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Smart Technologies to improve Grid Reliability and Service Continuity

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CESI

Shaping a Better Energy Future

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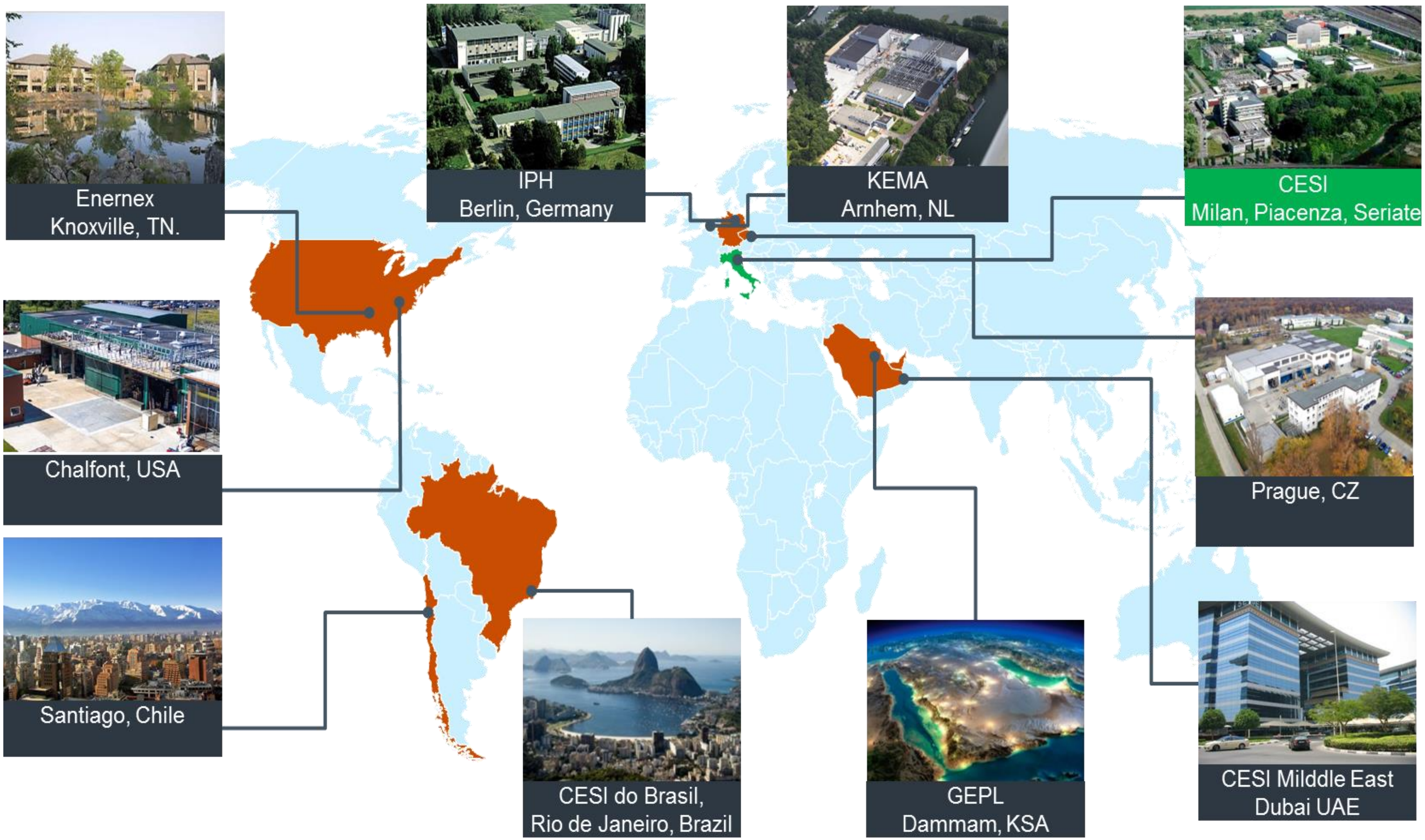
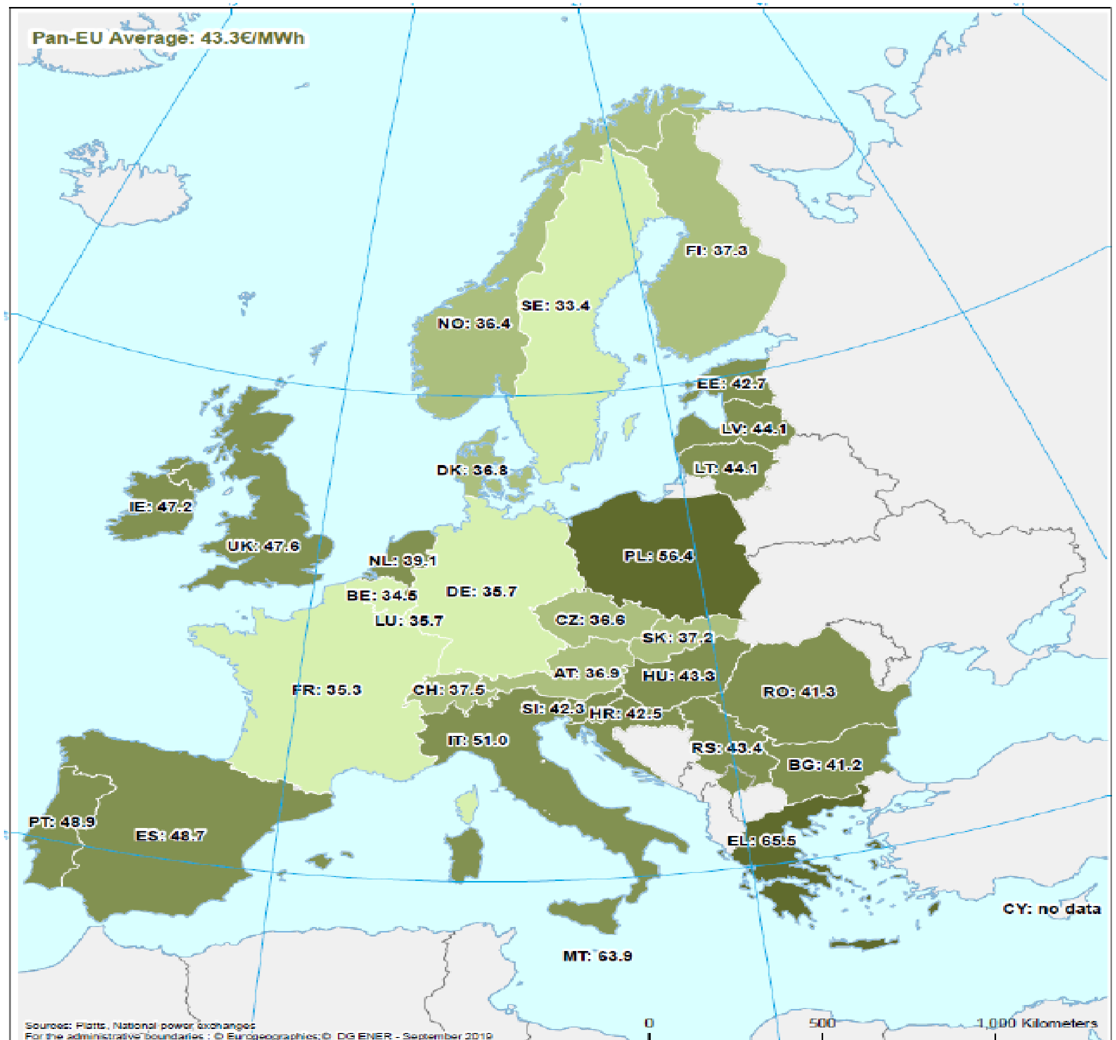
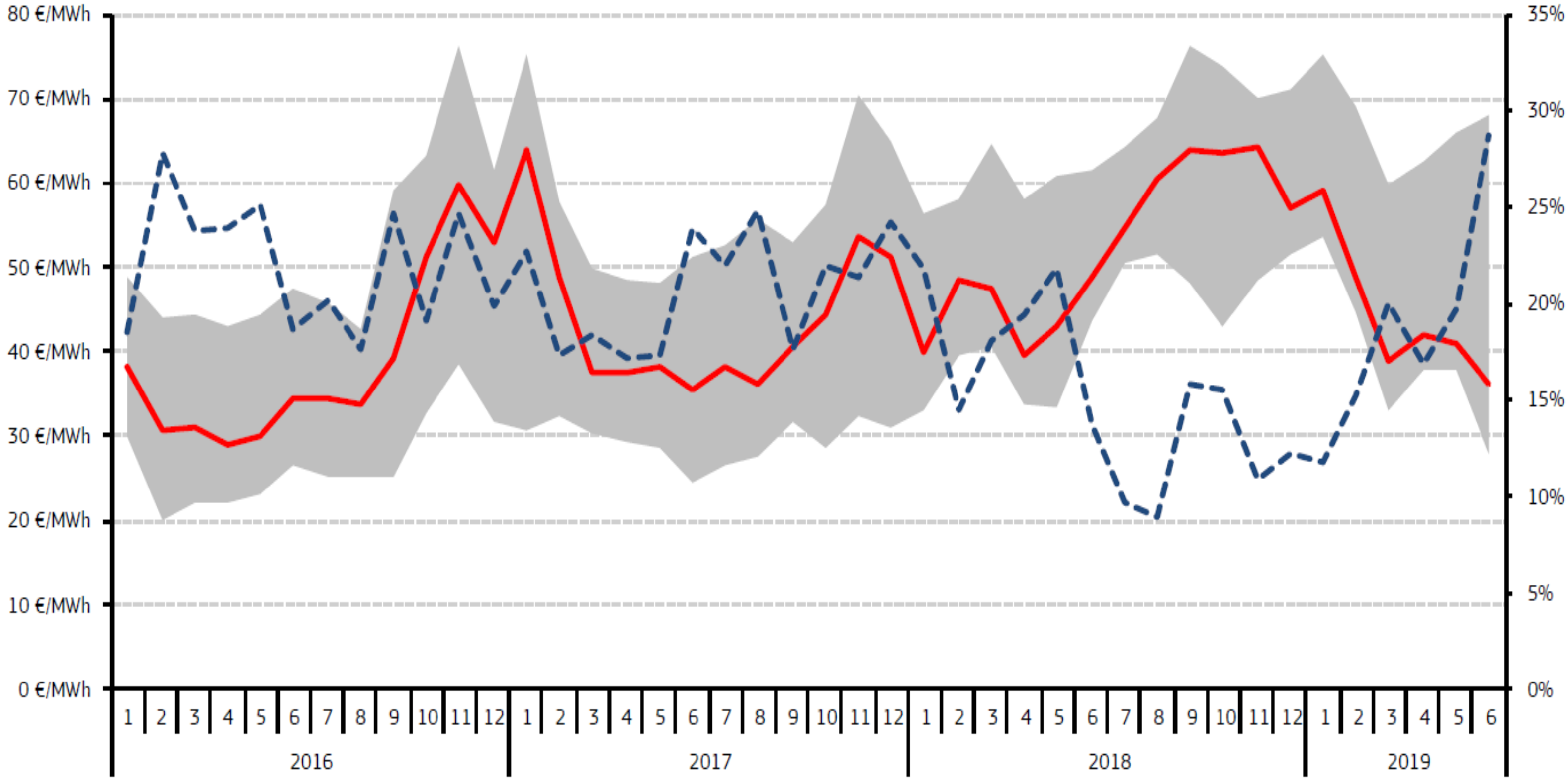


