ABOUT LARGE INTEGRATION OF SMALL RESIDENTIAL PHOTOVOLTAIC ENERGY CELLS INTO SEN

OCTAVIAN C., SILVIU D.
Technical University of Cluj Napoca
oct.capa@gmail.com

***Abstract*— The increase in domestic electricity consumption have forced the power industry to examine its health. The context is: The climate change exigencies and his threat to the survival of humanity is real; the fossil resources are mostly, politically controlled; In return, the rise of renewable technologies and its the democratic geographical distribution feature is a huge advantage: sun shines everywhere for everyone! Conclusion: mankind is at the turning point of its energy future. And the future power systems sould be a tissue of intelligent energy cells.**

In Romania (3GW wind and 1,3GW solar - large plant) it is a fear about more renewables, special wind. One root of this fear could be the gap between Romanian authorities: one authority establish rules without considered facts and the other authority must oparate in a hostile „enviromnent". To get an independently opinion about these facts we'll look on SEN. More, we had to compare the German toward Romanian legislation in the matter of renewables. Further we compare the actual SEN with a future one that is the actual national energy system with an added 1,7GW photovoltaic. Here, this new added photovoltaic are like the other 1,3GW active now în SEN. Another step further, we will model this hipothetical SEN with new 1,7Gw, but not large but small residential photovoltaic cell with storages. From here two conclusions comes out!

Keywords*— *power system, photovoltaic, future, intelligent

I. Introduction – A look to the future

As result of an holistic vision on the energy power systems, few years ago were introduced the concepts of Intelligent Energy Cell, IEC and Intelligent Energy System, IES as tissue of IEC [1]. Intelligent here mean that every important component should have its own DNA, that coordinates its own activity. These notions, IEC and IES cover all the new repeated attempts to get closer to the future in power systems: *enernet, smart grid, microgrid* or *distributed energy resources*, DER [2].

The are facts that will change, step by step, the energy systems, all over the world: i)The real need to reduce carbon emission, ii)The political controlled fossils resources and iii)The real danger of a war as many nuclear states are ruled by impredictible leaders and some of their nuclear rockets are directed to the large power generation groups.

These real threats are counterbalanced by: i)The advanced of computers, comunications and artficial intelligence will shape every component of the energy system and the system as a whole; ii)All components would be more intelligent, would produced, consumed or stored when is right; iii)Advance in photovoltaic technology, as harvesting of the infrared light (perovkit technology), Energy collected by photovoltaic panels, will increase segnificantly;[3] iv)The renewable energy is going lower as fossils energy v)Solar energy is a democratic energy: sun shines for everyone, everywhere.

In conclusion, the evolution in power systems is graphically suggested in figure1. The near future in power systems will be distributed, based on solar resources, in small cells with storage facilities and tied to the public grid. Further, the photovoltaic roof made with the future photovoltaic tiles would be common as today ceramic tiles.

