JASPERS Networking Platform

Supporting investments in Smart Grids in 2014-2020

Case Studies for Romania and Poland

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AGENDA

- International experiences on Smart Grid impacts
- Case study Romania
- Case study Poland

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CHARACTERIZATION OF SMART GRIDS INVESTMENTS

From assets to impacts

Smart assets

- 1-Voltage regulators
- 2-Adaptive protection relays
- ..
- 26-Smart Meters

Smart functionalities

- 1-Dynamic line rating
- 2-Volt/VAR control
- …
- 18-Customer electricity use optimization

KPIs

- 1-Reduction of greenhouse gas emissions
- 2-Extended hosting capacity for distributed generation
- …
- 14-Reduction of congestions

Mapping Assets-Functionalities

Mapping Functionalities-KPIs

26 Assets | **18 Function.** | **14 KPIs**

	KPI
Sustainability	1 - Reduced greenhouse gas emissions
	2 - Reduced local SOx, NOx emission
	3 – Increased share of RE in the generation mix
Integration of DERs	4 -Increased hosting capacity of distributed generation
	5 - Increased hosting capacity for Electric Vehicles and other new loads (e.g. heat pumps)
	6 - Increased number of generation hours provided by DG
Security and Quality of Supply	7 - Reduced peak demand
	8 - Reduced duration of interruptions per customer (SAIDI)
	9 - Extended asset life time
	10 - Reduced expected energy not supplied
Energy Efficiency of the Power System	11 - Reduced technical losses in transmission and in distribution networks
	12 - Reduced non-technical losses in transmission and in distribution networks
	13 - Reduced electricity consumption
	14- Reduced congestions in the system's electrical lines

Indicative ranking of Smart Functionalities based on international pilot project results

KPI

Functionalities

	Reduced greenhouse gas emissions	Reduced of local SOx, NOx emission	Reduced peak demand	Reduced technical losses in transmission distribution networks	Reduced electricity consumption	Reduced congestions in the system electrical lines	Increased hosting capacity of distributed generation	Increased number of generation hours provided by DG	Increased generation's share from RESin the generation mix	Reduced duration of interruptions per customer (SAIDI)
Dynamic Line Rating	+	+				+++			+	
Automatic fault identification and management										+++
Dynamic network reconfiguration	+	+		+++		+	+	+	+	++
Real-time measurement and visualization of distribution grid	++	++		++		++	++	++	++	++
Power flow control on distribution (DER dispatchability)	++	++				++	+++	+++	++	
Voltage and reactive power control on distribution grid	++	++	+	+++	+		+++	+++	++	
Provision of ancillary services by DER	++	++					+++	+++	++	
Optimization of DER output and operation	++	++						+++	++	
Consumers' real-time load measurement and visualization.	++	++	++		++					
Automatic and/or remote customer electricity use optimization	++	++	+++	++	+++	+	+		++	
Aggregation (VPP; DR)	++	++	+++	++		+	++	++	++	

Indicative KPI ranges based on international pilot project results

	KPI	Low impact	Medium impact	High impact
Sustainability	1 - Reduced greenhouse gas emissions	< 3%	3% - 10%	> 10%
	2 - Reduced local SOx, NOx emission	< 3%	3% - 10%	> 10%
	3 – Increased share of RE in the generation mix	< 2%	2% - 4%	> 4%
Integration of DERs	4 -Increased hosting capacity of distributed generation	< 10%	10% - 25%	> 25%
	5 - Increased hosting capacity for Electric Vehicles and other new loads (e.g. heat pumps)	No estimation	No estimation	No estimation
	6 - Increased number of generation hours provided by DG	< 10%	10% - 25%	> 25%
Security and Quality of Supply	7 - Reduced peak demand	<2%	2% - 10%	> 10%
	8 - Reduced duration of interruptions per customer (SAIDI)	< 5%	5% - 20%	> 20%
	9 - Extended asset life time	No estimation	No estimation	No estimation
	10 - Reduced expected energy not supplied	No estimation	No estimation	No estimation
Energy Efficiency of the Power System	11 - Reduced technical losses in transmission and in distribution networks	< 2%	2% - 5%	> 5%
	12 - Reduced non-technical losses in transmission and in distribution networks	No estimation	No estimation	No estimation
	13 - Reduced electricity consumption	< 2%	2% - 10%	> 10%
	14- Reduced congestions in the system’s electrical lines	No estimation	No estimation	No estimation