Wholesale baseload electricity prices – second quarter of 2019



Source: European wholesale power exchanges, government agencies and intermediaries

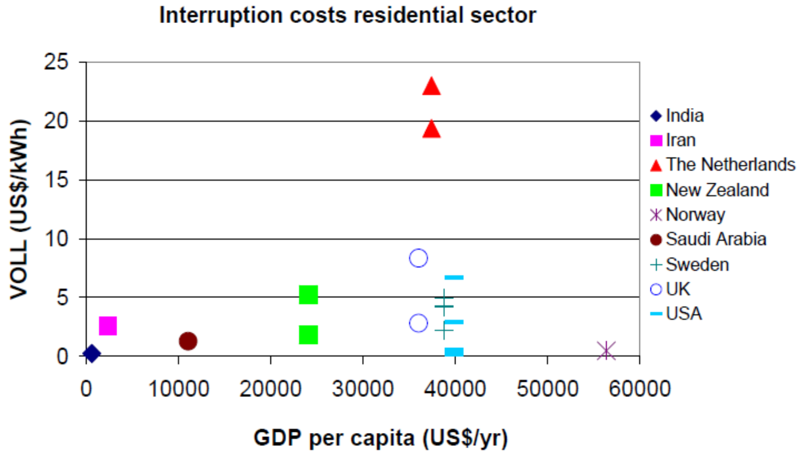
Lowest and the highest regional wholesale electricity prices in the EU

