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INFRASTRUCTURAL DEVELOPMENT NEEDS TO SUPPORT THE RENEWABLES

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In acest articol este descris cum disponibilitatea –sau non-disponibilitatea – infrastructurii rețelei existente are impact asupra potențialului tehnic al surselor regenerabile de energie.În unele cazuri, investițiile în infrastructură pot fi justificabile şi este prezentată o scurtă descriere a celor mai importante proiecte de dezvoltare a infrastructurii de rețea.

In this article is being described how the availability – or non-availability – of existing grid infrastructure impacts the technical potential of RES.In some cases, an infrastructural investment may be justifiable, and a brief descriptions of the most relevant infrastructure development projects are provided.

Keywords: renewable energy production, grid infrastructure, infrastructure development projects

1. Introduction

Recent studies have highlighted that renewable energy is a priority of EU citizens, the differences of views between the people of each country are linked to the national energy situation. Reaching 20% renewable energy target in 2020 is a challenge for each national energy market to introduce new actors and new rules of competition between energy producers[1]. For all producers, existing or new entrants, there are economic and technical constraints.

Of these, we will dwell on the technical constraints imposed by transmission network infrastructure.

2. The Romanian grid infrastructure

The Romanian power transmission system as is managed by Transelectrica comprises about 8,950 km overhead electric lines in-between 110 kV – 750 kV:155 km at 750 kV, 4,626 km at 400 kV, 4,128 km at 220 kV and 38 km at 110 kV (only interconnection lines).Transelectrica operates 77 substations and 135 main transformer units totaling 34,525 MVA.

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As transmission and system operator (TSO), Transelectrica coordinates the operation of the system and provides regulated third party access to the Romanian electricity transmission network under transparent and non-discriminatory conditions to all market players.

The Romanian power system is synchronously interconnected with the European one and the operation is based on a technologically advanced control system. Thus the Romanian power system has not suffered severe failures during the last years. The interconnected operation of the Romanian power system to the UCTE main network is one of the top priorities of the Romanian Government and considerable financial efforts will further have to be made to improve the operation of the different power facilities and meet the UCTE rules and standards.

Transelectrica is responsible for the grid and market infrastructure development and is continuously investing in-and commissioning of new installations to ensure the security of the power system. It is the link between electricity supply and demand and is responsible for matching all times power generation with demand[10].

The commercial Operator of the electricity market is OPCOM, which is a legal subsidiary of Transelectrica. This company operates various trading platforms and operates also the trading platform of Green Certificates. The metering operator of the wholesale electricity market is OMEPA, which also is a legal subsidiary of Transelectrica.

Based on discussion with a wide range of participants in the emerging wind industry, the largest barriers in Romania appear to be as follows:

- The largest technical barriers are network capacity uncertainties and issues regarding the stop-start nature of wind energy.
- The largest administrative issues revolve around the large number of laws and regulations; ambiguous or restrictive regulations, particularly on grid connection charges and the need to assure back-up power; and bureaucratic and uncertain planning, permitting, construction and network connection rules.

3. Power consumption forecast

The ETG Prospective Plan [2] contains various data on current and future development projects.

A forecast has been made for the electricity consumption 2006-2016. The following assumptions have been made for the consumption forecast:

- An average decrease in population of 0.35% (2006-2016)
- An average annual GDP growth rate of 3.6% per year (2006-2016)
- An average annual growth in power consumption of 3.4% per year (2006-2016)

These data reflect an anticipated reduction in power consumption intensity, due to relatively higher activity in less consuming manufacturing and commercial sectors and also due to use of more efficient technology in many industries. Therefore, the growth in power consumption will be smaller than the growth in GDP.

From the table, it is seen that the power consumption is expected to double by 2025.

Table 1

Power production forecast, 2006-2030 (Transelectrica)

Power production forecast		Transelectrica forecast (ETG Perspective Plan)							
Transelectrica (ETG)		**2006**	**2010**	**2015**	**2016**	**2020**	**2025**	**2030**	**Growth 2006-2030**
Final power consumption (ETG)	TWh	46.8	52.7	63.2	65.5	75.8	90.9	109.1	3.6%
Power production (ETG)	TWh	56.4	59.5	68.9	71.0	82.1	98.4	118.1	3.1%
Required net peak power	MW	8,415	9,678	10,847	12,158	14,062	16,868	20,232	3.7%

In Table 1, only the data marked in grey are from the ETG Prospective Plan; whereas the data for 2015 has been estimated and the data after 2016 has been extrapolated taking into account the growth in GDP.