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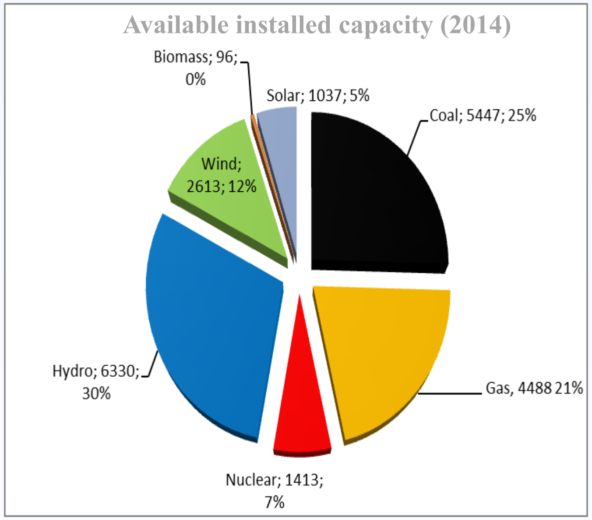
Overview of the Romanian power system

General info[1]:



- Net available generation capacity: 21GW (2014)
- Variable RES: 3.6 GW in 2014 (17%).Expected to double by 2020.
- Peak demand: 10 GW in 2012 (13.6 GW in 2030)
- Consumption: 2.8% yearly growth up to 2020
- Technical losses 12% (2012)
- Non-technical losses: 7% (2012)
- SAIDI: 630 min/year (rural: over 1000min/year) (2012)

Current status of the network and Smart Grid initiatives:

- HV/MV substations equipped with SCADA and radio controlled switches
- 20-30% of MV lines equipped with remote disconnectors
- In general, limited automatic/remote control and measurement of MV/LV networks
- MV-connected DGs required to be equipped with remotely controlled switchgears
- DGs>5MW are dispatchable and provide volt/var control. DGs>1MW are in the SCADA of the DSO for monitoring.
- Regulation allows for the operation of aggregators, but in practice there is no such activity. Integration of load in system balancing is virtually non-existent.
- Smart Metering roll-out by 2020 approved. 32 pilot projects on-going.
- Investments in dynamic line rating under consideration .

[1] ***Source: TRANSELECTRICA's Development plan for ETG 2014 - 2023***

Main improvement needs for the Romanian power system

Identified main needs	Current status
Integrating RES and DG	According to Transelectrica (TSO) the grid can integrate 2.5-3 GW of wind capacity in its current state . Currently 2.6GW of wind and 1GW of solar are present. Connection capacity much lower than requested wind connections.
	New stronger requirements on flexibility of traditional power plants to ensure the balancing of the system (ANRE's Order no.51/2009, Order no. 29/2013, Order no. 30/2013 and Order 74/2013)
Improving continuity of supply	-Average value (2012) for SAIDI 630 min/year (OECD average 300 mnin/year; western EU countries < 100min/year) -Average value (2012) for SAIDI in rural areas 1063 min/year
Increasing energy efficiency on the grid side and on the demand side	-67 % of electricity distribution networks are in an advanced stage of wear -Technical losses at 12% (OECD average 6%)
	-Non-technical losses (energy theft, inaccurate billing) at distribution level amount to 7%
	-Demand growth estimated at 2.8 % per year for the next 10 years. -Peak demand foreseen to increase from 9.2 GW in 2013 to 13.6 in 2030
Security of supply/ system adequacy	-out of the 24 GW of the total generation capacity, some 2-3 GW of installed generation is reported as unusable -80 % of thermal power plants in Romania exceed foreseen technical life being installed 40-45 years ago; -31 % of hydropower with an installed capacity of 6,450 MW have exceeded lifetime rehabilitation program targeting only a limited share.
	-Demand growth estimated at 2.8 % per year for the next 10 years. -Peak demand foreseen to increase from 9.2 GW in 2013 to 13.6 in 2030

ROMANIAN POWER SYSTEM – KPI WEIGHTS

Key priorities:

