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ROMANIA IN THIS ENERGY TRANSITION, OR THE EMANCIPATION OF SMALL INDEPENDENT POWER PRODUCERS AND THE GAIN FROM AUTARKY/ENERGY INDEPENDENCE

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Abstract: This past several years Romania made great progress with respect to power production from renewable sources. Being offered access to the daily electricity market was the main incentive for many power producers. In parallel with the increase of power generation capacity, the distribution and quality of the electricity offered to consumers deteriorated. Most small and medium size consumers, households and industrial alike, must face now all sorts of power quality issues, from use of a relatively old infrastructure. One perfectly fit solution for improving the quality of the power used by consumers is the deployment and further development of micro grids while increasing capacity for power production locally. This development will be aligned to the power needs of the local consumers, for certain. This paper will show a practical example, a solution adapted for households, with advantages and disadvantages, while making use of available materials and technologies.
Keywords: power production, renewable sources, micro grids, households

INTRODUCTION

By joining the EU, in January 2007, Romania committed to embrace the continental legislation and to follow Europe's development plans. Thus, all European directives shall be adapted to the national policies of each Member State. Changing the energy and environmental policies at European level to fight climate change, was to be felt in Romania as well. But, unfortunately, with some delay. The simple accession to the European bloc pushes Romania, among other things, towards predictability in terms of its energy policies.

Last decade brought throughout the European Union, and not only, a much higher integration of renewables in the total electricity generation capacities. As consequence, the rate of new conventional installations, that release greenhouse gasses, started to drop. Leading causes for this phenomenon revolve around costs. Meaning, raising costs for procurement of raw materials, like coal, diesel, and natural gas, and lowering the acquisition costs for alternative technologies that by now reached market maturity. If in 2009, considering the total new installed generation capacity of 26.363 GWh in EU, 62% [1] was using renewable sources, in 2010 the percentage was of renewables was lower, 41% [2]. However, in 2020, the total installed capacity was 55.363 GWh [2].

The following years occasional variations occurred. In 2011 the total newly installed capacity dropped to 44.939 GWh from 55.363 GWh, still the input of renewables grew to 33.043 GWh. Or 71,3% of that total [3]. 2012 came with reductions as well, in renewables. The percentage of renewables contracted 4%, or 31,3 GWh, while the total amount of new installations was kept the same, 44.9GWh (4). In 2013 reductions were recorded for both, total installations and renewables, 35GWh and 25GWh respectively (5). The silver lining that year came from the percentage of renewables, in the total, 72% (5). The year 2014 turned out being similar to 2013, leading to only a total of 26.9 GWh of new capacity installed but with almost 80% using renewable sources (6). 21.3 GWh out of the 26.9 GWh representing a record, percentage wise, for the volume of installations using renewables in all these years (6).

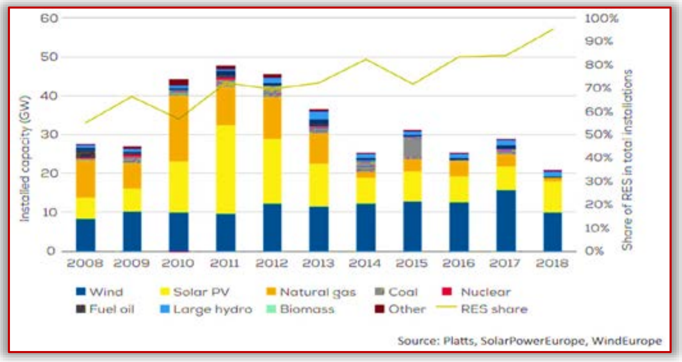


Figure 1. Annual installed capacity and renewable share in EU-28 (17)

Following 5 years of continuous net reduction, for total or renewable installations, 2015 shows first signs of recovery. 29 GWh of total capacity installed with 22.3 GWh, or 77%, using renewable sources (7). The momentum of that recovery from 2015 was kept in 2016 by a first record-breaking percentage of installations using renewables, 86%, from the 24 GWh of total installations (8). Renewable energy accounted for 85% of all new EU power installations in 2017: 23.9 GW of a total 28.3 GW (16) of new power capacity and an all-time record 95% of all new EU power installations was achieved in 2018. 2018 brought 19.8 GW out of a total 20.7 GW of new power capacity from installations using renewable sources (17).