4. System integration of renewable energy production

Much concern has been raised as to the integration of wind power into the Romanian power system. The valuation of costs related to integration of renewable power in the grid has a complex nature, since renewable power production units have an intermittent nature, as for wind power, hydropower and solar PV.

Until better data are known, it is suggested to adopt the findings from the RECaBS [3] study that has been investigating costs related to:

- Grid infrastructure (grid reinforcement)
- Power balancing (short term: seconds to hours)
- Capacity compensation (long term: ensuring reliability at system peak load)

Grid infrastructure costs comprise cost of reinforcement of the distribution and transmission grids that relate to integration of renewable energy production units and also include costs of changes in power line losses that could increase or decrease.

The assumptions behind these values are:

- The existing system is a typical electricity system based on fossil fuel fired power plants and some hydropower
- Some intermittent power production up to 10% of power production
- A well developed transmission grid

It is assumed that integration of RE production in Romania having an intermittent character will not in itself require investments in the transmission grid during the coming 15-20 years, since to share of intermittent RE power production will not reach a critical level in this period. Also, the existing transmission grid development plans of Transelectrica will contribute to eliminating potential problems in this respect.

Small hydropower plants (SHP) behave much like wind power and will in addition to cost of grid connection also induce costs for balancing power and cost for ensuring system reliability at system peak load. On the contrary, SHPs with a reservoir/dam may contribute with grid balancing power. Hence, such systems may compensate for other fluctuating power production units, like e.g. wind power. The data for small hydro with reservoir has been estimated. For these plants it has been assumed that 80% of the electricity delivered by a hydro plant with reservoir could be used as balancing power. Although the remaining 20% could be used during peak load hours, there is still a need for ensuring system reliability at system peak load, which is why capacity compensation costs are anticipated.

Integration of CHP based on biomass and biogas **is considered similar to integration of conventional CHPs operating on coal and gas.**

5. Security of supply

Utilization of renewable energy has a positive effect the **security of supply**, because the economy will be less sensitive to price increases on imported fuels.

The RECaBS Study recommend to apply an economic benefit of 7 EUR/MWh produced on renewable energy from indigenous resources compared to electricity production on oil and gas. Hence, this amount can be interpreted as an externality for the use of oil and gas. Similarly, the externality for coal-based power can be estimated to one third of this amount.

For Romania, when taking into account that 68.9% of the fossil-based power production is produced on coals (hard coal and lignite), the estimated benefit is calculated to 3.79 EUR/MWh RE power production, covering the Romanian power production fossil fuel mix.

For heat production, when taking into account that 24.6% of the fossil-based power production is produced on coals (hard coal and lignite), and when converting the economic benefit to the Romanian heat regime, the estimated benefit is calculated to 2.04 EUR/MWh RE-based heat production, covering the Romanian heat production fossil fuel mix.

Table 2

Security of supply benefits from RE power production and heat production

Security of supply – benefits of RE supply	
	EUR/MWh
Benefit of supply for RE power	7.00
Benefit of supply for RE heat	2.45

	Fuel input/energy output		Benefit
	GJ/GJ	**%**	**EUR/MWh**
Power production			
Coals	2.18	68.9%	2.33
Petroleum and gas	0.98	31.1%	7.00
Weighted average	**3.16**	**100.0%**	**3.79**
Heat production			
Coals	0.26	24.6%	0.82
Petroleum and gas	0.79	75.4%	2.45
Weighted average	**1.05**	**100.0%**	**2.04**

The rationale behind this externality, showing benefits for RE-based production is that imports of oil, gas and coal form the risks of impacts from growing prices on energy. Growing energy prices induce economic losses to the extent of 0.5% loss in GDP per 10% increase in oil prices [4], which is mainly because the uncertainty of future fuel prices impact investments decisions and hence lower the GDP.