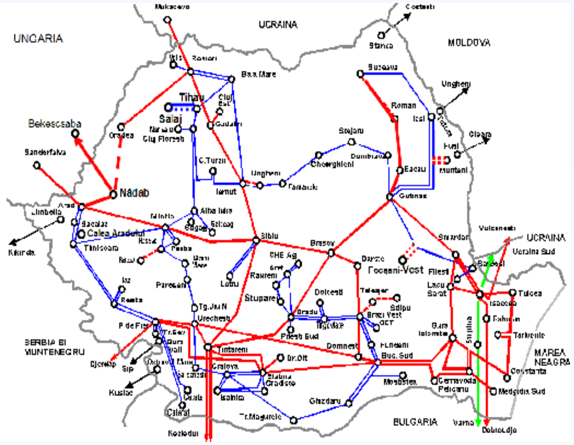
- **Increased hosting capacity of RES/distributed generation**
- **Continuity of supply (reduction of SAIDI)**
- **Technical/non-technical losses**

Category	KPIs	Weight
Sustainability	1 - Reduced greenhouse gas emissions	2
	2 - Reduced local SOx, NOx emission	2
Integration of DERs	3 -Increased hosting capacity of distributed generation	5
	4 - Increased hosting capacity for Electric Vehicles and other new loads	1
	5 - Increased number of generation hours provided by DG	4
Security and Quality of Supply	6 - Increased share of RE in the generation mix	3
	7 - Reduced peak demand	4
	8 - Reduced duration and frequency of interruptions per customer (SAIDI; SAIFI)	5
	9 - Extended asset life time	2
	10 - Reduced the expected energy not supplied	3
Energy Efficiency of the Power System	11 - Reduced technical losses in transmission and in distribution networks	5
	12 - Reduced non-technical losses in transmission and in distribution networks	5
	13 - Reduced electricity consumption	2
	14- Reduced congestions in the system's electrical lines	4

- **Proposed ranking of priorities for the KPI are solely intended to provide some guidance to National Authorities.**
- **National Authorities are to select the most appropriate KPI ranking based on national context and policy priorities**

ROMANIA – Example of simulation analysis for KPI assessment

- **Model characteristics:**
- Techno-economic model of 1 year of operation, based on marginal costs of generation units.
- 3 time horizons considered: 2014, 2023, 2030.
- Modelling of transmission grid, generation, demand and exchanges with neighbouring countries.
- Use of Tractebel's SCANNER simulation tool



Main expected outputs:

- Assessment of the impact of Smart Grid measures like dynamic line rating and demand response, on the following KPIs:
  - Electricity generation costs
  - CO_2 emissions
  - Renewable generation curtailment

ROMANIA – Example of simulation analysis for KPI assessment

Impact of dynamic line rating (compared to BaU scenario), assuming 10% of increase of line capacity due to dynamic line rating*

	Absolute values			% of baseline value		
	2014	2023	2030	2014	2023	2030
Total O&M costs of generation (M€) (including fuel)	1422	1792	2239	99.4%	99.%	97.9%
Congestion costs due to grid constraints (M€)	42.3	48.4	66.1	84.3%	81.9%	58.3%
Curtailed renewable energy, including hydro (%)	4.0%	3.7%	3.0%	83.0%	83.2%	78.9%
Share of renewable energy in the mix, including hydro (%)	39.8%	37.1%	37.5%	100.8%	100.9%	100.7%
Total CO2 emissions (Mtons)	24.8	25.7	30.8	99.39%	99.1%	98.9%

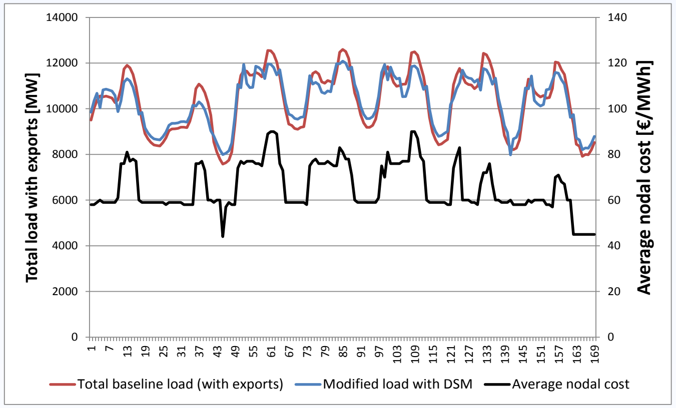
*Conclusion of EU-funded project TWENTIES