The following graph shows the yearly evolution of electricity production from renewable sources and their share in total installations (9).

SPREAD OF PV AND WIND INSTALLATIONS

Among all alternative installations for electricity generation, the solar and photovoltaic installations grew the most these past decade. The wind installations (turbines) became accessible, financially, and popular, among people, in the same time.

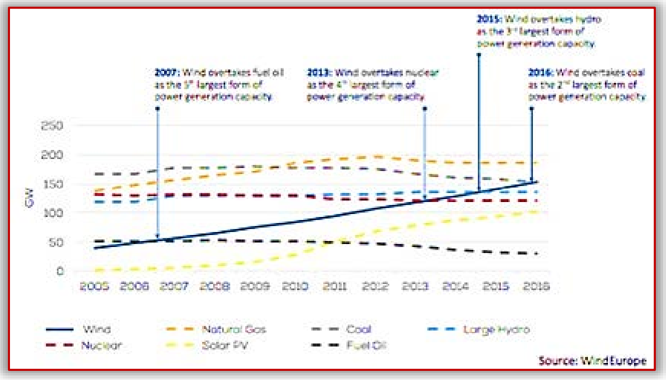


Figure 2. Evolution of wind as form of power generation capacity in Europe (8)

— **Wind power installations**

Analyzing more than a decade of available reports, the evolution of wind as form of power generation in Europe saw incredible growth. To 3-fold between 2005 and 2015 (8) and reaching 205 GW in 2019 (18). In context, the installed capacity grew constantly from 814MW/year in 1995 to almost 10GW/year in 2011, at a growth rate of 15,6% year-on-year. After this period, wind saw periods with reduced rates of grow. Of all the years to follow, 2012 was highly significant for Europeans, and Romanians in particular, because of two particular situations. First, the wind installations in Europe that year accounted for 26,6% of total new power generation installations. Second, 2012 saw the launch of the 600MW Fântânele - Cogealac Wind Park in Romania. For half a decade, this particular wind park remained the biggest in Europe. From 2013 to 2016 wind installations accounted for about 45% of all new power generation installations (5, 6, 7, 8). With renewables reaching that all-time high, then, 86% of all power generation installations in 2016, wind power installations represented 50% of those installations. Around Europe, almost 300 TWh of electricity has been harvested from wind that year. Also remarkable in 2016 was the initiation of the next big wind project in Europe, a wind park built by the Statkraft and TroenderEnergi consortium. 278 wind turbines of 3.6 MW each, at 6 different sites, in Norway. Together, these 6 sites will total 1 GW of new wind power installations (9). In 2017 wind power installations accounted more than any other form of power generation in Europe to reach an astonishing 55% of total power capacity installations (16). Sadly, some of that momentum was lost in 2018 when wind power installations accounted for only 49% of all new power generation installations (17).

— **PV installations**

Identical to the wind power installations, the photovoltaic (PV) installations saw a spectacular evolution these past 15 years. After finally breaking the 3 GW ceiling of electricity produced with PV installations in 2006, 10 years later Europe was accounting more than 100 GW of installed PV capacity. At the end of this same 10-year period, Europe was closely followed by the Asia-Pacific region with 96 GW of installed PV capacity (10). Still, if wind power installations evolved in a progressive manner, we can't say the same about our PV installations. Between 2006 and 2011, there was an explosive expansion of PV installations, supported by governmental subsidies. While the period 2011 to 2014, the expansion, saw a massive contraction. It is only in 2015 when the first signs of recovery emerge, with respect to sustained growth in PV installations. What caused this recovery is a normalization on prices in the PV panel market. The technological advancements, and the PV panel market reaching maturity, incentivize people, and organizations, to invest in new PV installations.