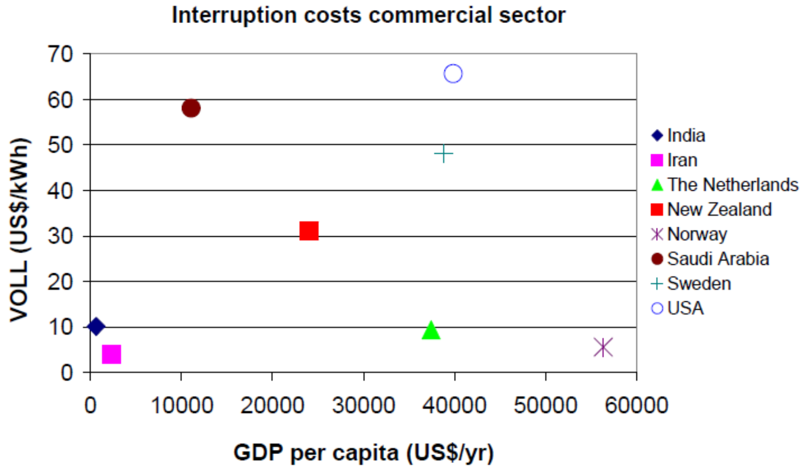


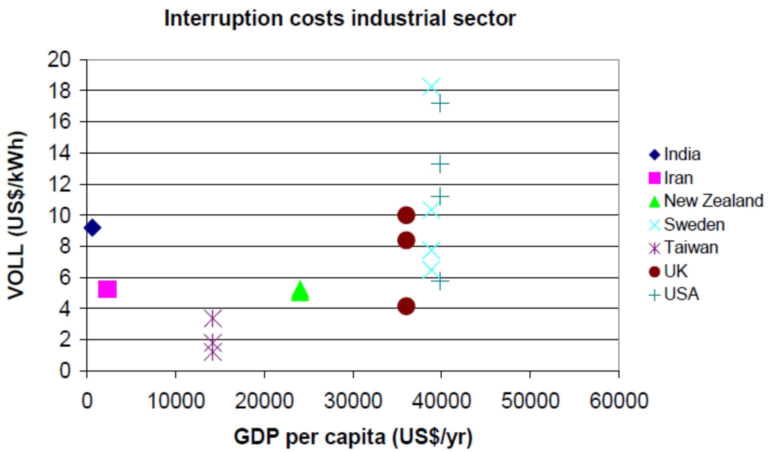
- Value of Energy Not Supplied (ENS) mustn't be confused with Electricity Prices

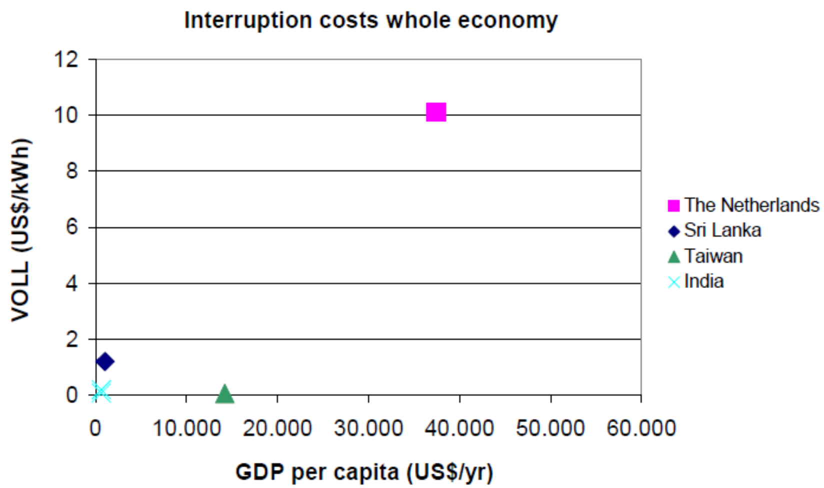
Source: Platts, European power exchanges

Value of Lost Load (VOLL)









- Value of Lost Load is dramatically higher than Electricity Prices (100 times)

Source: University of Bath – Case Project

Customers interruptions, minutes lost and power quality

FIGURE 2.1 OVERALL PLANNED AND UNPLANNED LONG INTERRUPTIONS (MINUTES LOST PER YEAR)

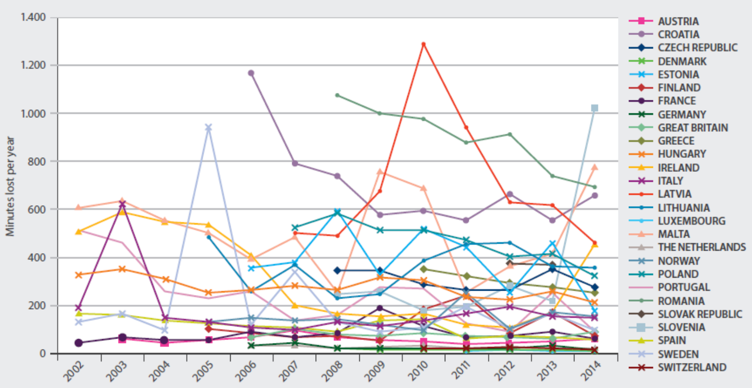


FIGURE 2.3 OVERALL PLANNED AND UNPLANNED LONG INTERRUPTIONS (NUMBER OF INTERRUPTIONS PER YEAR)