Table 3 summarizes the costs for system integration and derived benefits for different technologies. Most of the data is from the RECaBS (IEA) study, except the estimates on small hydro, biomass plants and biogas plants with reservoir and except the estimates on benefits for security of supply that we have estimated for Romania based on the basic figures from the RECaBS Study**.**

Table 3

Total costs for system integration, including security of supply-related benefits

€/MWh	Infrastructure	Balancing	Capacity compensation	Security of supply	Total
Wind on-shore	2.2	4.0	5.0	-3.8	**7.4**
Wind off-shore	8.6	4.0	5.0	-3.8	**13.8**
Solar PV	-18.4	4.0	-10.0	-3.8	**-20.6**
Small hydro,	2.2	4.0	5.0	-3.8	**7.4**

run-of-river					
Small hydro with reservoir	2.2	-3.2	5.0	-3.8	**0.2**
Biogas CHP	2.2	0	5.0	-3.8	**3.4**
Biomass CHP	2.2	0	5.0	-3.8	**3.4**

Regarding the benefit to security of supply, heat produced from renewable energy sources in the study will be given a benefit of 2.04 EUR/MWh, as derived above.

For Romania, it is suggested that a dedicated project is launched focusing costs and benefits of integration of renewable power production units based on renewable energy; e.g. wind, hydro and solar PV.

6. Constraints and requirements of renewable energy plants

In this section we will present identified constraints and requirements related to each of the renewable energy technologies.

Small hydropower (SHPs)

Unlike wind power, SHPs are disbursed widely across so grid connection capacity is not a normally a limiting issue.

Like wind power, run-of-river SHPs are intermittent and so costs balancing power and cost for ensuring system reliability at peak load (long term: capacity compensation). However, SHPs with a reservoir/dam may contribute with grid balancing power, and help compensate for other fluctuating production sources such as wind power.

Biomass

Electricity grid limitations will be an important barrier in many areas of the country for smaller biomass CHP plants. The power companies acting in Romania will in some cases not be prepared to integrate all the small producers into their grid systems.Transport of biomass to the biomass plants may input extra pressure on the road systems if the plants e.g. are located in towns as well as cause noise problems.

Geothermal energy

Deep boreholes for high temperature heat extraction are restricted to a few locations with the right geology, and must at the same time not be too far away from possible consumers.

Ambient energy – heat pumps

In order to exploit the technical potential for ambient energy heat pumps, the following limitations should be addressed along with the implementation of projects:

- Ground source heat pumps must have access to either a borehole or a piece of land where the serpentine probes can be laid.
- In the case of medium-deep boreholes, it may be necessary to recharge them with heat during the summer, if the temperature of the earth volume serving as heat source should be kept stable over the years. The heat could be coming from solar collectors or excess heat from the building if a reversible heat pump is used.
- Boreholes may in general conflict with water supply interests, though there are methods to minimize the risk of water pollution.
- Heat exchangers work best in wet soil, poorest in dry sand.
- Existing heat distribution systems in residential, public and commercial buildings with individual heating must be upgraded to low temperature operation, and/or the buildings should be insulated in order to reduce the necessary temperature level of the radiators. In some cases the distribution system must be built from scratch.
- The electricity consumption from a large number of heat pumps will be significant, and will in particular result in peak load situations on cold winter days, as many heat pumps have electric heaters as back up. Grid reinforcement may therefore be necessary.
- The power supply system may need grid reinforcement in some regions where the power demand for heat pumps causes a major increase of peak power demand. It is an open question whether this increase of peak power demand would have developed anyway, through an increasing number of household appliances and air conditioners.
- If gas driven central heat pumps are introduced, they must be given access to the district heating system, either by replacement of current DH centrals or construction of new ones.

Large heat pumps have been suggested, as a buffer in electricity grids with a high degree of unregulated power, like wind turbines and PV. In this case, heat pumps may be used actively to absorb excess power and convert it to heat, which can be stored or used directly in district heating.