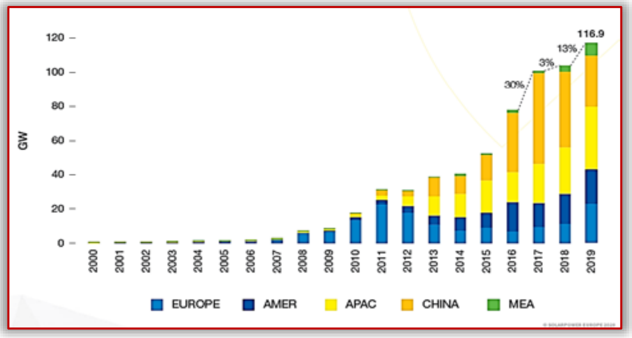


Figure 3. Annual solar PV installed capacity 2000-2019 (19)

WHOLESALE ELECTRICITY MARKETS AND DEVELOPMENT OF ELECTRICITY SMART GRIDS

Up until 2016, short-term trading of electricity and power purchasing agreements, and other similar long- term trades, were exclusively at the disposal of large electricity producers. Independent of the commodity sold, power or energy, lacking access to the electricity market disincentivized investments smaller in size. For small and medium size electricity producers, produce for your own use was their only option. Even today, in some places, this situation still applies unfortunately.

The growing numbers of medium and small electricity producers, household and industrial alike, and the influence they start to have over politicians, pushed several EU countries to open their national electricity markets to smaller producers than before. This way, many small and medium size electricity producers manage to sell all, or the surplus, of their electricity.

Depending on its intended use, for small and medium size electricity producers, 4 types of business models have been identified thus far. Most common, as mentioned above, is to produce electricity solely for personal use. Typical of this business model is the fact that the both, the owner/operator of the power station and the consumer of electricity, are one and the same. Financing this type of business model and the maintenance on the investment, as well as the assuming the risks and operational costs, all to be provided by a person/organization. On top of the above-mentioned difficulties, for the most spread type of business model, should be added the absence of a legal framework to sell the surplus of electricity to the grid. And in those places where the legal framework is in place, the existence of feed-in costs, and tariffs, causes complications too. Therefore, to maximize the gains from such business model, these investors/ consumers should use/store all the electricity produced.

The following type of investment is about selling the electricity, partially or entirely, to customers. Said customers can be end users or distributors/middlemen alike, all interested in securing a steady supply of electricity at a fair price for longer periods of time. Typical of this business model are the existence of an electricity producer, the plant operator, one or more distributors, and the end consumer(s). Financing this type of business model could come from external sources (investors and credit lines). This business model, where the legal framework allows it, would make the regional electricity distribution companies direct customers to small producers of electricity through feed-in tariffs. Something not yet possible in Romania, sadly. The only part of this business model available to Romanians brings independent producers and consumers together with grid operators and distribution companies.

The 3rd business model is in fact a cooperative. It is an association between people and organizations to meet their common economic, social, and cultural needs and aspirations through a jointly-owned enterprise. In case of generation, distribution, and use of electrical power, each participant in this co-op will benefit from this power in its own way. Typical of this business is, same as with the first business model, to generate power for own consumption. What is different here are the number of participants and the fact that such projects could be financed through crowdsourcing, and direct participation, or an eventual external investor. Around Europe, this model is not that popular simply because of current legal restraints and the absence of specific norms and regulations.

The ultimate business model in Europe is all about virtual power plants. This way, a number of installations, using various technologies, unite to form a single, bigger, entity. Typical for this business model is the diversity. From the means of production up to the consumers it serves, and into the means to finance the installations and operations, almost everything is different.

CASE STUDIES TO IDENTIFY A BEST FIT FOR ROMANIA

Based on previous work [20] from all four business models from chapter 2, only two seem to be adapted/ applicable for Romania. The production to satisfy one's needs and for selling to others. But said previous work [20] is aimed at industrial applications instead of households. This chapter we'll research the ideal business case for a newly built farmhouse, the own consumption business model.