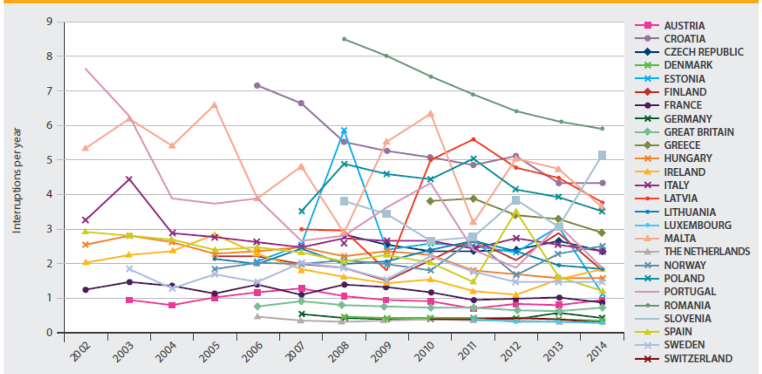


TABLE 2.14 CONTINUITY OF SUPPLY REGULATION AT SYSTEM LEVEL

System	Rewards	Penalties	Combination	Continuity indicators used
Distribution		DK, HU	BG, CZ, DE, ES, FI, FR, GB, IE, IT, NL, NO, PT, SI, SE	BG (SAIDI, SAIFI), CZ (SAIFI, SAIDI), FI (outage costs based on planned and unplanned long interruptions), FR (SAIDI), DE (SAIDI for LV, ASIDI for MV), GB (customer interruptions and customer minutes lost), HU (SAIDI, SAIFI, outage rate), IE (customer minutes lost, customer interruptions), IT (SAIDI and SAIFI+MAIFI), NO (interrupted power at a specific time, duration, time of occurrence, planned, unplanned), PT (END), SI (SAIDI, SAIFI), ES (TIEPI, NIEPI), SE (ENS, PNS, SAIDI, SAIFI, CEMI4)
Transmission	BE, ES	HU	DE, FI, FR, IE, IT, NO, PT, SE	BE (AIT), FI (outage costs based on planned and unplanned long and short interruptions), FR (AIT and SAIFI+MAIFI), DE (SAIDI for LV, ASIDI for MV), HU (outage rate, AIT), IE (system minutes lost), IT (ENS), NO (interrupted power at a specific time, duration, time of occurrence, planned, unplanned), PT (TCD: Combined average availability rate in %), ES (availability of facilities), SE (ENS, PNS)
No existing CoS scheme	AT, CH, CY, EE, EL, LT, LU, MT, PL, SK			
Intentions/plans for implementation	AT (details under consideration), EL (penalty and reward scheme on basis of SAIFI and SAIDI indicators), LU (Q factor currently under discussion), RO (implementation under consideration)			

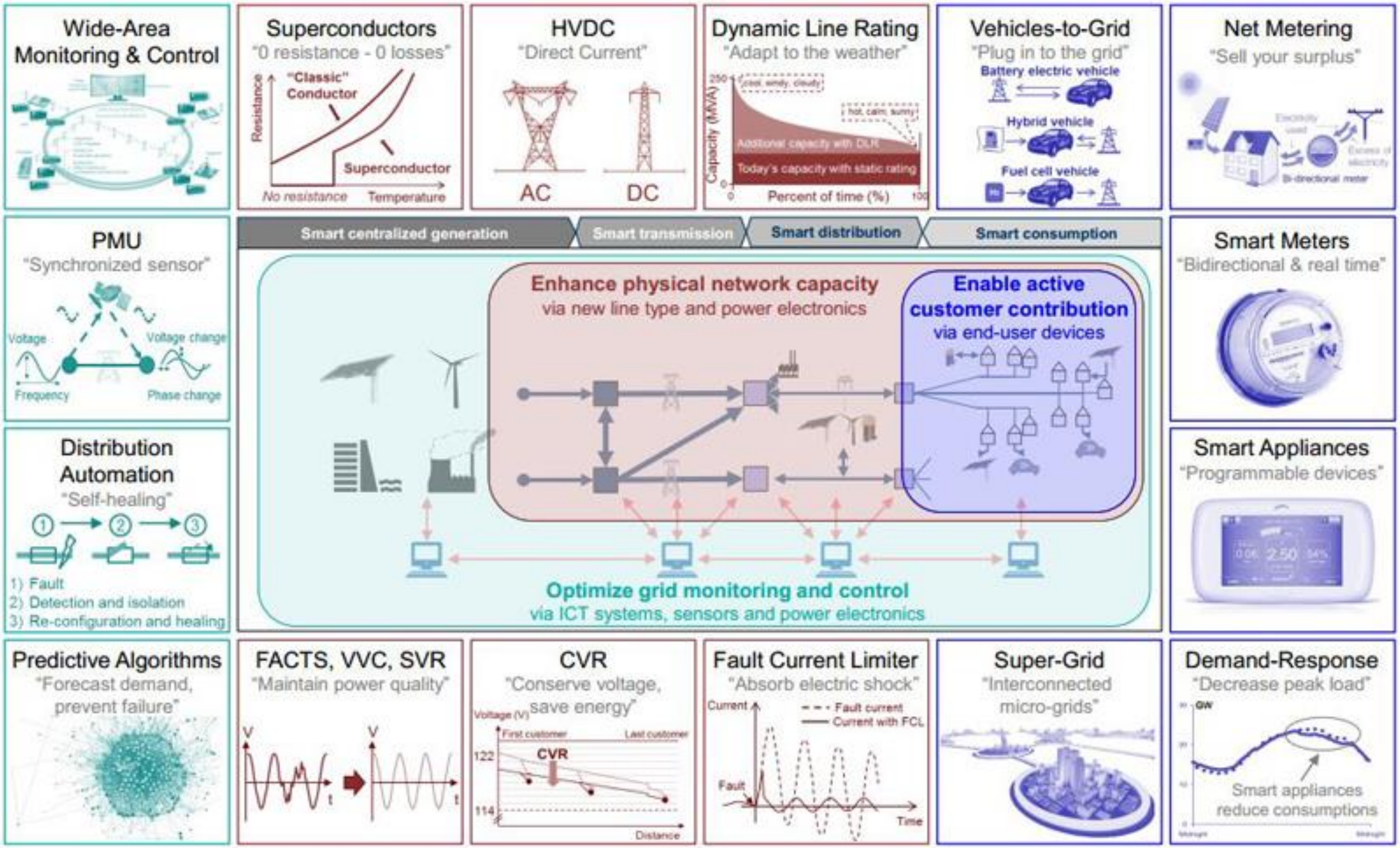
TABLE 20 VQ standards enforced/used on CP level

