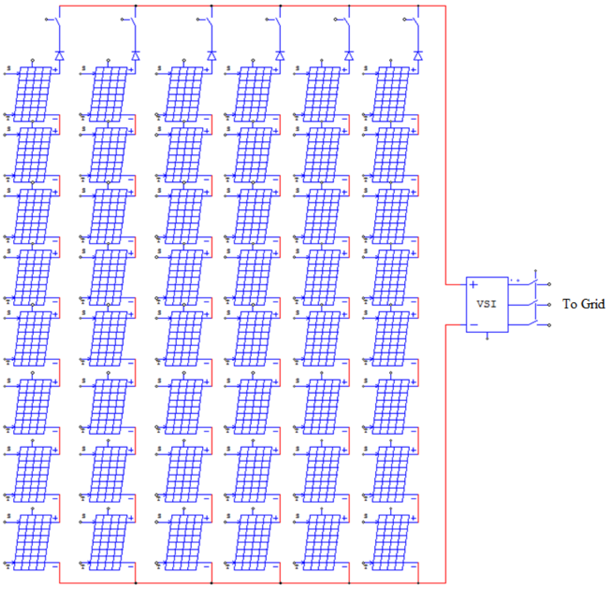

Figure4. PV system

Choosing cables

The modules are connected in series by the cables provided by the panel manufacturer with the 2,5mm^2 section and the open air carrying capacity I_o=55A. The current capacity of the I_o cables is usually declared by the manufacturers at θ_o =30°C in open air. To take account of the temperature conditions (temperature is proportional to the square of the current), the current load capacity I_o must be reduced by a correction factor (when not stated by the manufacturer) given by the equation

$$k_1 = \sqrt{\frac{\theta_{max} - \theta}{\theta_{max} - \theta_o}} = \sqrt{\frac{90-70}{90-30}} = \sqrt{\frac{1}{3}} = 0,58$$

Calculated at ambient temperature of 70 ° C and assuming a maximum working temperature for insulating material equal to 90 ° C.

- Checking the load capacity of cables on a row of panels must satisfy $I_z = 0,91 \cdot 0,58 \cdot I_o \geq 1,25 \cdot I_{sc}$ where a 25% overload is allowed. Based on nominal panel data [7], results 29A> 11.15A
- Verification of the load capacity of the cable connecting the rows of panels should be $I_{zr} = 0,91 \cdot 0,58 \cdot I_o \geq n_{PVr} 1,25 \cdot I_{sc}$
- Verification of voltage drop. In DC, the cables are purely resistive, and the percentage drop is the percentage loss of power given by the equations:

$$\Delta U[\%] = \frac{\Delta U}{U_n} = \frac{\Delta U \cdot I_n}{U_n \cdot I_n} = \frac{\Delta P}{P_n} = \Delta P[\%] < 2\%$$

Economic analysis of the system

The system allows the economic analysis on the basis of the list of devices and their price including installation, to determine the costs, the depreciation period on the basis of the average annual consumption of the 19 apartments in the building, the benefits and implications of the micro-network on DSO.

The following table shows the equipment and prices [9]

	Components	Cost range	Total
1	Photovoltaic panels=48, 14,4kW	€0,65-0,68/W	9360-9792 €
2	Switch= 6 +1	€ 37-43/unit	222-258 €
3	Inverter=1	€6200-6690/unit	6200-6690 €
4	Cable =100 m	€355	355 €
5	Labor costs	€3500	3500 €
	Total		19637-20600€

The average monthly electric energy consumption of each family according to the contracts with the energy provider is 150kWh/month. Under these circumstances there results an annual consumption of 34200kWh/year, respectively an average daily consumption of 93,7kWh/day. Comparing the average daily production of 57,3kWh with the average daily consumption there results that the PV system covers 61,15% of the necessity in the self-consumption mode of the users. This percentage is the basis of the economic calculation for determining the duration of the investment's recovery, without taking into account the evolution of the energy price (fully liberalized prices starting with 1 January 2018). Nowadays the price per kWh is 0,15€. The calculation of the annual saving is as follows: 57,3kWh/day x 365days x 0,15€/kWh=3137€. Dividing the cost of the investment to the annual amount, their results a duration between 6,25...6,56 years to recover the investment. Life expectancy of a photovoltaic plant is about 15 years. This result has a profit within the lifetime of the installation between 27417...26394€.

Of DSO points view the distribution networks have been designed to be passive. If renewable energy increased in the distribution network can appear the reverse power flow which can cause unfavorable effects for grid operation. To combat this effect is necessary to change the distribution network, from “passive” and dependent on human operator’s intervention to an “active” one. Active distribution networks must provide a balancing and management role in the electric power supply chain by:

- facilitating the constant exchange of data on production and consumption among network connections.
- facilitating prosumers willing to sell any excess energy to the electricity market;
- improving energy efficiency through a shift in consumption (when production is high) – introduction of energy storage and use of intelligent equipment;

Taking advantage of new technologies, DSO should enable all consumers to raise their awareness of their energy consumption and to fully participate in the energy

CONCLUSIONS

In the urban energy community, PV electricity comes from a large number of small power generators distributed in the area. Therefore, the assessment of the PV potential requires a detailed analysis of the available buildings and surfaces for the installation of photovoltaic modules.

To calculate the solar potential, PVGIS can be used, which calculates the annual and monthly values of the photovoltaic potential for a selected site, with the parameters of the roof of the building being evaluated. Parameters include geographic location, roof inclination and orientation.

The technical calculation of the PV system mounted on a flat roof is 240 m^2, indicating that a PV system connected to the grid with an installed power of 14.4kW and an average daily output of 57.3kWh can be installed. At a daily average consumption of 93.7 kWh / day, the photovoltaic system covers 61.15% of current consumption in the self-consumption of residents.

From an economic point of view, the percentage of saved energy and the cost of kWh leads to a duration between 6.26-6.56 years of investment recovery.

REFERENCES

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