Built using materials and technologies required by the passive house standard [21, 22], this case study is located in the country side, near Deva, Hunedoara County, Romania. The farm house has perfect sun exposure during the day and being positioned in a valley has almost guaranteed wind movement.

The 50 cm thick walls, 40 cm Ytong A+ bricks and 10 cm Multipor thermal insulation, the farmhouse was designed to withstand the harshest weather condition with minimum energy losses with U = 0,23 [W/ m2*K]. Several large windows and a thatch roof provide access to solar heat and an additional lair of insulation when needed.

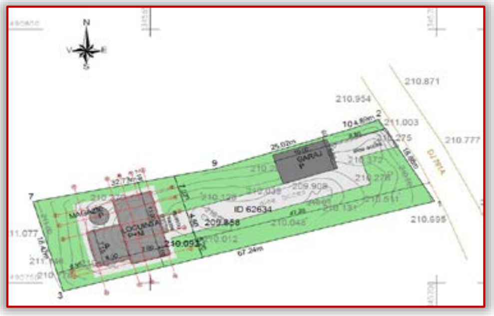


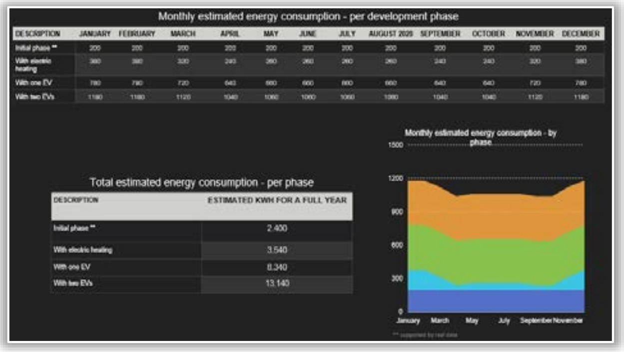
Figure 4. Site plan and solar exposure

All energy needs, are satisfied with electrical energy, including for heating and transportation. The largest consumers are listed in the table below:

Table 1. Typical power consumers

Consumer	Power	Operation regime	Time on line
Electric vehicle (EV)	30 kW	3 x per week	8 - 10 hours per charge
Electric heating	50W/m2	daily	2 hours on average
Water heating	2 kW	daily	2 hours on average
Cooking appliances	3 x 2 kW	daily	1 hour on average

Based on the living habits of the peak power demand should only rarely reach 5kW and the total daily energy consumption is calculated to reach 26 kWh during winter time and with one EV, or 40kWh with two EVs.



Monthly estimated energy consumption - per development phase

DESCRIPTION	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST 2020	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER
Initial phase **	200	200	200	200	200	200	200	200	200	200	200	200
With electric heating	380	380	320	240	260	260	260	260	240	240	320	380
With one EV	780	780	720	640	660	660	660	660	640	640	720	780
With two EVs	1180	1180	1120	1040	1060	1060	1060	1060	1040	1040	1120	1180

Total estimated energy consumption - per phase

DESCRIPTION	ESTIMATED KWH FOR A FULL YEAR
Initial phase **	2.400
With electric heating	3.540
With one EV	8.340
With two EVs	13.140

Figure 5. Calculated energy consumption

To encourage development of new capacity using renewables, the Romanian government issued the law 220/2008. This law guarantees direct access to the grid for all installations lower than 100 kW without special approvals. This law is expected to change and raise the level to 500kW, in a push to allow more development in this field.

By using electric heating, peak power demand is expected during winter and with occasional incidents during spring and fall. And the main power source is expected to come from a series of solar panels installed over the carport, as exemplified below (©https://cedel.nl/en/project/solar-panels-carport-parkingware/). A total of 24 to 36, 350 Wp, PV panels should provide most of the power needed.