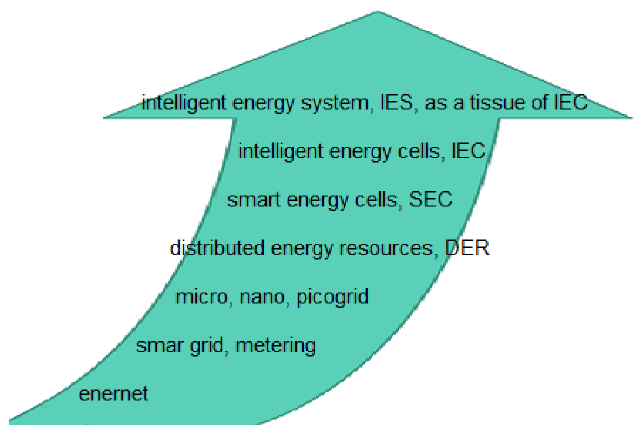


Figure1. A possible evolution of the power systems

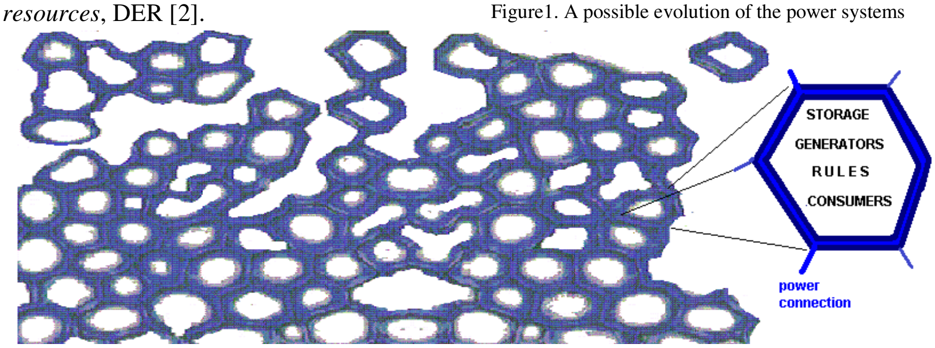


Fig.2. Intelligent energy system as a tissue of intelligent energy cells (1)

Anya Kamenetz, an american futurologist, thinks: *The evidence is growing that privately owned, consumer-driven, small-scale, geographically distributed renewables could deliver a 100% green-energy future faster and cheaper than big power projects alone. Companies like GE and IBM are talking in terms of up to half of American homes generating their own electricity, renewably, within a decade [4].*

II. DIFFERENT LEGISLATIONS HAD SHAPE DIFFERENT ENERGY SYSTEMS

In Germany, the EEG-2000 law, (Erneubare Energy Gesetz), states that wind energy produced onshore is taken over by the German Energy System as energy systems need it. In Romania renewable energies must be taken over by the SEN (Law 220/2008). In Germany, small photovoltaic plants are favored, small plants in Romania are not recognized, they are out of the law.

EEG 2017 STIMULENT euro centi/kWh	photovoltaics on residential building's roof < 10kW	photovoltaics on residential building's roof < 40kW	photovoltaics on residential building's roof < 100kW	photovoltaics on other building's roof < 100kW
after 1 febr. 2018	12,20	11,87	10,61	8,44

Tabel 1 The form of promoting photovoltaic in Germany with current figures

Hence, in Germany, 85% of the photovoltaic power installed is in small installations, in Romania all the installed power is in large installations. In Germany, all produced photovoltaic energy is the beneficiary of the financial support scheme, in România only some of the energy delivred to the public grid!

Renewable efficiency		Germania	România
$1W_{inst}$ wind	[kWh/mp]	1,773	2,523
$1W_{inst}$ photov.	[kWh/mp]	0,985	1,076
GHI*	[kWh/qm/yr]	1,066	1,301
Installed power in photov. [GW]		44,45	1,3

Tabel 2 About efficiency of wind and photovoltaic sources in Germany and Romania

From these differences in legislation are coming out a different picture of social thinking and at least of renewable in Gernany and Romania (table 2, 3):

- The surcharge tax gathering from German consumer remains in Germany, in Romania this surcharge is getting out of Romania
- Romania with more then 26% solar irradiaţion harvest only 9% more photovoltaic energy as in Germany.
- Romania with 15% wind power installed seems to be at the limit of wind acceptance [5], Germany with more then 27% wind power and 20% photovoltaic power installed has no problem in its energy systems.
- Romania is out of the trends in power systems, Germany is on the track. Romania has no plan for the future, Germany has a plan: till 2050 the photovoltaics should grows at least to 150GW and maximum could be 200GW installed [6].

As finally results, in Germany, energy systems manage without problem 47,56% wind and sun, and intend the add much more! Only for sun Germany plan, cripted in EEG 2017 law, is to increase photovoltaic at least to 150GW and up to 200MW! We have no future plan. Romania has tied itself hands and feet by legislative provisions. More, Romanian authorities seem to understand nothing about the future of electricity [1], [2], [3], [4].