CP	Supply voltage variation standards	VQ standards for other voltage characteristics
Albania	400 kV: +5%, -10%; 220, 150, 110 kV: ±10%; 35 kV: 31-39 kV; 20 kV: 24 kV (highest voltage); 10 kV: 10,75 kV (highest voltage); 380 V, 220 V: +10%, -15%	No
Bosnia and Herzegovina	Partially EN 50160, IEC 60038 400kV: ±5%; 220kV: ±10% HV, MV: ±10% LV: ±10%(RS), +5%, -10% (F BiH)	Yes, IEC 61000-3-6, IEC 61000-3-7 IEC 61000-3-12, standards
Croatia	400 kV: +5%, -10%; 220 kV: ±10% MV, LV: EN 50160	Yes, mainly in line with EN 50160
FYR of Macedonia	EHV: ±5%; HV, MV: ±10% LV: +5%, -10%	Planned for 2012
Moldova	All voltage levels: ±5%	Yes, GOST 13109-97
Montenegro	400 kV: +5%; 220 kV: ±10%; 110 kV: ±10%; 35 and 10 kV: ±5% LV: ±10%;	No
Serbia	400kV: ±5%; 220kV: 200-240kV HV, MV, LV: ±10%	Planned for 2011
Ukraine	All voltage levels: ±5% (95% of the time) ±10% (marginal voltage variation)	Yes, GOST 13109-97
UNMIK	400 kV: ±5%, (exceptional event ±10%); 220 kV: ±5%, (exceptional event ±10%); 110 kV: ±10%, (exceptional event 88 to 130kV); MV, LV: (35kV, 20kV, 10kV, 6.3kV, 400 V, 230V): +10%; -15%	Yes

- Revenues, Penalties and Compensations are linked to such KPIs

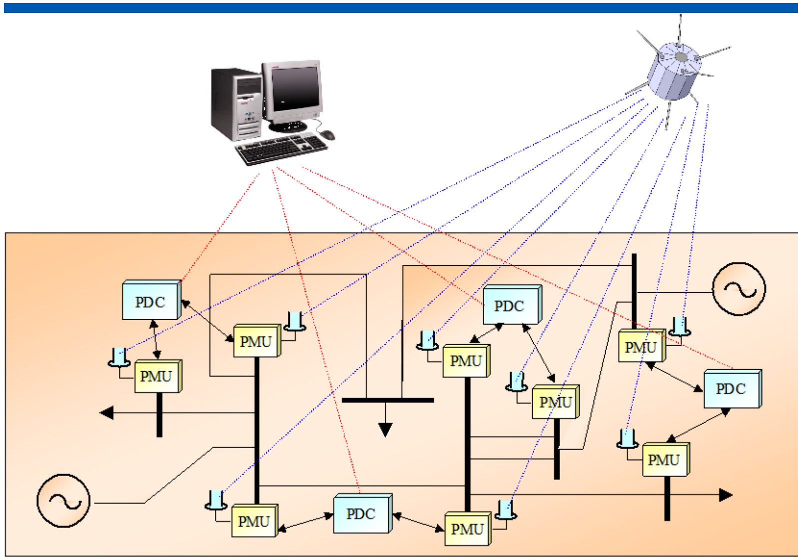
Source: 6th Ceer (Council of European Energy Regulators) benchmarking report on the Quality of electricity supply

The modernization of the grid to handle variability and bidirectional electricity flows