As a maximum theoretical benefit (dynamic line rating on all lines):

- Congestion costs can be reduced from 16% (2014) to 42% (2030), representing several millions of Euros in savings per year.
- The curtailment of renewable generation can be reduced by 17-21%, which allows increasing the share of renewable energy in the mix by 0.3-0.4 percentage points.
- Avoided congestions and renewable curtailment allow reducing CO2 emissions by 0.7-1.1%.

ROMANIA – Example of simulation analysis for KPI assessment

Impact of demand side management for peak reduction, assuming a shift of 2% of daily load



	2014	2023	2030
Shifted energy over the year (GWh)	912	1170	1539
Maximum shift at peak hour (MW)	495.9	503.3	530.3
Estimated reductions of total O&M costs of generation (including fuel)			
(k€)	6862	10973	35120
(%)	0.48%	0.61%	1.54%
Average value of shifted energy (€/MWh)	7.5	9.4	22.8

- Significant reduction of total O&M costs of generation (including fuel)
- Highest benefits expected in 2030 because the use of natural gas fired power plants (with high marginal prices) was expected to be higher by this year compared to 2014 and 2023

Romania – Main recommendations for Smart Grid investments

INVESTMENT TYPE	SAIDI	Technical losses	Non-technical losses	Hosting capacity for DG	Congestion and dispatch costs	Curtailed RES
Monitoring and visualization on the distribution network	++ Faster and more accurate identification of faulty sections and of restoration plans. High improvement margins in rural areas.	++ Higher awareness of line power flows and phase line balancing	+++ High impact thanks to Smart metering implementation	++ Higher awareness of DG impact		
Increased automation of distribution grid (remote switches; fault identification and management)	+++ In combination with monitoring functionality, remote grid reconfiguration for restoration after a fault. Higher fault selectivity.	+ Optimization of power flows with remote network reconfiguration.				
Integration of DGs in grid operation (DG volt-var control; DG dispatching - variable access contracts; adaptive DG protection). Virtual power plants.		++ Volt-var control by DG can mitigate technical losses. Coordination with centralized volt-var.		+++ High impact particularly on feeders with higher DG penetration. VPPs should be explored.		
Dynamic line rating					+++ Scanner simulation: reduction of congestions costs up to 42% (in 2030)	+++ Scanner simulation: a reduction of curtailed RES up to 20% in 2030.
Demand flexibility (industrial/commercial)		+ via reduction of peak demand			+++ reduction of dispatching costs via lower peak demand	++ Flex demand for balancing

- **Proposed ranking is intended to provide some guidance to National Authorities.**
- **More detailed assessment of Smart Functionalities to be done according to specific local grid conditions of the project**

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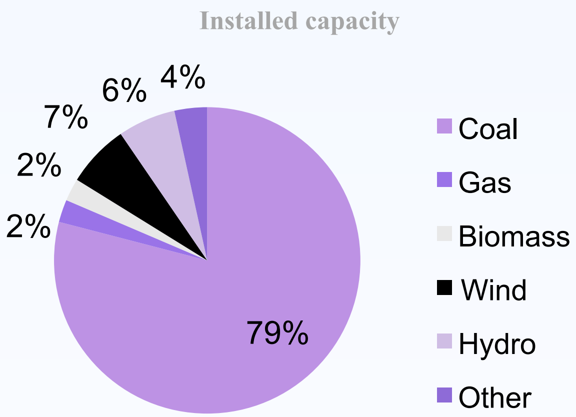
- **Case study Poland**

Overview of the Polish power system

General info (in 2012):



- Net generation capacity: 37.7 GW
- Wind: 2.5 GW (target of 6 GW by 2020)
- Peak demand: 26 GW (+25% forecasted by 2020)
- Consumption: forecasted 1.5% yearly growth up to 2020
- RES: 10.5% of produced energy (target of 15% by 2020)
- Technical losses 7%
- SAIDI: ~400 min/year (including catastrophic breaks: 859 min/year)