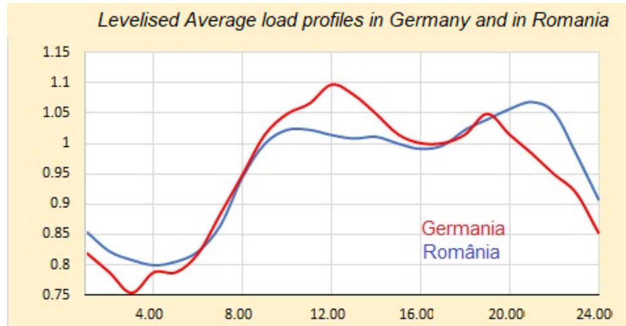
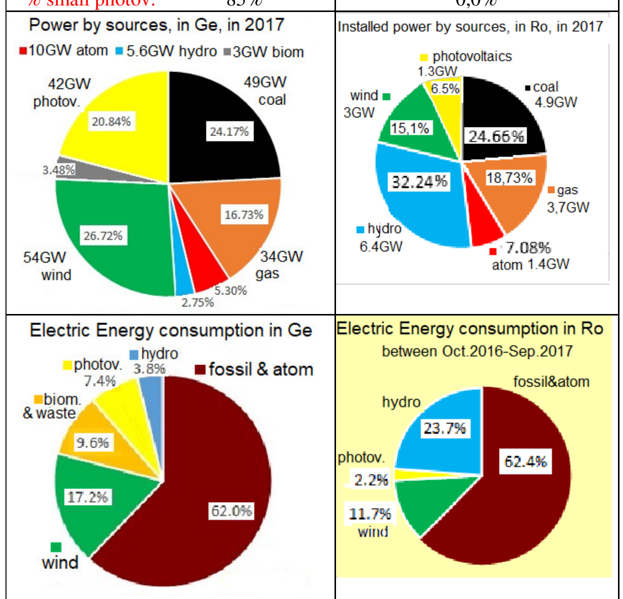
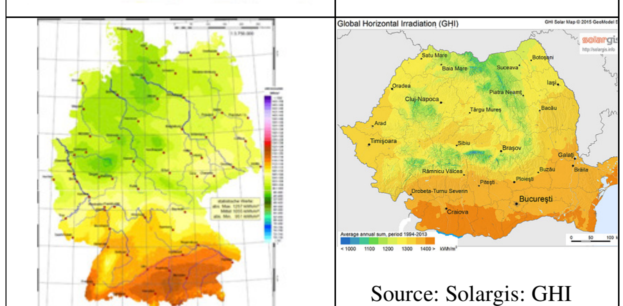


Fig.3. Differences between average hourly consumptions [7]

Germania (ISE Fraunh. '17)		**Romania** (Transelectrica, '17)
Installed Power (GW).	203,67	19,95
photovoltaics (GW)	42,4	1,30
% photovoltaics	20,8%	6,51%
% small photov.	85%	0,0%





DWD: GHI 1066kWh/mp*

Source: Solargis: GHI 1301kWh/mp *

Tabel 3. Beyond proportions, resemblances and differences [7]