Wind Power

For wind energy projects, the infrastructure constraints comprise:

- **Limitations in physical access to sites:** Parts of large wind turbines are heavy and requires road access to the site.
- **Limitation in the mounting equipment:** This is a temporary limitation. In Romania, at present there are no cranes able to erect over 2 MW rated machines.
- **Electricity grid limitations:** Electricity transport capacity: The transmission capacities of local electrical grids, or the transport lines,

may be limited or insufficient in order to transport the energy from remote areas to the load centers. Transelectrica has assessed that at the moment the grid can integrate up to 2000 MW wind power capacity, whereof the major part is in the Dobrogea region. Based on a number of planned grid reinforcement projects, the ability to absorb wind power will grow to 3000 MW during the period 2013 to 2018. Small wind farm up 10-12 MW may be connected to existing 20 kV lines, but higher capacities require connection to 110 kV or in some cases even to a higher voltage level.

- **System balancing:** Power flow needs to be continuously balanced between generation and consumption. This balancing takes place within seconds and various types of reserve capacity are used.[5] The fluctuating character of wind causes unbalances in the grid, requiring other conventional fast regulating power plants to compensate. The needed extra reserve capacity for wind power is in the order of 2-8 % of installed wind power capacity at 10% penetration of wind [6]. The actual specific requirement depends on the applied interconnection, geographical dispersion of wind power and on the forecasting techniques for wind. At higher wind energy penetration levels, higher shares of reserves are required. In Romania there is a lack of experience and tools to manage the system balancing requirements caused by wind power [7]. Nevertheless the Romanian conditions are better than in many other countries, due to the high share of hydro power in the energy generating mix, strong geographical dispersion and quite strong interconnection within UCTE.

Solar PV

Solar PV plants can either be connected to the demand side of an electric installation (as a saving device) or as an independent production unit. In general, solar electricity is generated locally, so that line losses are smaller than for central power stations.

Solar energy is an abundant resource, but a few constraints should be mentioned:

- In order to exploit the technical potential for solar PV systems, land requirements for a number of major PV power plants should be considered.
- The output form solar PV modules is sensitive to shadows from mountains, buildings, trees etc., so the sites must be carefully evaluated, also for future planning of buildings.
- PV systems for grid connection must be mounted not too far from a grid connection point, normally at low or medium voltage, depending

on the system size. The size of a single installation (inverter) may sometimes be up to one MW; larger systems use several inverters.

- In case of roof-mounted systems, the building structure must be in a healthy condition.
- If the system is mounted near roads or polluting industry, there may be need for regular cleaning of the surface.
- Grid connected PV systems only operate when the grid voltage is stable, so in case of major fluctuations in weak ends of the grid, some of the production may be lost.

Seen in a large-scale perspective with high PV penetration, the fluctuating nature of solar PV electricity must be taken into consideration in energy planning. On a diurnal timescale, PV electricity peaks in the noon hours where the use of electricity is also high and has no output at night when demand is also lowest. PV is therefore to some extent a means of peak shaving, and may reduce or postpone the demand for new capacity caused by increasing use of air conditioning. On an annual basis, the peak production is in summer where the cooling demand is also highest, and the need for heat from CHP power plant is at a minimum. CHP production may therefore be reduced in summer time when it is least efficient, in case of very large-scale penetration with PV electricity.

Solar Thermal

As solar heating systems are strongly dependent on a nearby regular consumer of heat, some infrastructure barriers exist for this technology:

- Land must be allocated for large scale systems; e.g. for solar systems for district heating.
- The system must be installed on or next to the building where heat is used, except in the case of solar district heating.
- The surface must be reasonably free of shadows, so urban planning must be considered when building a new plant.
- In case of district heating, there may be competition with the heat produced by CHP plants, but also benefits if the boilers can be closed down when they are least efficient during the summer.
- Most solar thermal systems rely on grid electricity, so a small supply must be provided. This does not count for solar thermo-siphon systems for hot water production.
- Solar energy systems always need some form of back-up energy with today’s energy storage technology.

Biogas

The performance of biogas plants depends on the types of organic material used and the location and size of the plant.

The most effective biogas plants will use different organic waste products and these products has to be transported to the plant by the road system, means that the access roads to the plant need to be suitable for these kind of transports.

The most important constraints are:

- Biogas plant based on co-generation must have access to electricity grid.
- Produced heat is used for own processes and possibly also for own heat demand for buildings, but it is normally much more feasible if surplus heat all year round can be supplied to e.g. district heating network.

Some major benefits are:

- Possibility to establish gas storage and thereby produce power and heat in accordance with demand and possibly produce peak load electricity.
- Biogas plant operation creates local employment and development.