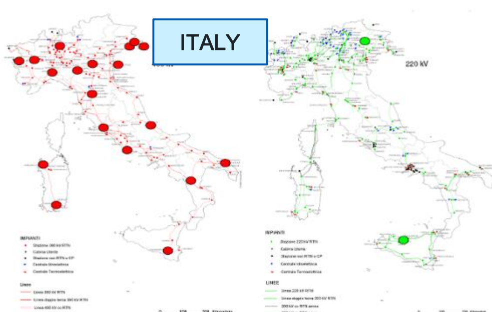


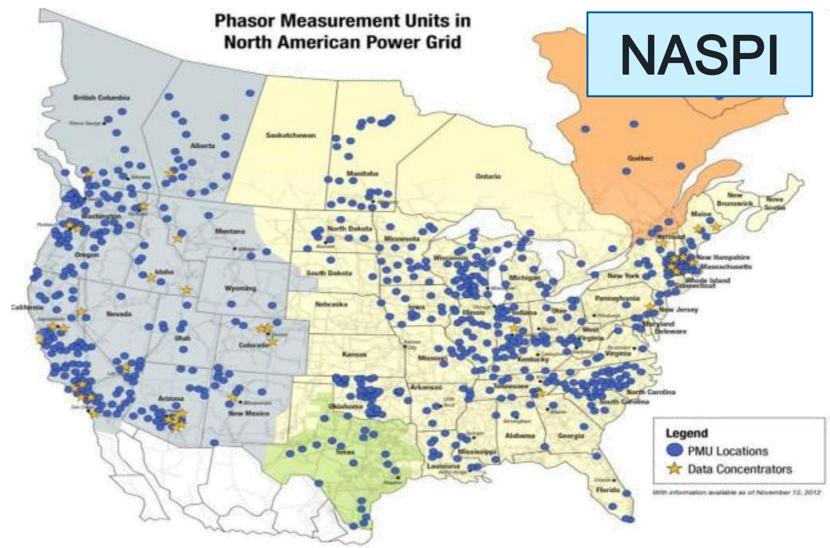
Source: BC Energy Institute

Wide Area Monitoring through Phasor Measurement Units



- Voltage instability monitoring
- Oscillation detection
- Maximum transfer capacity identification
- Load-ability factor determination
- Islanding detection
- Loss of synchronism recognition