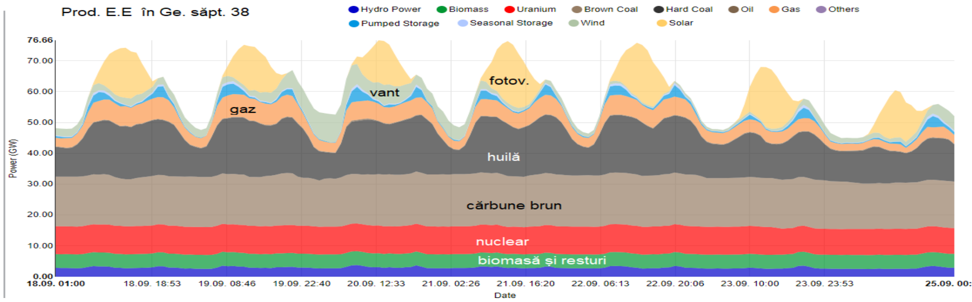


Figure 4. Electricity production in Germany, in week 38, 2017 by sources

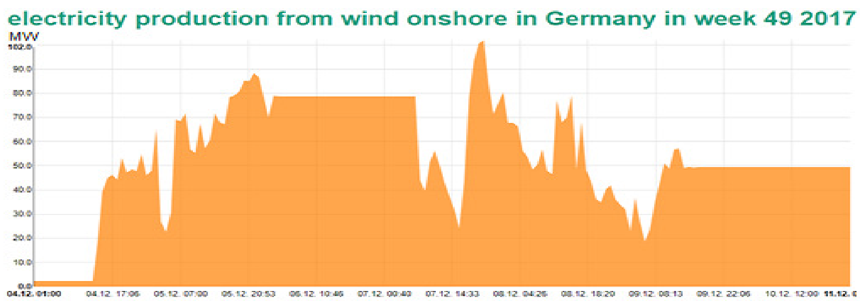


Figure 5. Electricity production in Germany, from onshore wind in week 49, 2017

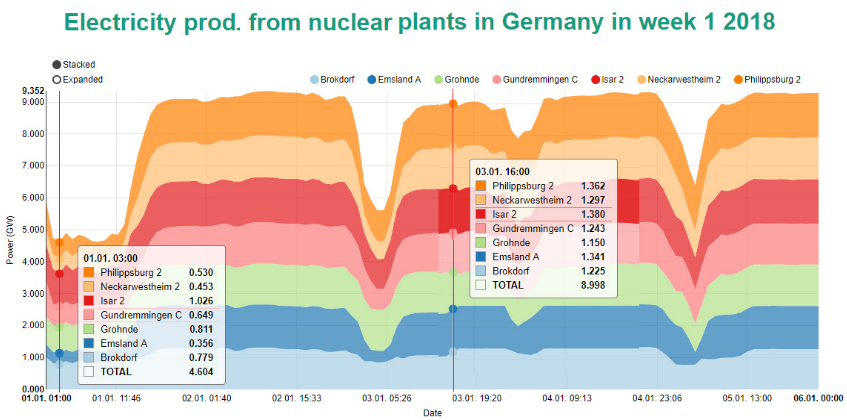


Figure 6. Electricity production in Germany, from nuclear plants in week 1, 2018

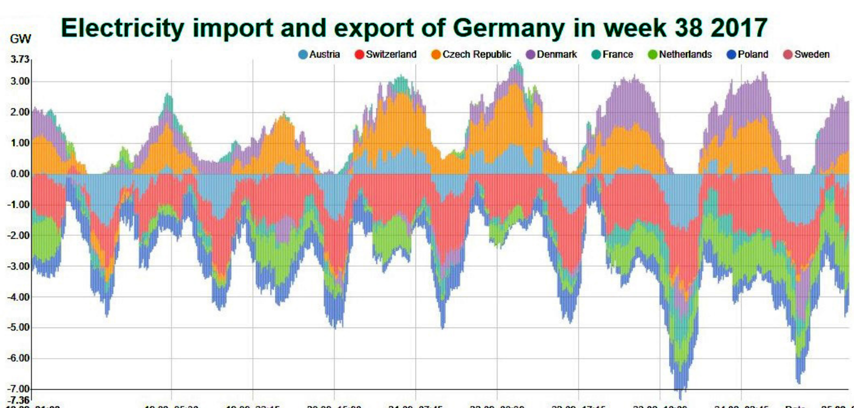


Figure 7. Electricity import/export in Germany, in week 38, 2017

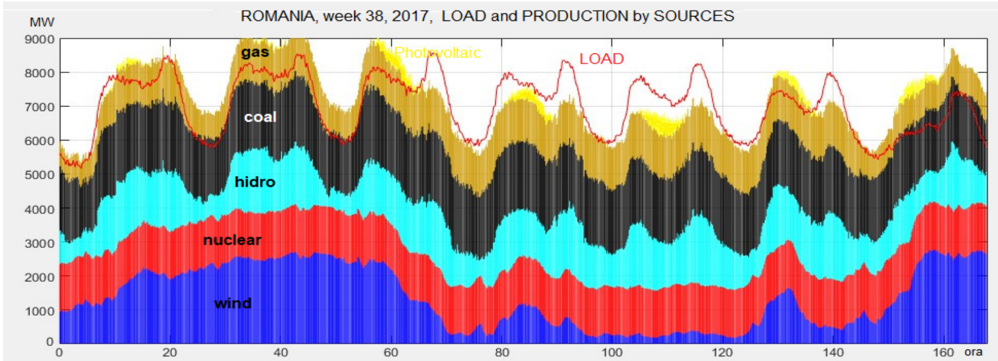


Figure 8. Electricity production in Romania, in week 38, 2017 by sources towards consumption