Concerning the solar irradiance, the carport has free, direct, exposure towards South allowing for a maximum estimated electricity production of 1460 kWh/m^2/year (15).

Figure 6. Approximative representation of the situation at site (© https://cedel.nl/en/project/solar-panels-carport-parkingware/)

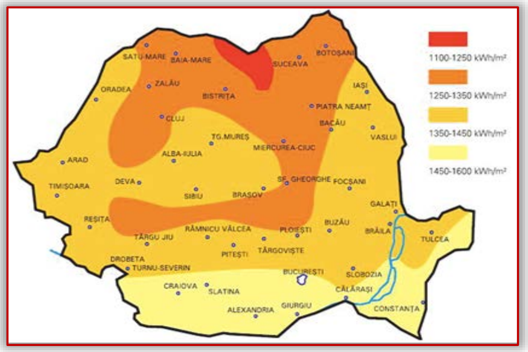


Figure 7. Solar irradiance map of Romania (15)

During cloudy or short winter days, additional electricity is provided by a wind turbine, a Skystream 3.7 wind generator. The Skystream is capable to provide 2,1 kW at 11 m/s wind speed.

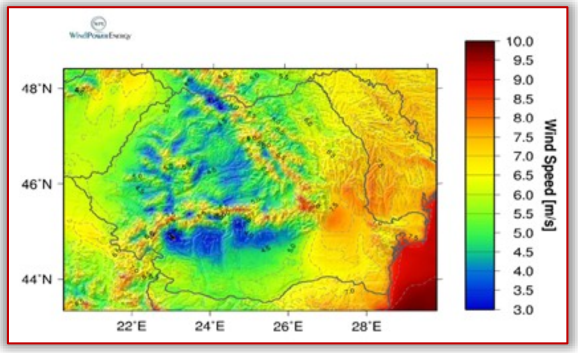


Figure 8. The average wind speed across Romania (12)

Considering that recorded wind speeds in the area are way lower compared to, say, the south-east part of Romania, a turbine with variable rotor speed has been selected.

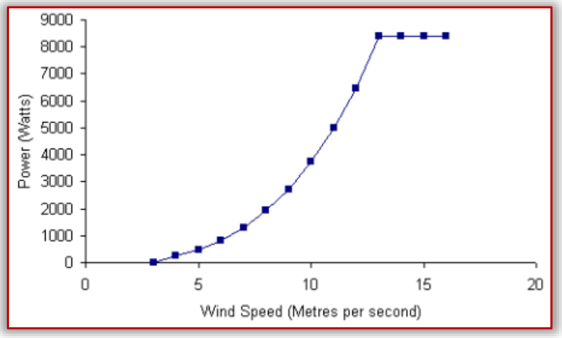


Figure 9. Wind-power characteristic for the Skystream 3.7 wind turbine (© https://www.renugen.co.uk/southwest-windpower-skystream-3-7-2-1kw-wind-turbine/)

Added to the wind and solar solutions, an energy storage installation has been considered. A set of batteries capable of storing 15 kWh of electricity. Because of the massive developments in the field of EVs and Lithium Ion batteries, the price and availability of such solutions improved rapidly. By giving a second life to car batteries, companies like Tesla, Eaton-Nissan, or Alfen, bring highly attractive products to market. Attractive by price and specifications alike.

CONCLUSIONS AND FUTURE PERSPECTIVES FOR ROMANIA

The current requirements in law 220/2008 offers a number of permits ad freedoms to small and medium size electricity providers. In opposite side, limiting the capacity to 100 kW could demotivate investors in similar projects. Any exposure to the public grid brings exposure to several risks and shortcomings, financial and operational alike. By changing the above-mentioned law, and raise the threshold to 500 kW, would offer organizations the chance to stay relevant in this energy transition and to prepare for the horizon 2020. Renouncing the use of fossil fuels, for living and transportation, and implementing national and continental wide policies to encourage the transition towards batteries and hydrogen would still create new problems. And the solutions to said problems might be found in micro grids and their deployment on a larger scale.

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