Biofuels

Biofuel production implies partial use of agricultural land, which may be otherwise used for food crops; and partial use of biomass, which may otherwise be used as fuel for heat and electricity production purposes. So the constraints are much related to sharing the same land with agricultural food production and related to the direct use primary biomass resource for heat and power production.

Already a recent World Bank report revealed that these reportedly ‘green’ fuels have pushed up food prices worldwide by a massive 75%. The EU member states realized that the Commission’s plan specifies that 10% of transport needs must come from renewable energy, but not necessarily all from biofuels.

Romania has a more relaxed situation here, relying on the large amount of not cultivated agricultural land of more than 2 million ha.

7. Proposed infrastructural development projects

Hydropower pumped storage facility

A very important step to provide more capacity for connection of wind and/or solar PV to the grid will be to implement the Tarnita – Lapustesti pumped storage hydro power plant. The project will establish a reservoir of approx. five million m^3 and the capacity is planned to be around 1,000 MW. The project is a cornerstone in the future plan of Hidroelectrica, and will be the basis for further development of nuclear power, wind power, solar PV etc.

The Tarnita – Lapustesti SPHPP project, having the power variation of ± 1,000 MW ensures the deficit capacity in the peak hours by transfer in the low load hours in its own system or in the interconnected one. The project also delivers the safety of services as well as the increase of Romania’s position on the Central and South-Eastern Europe ancillary system services market. The Tarnita –

Lapustesti project presents a very important project in terms of securing Romania’s strategic resources and is completely in line with the idea of using domestic resources.

According to Hidroelectrica, the plant would not only stabilize the Romanian grid, but also provide a similar service and balancing power for neighboring importers of electricity from Romania such as Hungary, which currently not has such capability.

Another ongoing project with planned pumping capacity is on the lower Olt River. The project will totally have an installed capacity of 265 MW in the power turbines and 210 MW in the pumps. This project creates also the possibility for the participation on the ancillary service market and to stabilize the power system and balancing of the system as the Tarnita – Lapustesti project, but this project also has other objectives such as prevent flooding of neighboring areas of the Olt River and irrigation of farmed neighboring areas [8].

Grid reinforcement projects

With the present capacity in the Romanian power system and the connected types of power production units as well as interconnection with neighboring countries, the available maximum capacity for wind power or solar PV is assessed to 2,000 MW[9].

It is estimated that this capacity can be increased up to 3,000 MW including the 3^{rd} nuclear power unit and the implementation of the Tarni□a – Lapuste□ti SPHPP and it is necessary also to assure a tertiary power reserve in the thermal power plants and to reinforce the power network system.

To reach this higher available capacity the following projects should be realized [10]:

- 400 kV (overhead line) Medgidia Sud – Constan□a Nord
- 400 kV Nuclear PP Cernavoda – Stalpu
- 400 kV station Brasov passing to 400 kV Brazi West – Teleajen – Stalpu
- 400 kW connection line between Gadalin station and Suceava station, and passing the Suceava station to 400 kV (today it extends to Roman) so the 400 kV of Moldavia axis will be realized
- Reinforcement of the networks of 220 kV and 400 kV through “re-wiring” – i.e. changing the current Al/St conductor with Alloy types that have larger transport capacity
- Carrying out works to improve the scope for automated dispatch
- Building a 750 kV connection between Medgidia and Bulgaria, and analyzing the integral use of 400 kV and 750 kV links with Bulgaria
- Increasing the capacity of the stations between Isaccea and Smardan stations.

8. Conclusions

At present, the use of the technical potential for the various RES differs widely.A significant amount of the potential for biomass and hydro power is already utilized, but the technical potential of other types of RES is under-exploited at present.It is assumed that the investment priority will be focus on those parts of the technical potential that are already feasible, hence avoiding the need for major related infrastructural investments.

In some cases, an infrastructural investment may be justifiable, if this investment may release a relatively large amount of technical potential for RES.The best known example is that of how investments in the electricity network can raise the technical potential for wind power, especially that Cernavoda nuclear power station is happen to be located near the sunniest and windiest parts of Romania.

But for all the projects, it is mandatory to reduce the period between the decision to make an investment and the achievement of this, estimated at 4 to 15 years [11]**.**

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