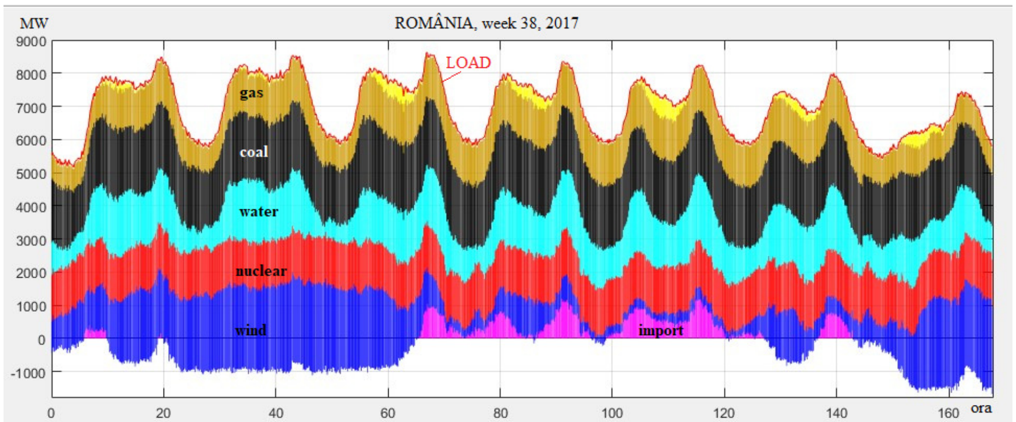


Figure 9. Production&import/export in Romania, in week 38, 2017 by sources towards consumption

In figures 3 to 6 on can see the energy systems of Germany, presented as a whole. From this picture on can see the facts in the power systems of Germany and specially the effect of legislation in the matter. From figures 7 and 8 rises at least one question: we, all Romanian consumer, are paying for all green certificate that are received the eolian farmer owner?

III. HOW MUCH PHOTOVOLTAIC CAN BE INTEGRATED IN SEN

Transelectrica, Romanian TSO, concluded in [5]: „*..the fast secure tertiary reserve would allow the installation and operation of approximately 1,5GW in the wind farm. .. Wind generation requires the installation of additional power in the system, capable of providing the rapid tertiary reserve. From the experience of European countries where wind parks with significant powers have been installed, it is necessary to increase the tertiary reserve reserve capacity of the system by approx. 0.6 ÷ 0.8 MW for a MW installed in wind farms*.” Now, there are in SEN 3GW eolian into SEN! And the problem are huge, and costs are higher.

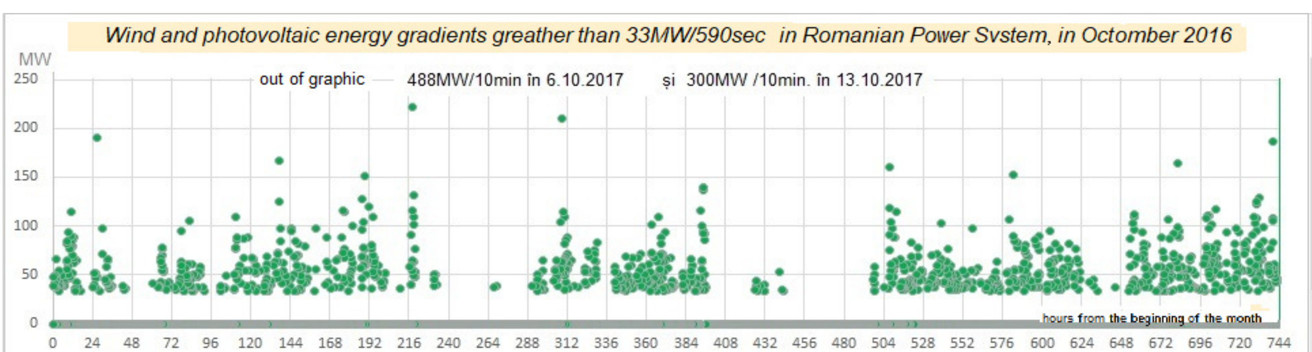


Figure 10. In today SEN, wind and photovoltaic, peaks greater then 33MW inside 590seconds.