Current status of the network and Smart Grid initiatives:

- At MV level, only a **limited percentage** (<30%) of **switches** can be **remotely controlled.**
- **Radiocontrolled switches for new constructed lines** or modified lines (and substations). New LV lines are equipped with switches that can only be operated manually.
- **Observability of MV and LV grids is very limited**. DSOs have access to energy measurements only for HV/MV substations
- **DG hosting capacity** is very limited. This issue is particularly acute in the north, where all the wind potential is located.
- **DG connection** through **fit and forget** approach.
- **Smart Metering roll-out** by 2020 approved (on-going AMI project by ENERGA targeting 1M customers)
- DSO ENERGA **piloting Smart solutions**: **fault management and grid reconfiguration** (Smart Lab project), MV and LV monitoring (Nowy Staw project - 4k customers) and **MV and LV monitoring and controllability**, e.g. volt-var, (Hal peninsula – 10k customers)

Main improvement needs for the Polish power system

Identified main needs	Current status
Integrating RES and DG	2.5 GW of wind (target of 6GW of wind by 2020). 10.5% of RES produced energy (target of 15% by 2020).
	Wind farms developments are mainly located in the north whereas biggest areas of consumption are located in the south
	System operator is not allowed to control RES for ancillary services. No compensation mechanisms for RES curtailment foreseen.
	Very limited hosting capacity for new generation at distribution and at transmission level.
Improving continuity of supply	SAIDI is higher than the mean value among OECD countries (around 400 min against 300 min) and much higher than typical values of most western European countries (lower than 100 minutes).
	Under study, incentives for the TSO and DSOs through the tariff to encourage them to reduce outage times.
Security of supply/ system adequacy	Peak demand expected to grow by 25% from 2012 to 2020.
	44% of the power plants are more than 30 years old. The system might face a lack of capacity by 2016.

POLISH POWER SYSTEM – KPI WEIGHTS

Key priorities:

- **Increased hosting capacity of RES/ distributed generation**
- **System adequacy/meeting peak demand**
- **Continuity of supply (SAIDI)**

Category	KPIs	Weight
Sustainability	1 - Reduced greenhouse gas emissions	3
	2 - Reduced local SOx, NOx emission	3
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	9 - Extended asset life time	2
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Poland – Main recommendations for Smart Grid investments

INVESTMENT TYPE	SAIDI	Technical losses	Hosting capacity for DG	Reduced peak demand
Monitoring and visualization on the distribution network	++ Faster and more accurate identification of faulty sections and of restoration plans. High improvement margins in targeted areas (e.g. rural)	++ Higher awareness of line power flows and phase line balancing.	++ Higher awareness of the grid state and of DG impact.	
Integration of DGs/interface with DSM (DG ancillary services; DG dispatching - variable access contracts) Centralized voltage and reactive power control (grid side)		+++ Impact should be significant especially in those feeders with high penetration of DGs.	+++ Automatic/remote interface DG-DSM (DG volt-var control; variable access contract) would be a strong change compared to current "fit and forget" approach. VPP should be explored. Centralized Volt-var control would also be beneficial.	
Grid automation (Dynamic grid reconfiguration, fault management via automatic reclosers, adaptive protect. etc.)	+++ In combination with monitoring functionality, high impacts (possibly reduction of over 20%) with remote switch operation and specific fault management investments.	+ Dynamic network reconfiguration for grid optimization in normal conditions		
Demand side management(industrial/commercial)		+Positive impact possible due to reduction of peak demand and of consumption.		++ Aggregation should be supported to maximize impact

- **Proposed ranking is intended to provide some guidance to National Authorities.**
- **More detailed assessment of Smart Functionalities to be done according to specific local grid conditions of the projects.**

SUMMARY OF KEY POINTS

- **Evidence of KPI impacts of Smart assets and functionalities in Smart Grid projects in EU and US**
  - Indicative ranking of Smart functionalities according to KPI impact
  - Indicative KPI ranges to assess impact of Smart Grid investments on KPIs (Low, medium, high)
- **Analysis of the major needs of the Polish and Romanian power systems**
- **Recommendations for Smart Grid investments for Poland and Romania**

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