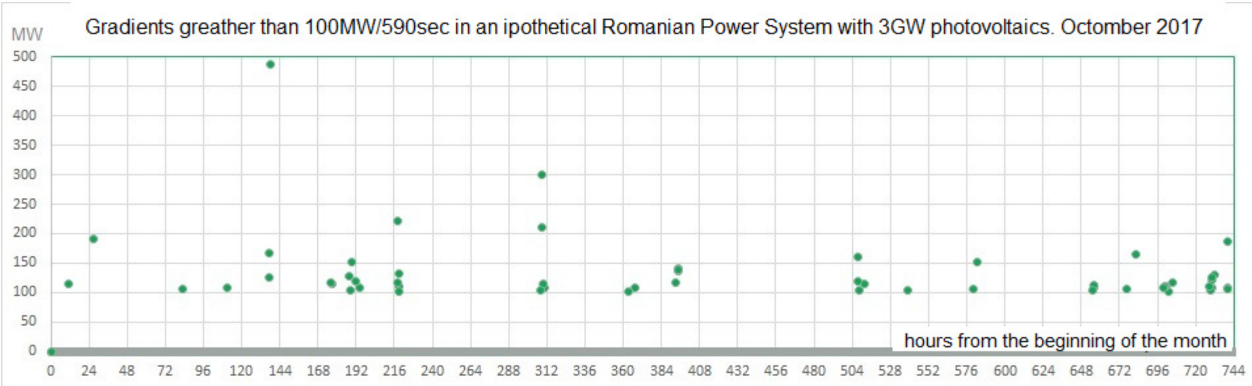


Figure 10. In an hypotethical SEN, with 3Gw insted of 1,3GW photovoltaic generators wind and photovoltaic peaks greater then 100MW inside 590seconds

Comparing the gradients higher than 33MW/590sec in the current SEN, we do not count any record of photovoltaic energy (fig.10). If we compare the wind and solar effects to the SEN, then we must consider the same power installed in the solar and wind and use the same threshold to measure the high energy leaps due to each resource. For this we must imagine a hypothetical SEN, in which beside the 3GW wind to have 3GW photovoltaic. From Transelectrica data from 1 October 2016 to 30 September 2017, photovoltaic energies were multiplied by factor 3/1,3 to compare effects. On these new, hypothetical data, we looked for deviations greater than 100MW over the sampling interval of 590sec. At this threshold there are no deviations in photovoltaics (figure 10). The largest deviation from the 3GW hypothetical photovoltaic is at 71MW. To have a comparation we have lowered the threshold from 100MW to 70MW. The results are in Table 4.

3GW eolian, 3GW photov. virtual photovoltaic in the SEN			
	wind	*photov*	*raport*
Total amount of "deviations [MW]	19.517	*71*	*213*
Total number of "deviations"	201	1	201
Absolute maximum deviation [MW] in 590sec	*488*	*71*	*6,8*
Average / day number of "deviations" above threshold	*6,5*	*0,03*	*216*

Tabelul 4. - Wind-photovoltaic weather differences in terms of energy production in the ipotetic SEN

In conclusion, a plus of 1.7GW of photovoltaic energy in large installations will not produce any "disturbance" into the SEN (fig.10). But if this added photovoltaic sources is materialized in 850,000 small residential installations of 2kWdc, then due to the double effect of spatiality, then the less disturbances may occur (fig.11).

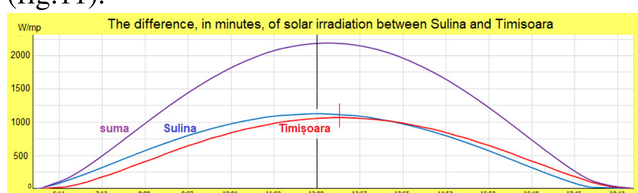


Figure 11. The spatial effect of photovoltaics

Rising photovoltaics from 1,3GW large farms to 3Gw in small residential photovoltaic we assumed that the results found in figure 10 will be fully conserved [7].

IV. CONCLUSIONS

More, in the left square of figure 12 is assigned a random value of consumption between 0 and 1000 for the consumption of 1 milion homes. These values are assumed to be the consumption of these 1 million homes. Let's see what happens when 10% of these homes pass on their own production. We chose from this random distribution the homes with over average consumption, that is, those with values attributed to their own consumption between

600 and 700. If these homes passed to self production and consumption, then all the 1 million sample are getting cooler (rightside of figure 12). The mean consumption sinks from 500 to 430 [7].

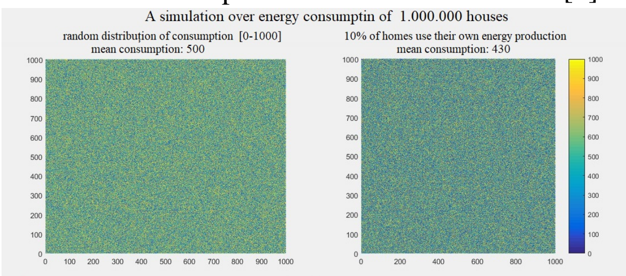


Figure 12. A simulation over the 10% homes that pass to selfproduction inside 1 million samples [10]

If the current transmission network, RET, is how it is [10], then after passing some residential consumers on self production and consumption the RET becomes less charged or cooler. Further on considered 5,117,000 private and unique homeowners [8] that 10% had a minimum salary of about 1,000 euros [9]. On assumed that these people from the future midle class are able and willing to invest 2000-3000 euros in residential photovoltaic cells to produce their own energy at 8eurocents instead of paying 14eurocents to the distributor [7].

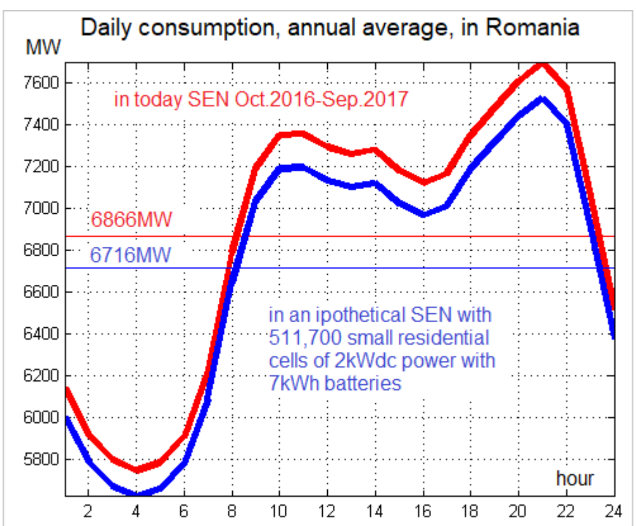


Fig.13. Effect on overall consumption if 511700 homes are passing to selfproduction and consum [10].

Then the average hourly consumption is getting down from the mean of 6.866MW to 6.716MW, as on can seen on figure 13. In other words, the SEN is getting cooler. And by default, the fast-secure tertiary reserve grows without any additional investment. SEN safety will increase.

The average square deviation decreases from 161MW, as it is now in SEN, to 117MW in an ipothetical SEN with 511,700 photovoltaic residential cells with conservation facilities [7]. In fact, the consumption curve is getting plainer. And this is again favorable to the SEN (fig. 14).

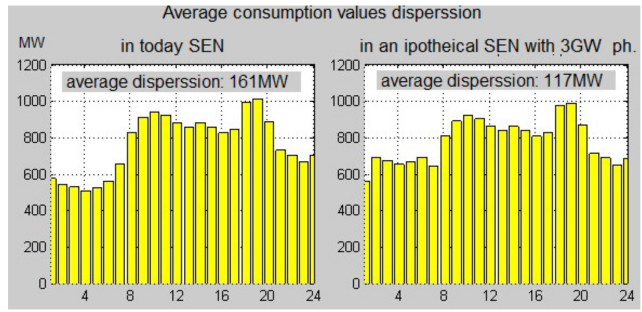


Fig.14. Values of consumption dispersion in today SEN versus an ipothetical SEN with 511,700 homes with residential 2kWdc cells photovoltaic

Note: SEN is the national Romanian Energy System.

References

[1] Octavian Căpățînă, "One holistic vision of the future energy systems," IJEE, April 2013, Vol. 3 Iss. 2, pp 34-40

[2] Octavian Căpățînă, Silviu Darie, The future in the power systems, CRSTS, 2018, Brașov

[3] ***, "Modernizing Rooftop Solar with Tandem Solar Panels", http://www.renewableenergyworld.com/articles/2018/02

[4] Anya Kamentz, "Why microgrid could be the answer to our energy crises", http://www.fastcompany.com/1297936/why-microgrid-could-be-answer-our-energy-crisis

[5] ***, Studiu de fundamentare a strategiei „TRANSELECTRICA" S.A. de integrare în Sistemul Energetic Național a centralelor eoliene

[6] Harry Wirth, *Recent Facts about Photovoltaics în Germany*, ISE Fraunhofer, 2017, Freiburg

[7] Octavian Căpățînă, "Contribution to integration at large scale of the small residential photovoltaics in the National Energy System", unpublished.

[8] ***. Recensământul populației și locuințelor 2011, INSSE

[9] ***, Anuarul statistic 2016, INSSE

[10] Virginica Zaharia , *Planul de Dezvoltare a RET perioada 2016 – 2025, Transelectrica, 2016, document public*