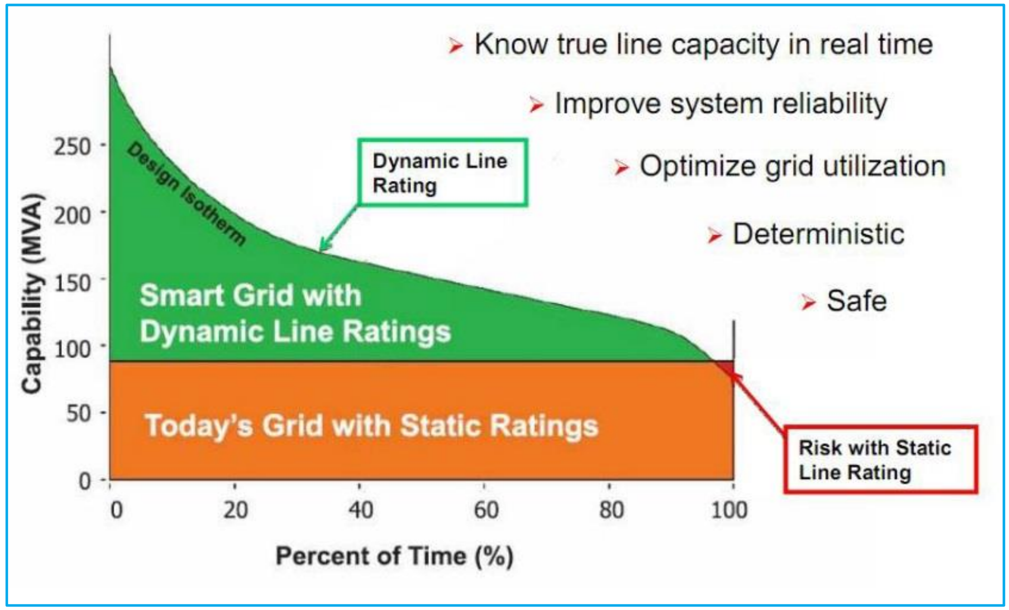




- Predictive algorithms can exploit synchronized wide-area measurements

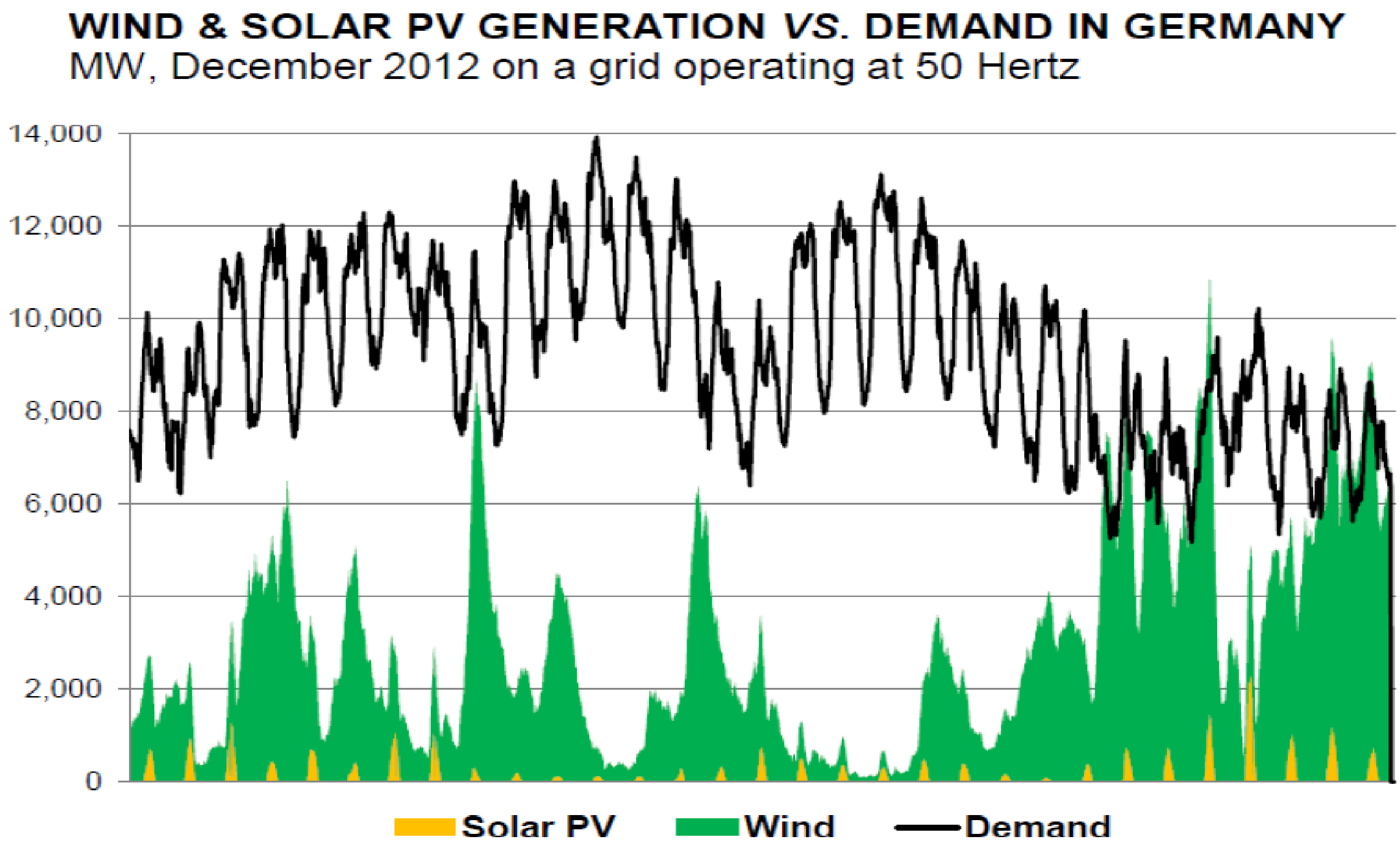
Dynamic Line Rating: dynamic characterization of network limits

- Dynamic Line Rating (DLR) permits to take into account the real thermal stresses on lines and equipment



- DLR allows to know the actual loading of the line and if it can be further loaded without incurring in premature aging of the conductors
- DLR methods are based on the real-time line's temperature estimation and the following calculation of the residual loading margin

Volatility of wind and solar generation creates challenges to the secure operation of the power system



A shift from conventional generation to renewables **requires new sources of flexibility to balance renewables volatility**

New services required to distributed resources

Delibera 300/17

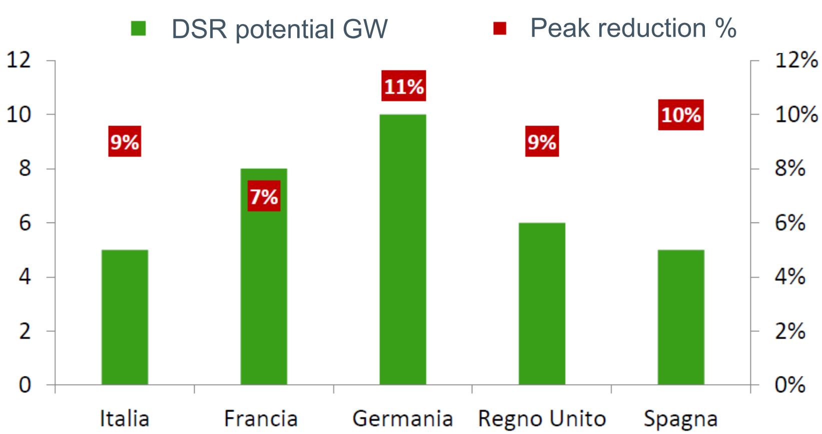
Pilot projects driven by Terna in its role of dispatching system operator in charge of primary, secondary and tertiary voltage regulation as well as congestions resolution and power balance.

Pilot projects involve plants for which those types of services are currently not required, e.g. renewables plants.

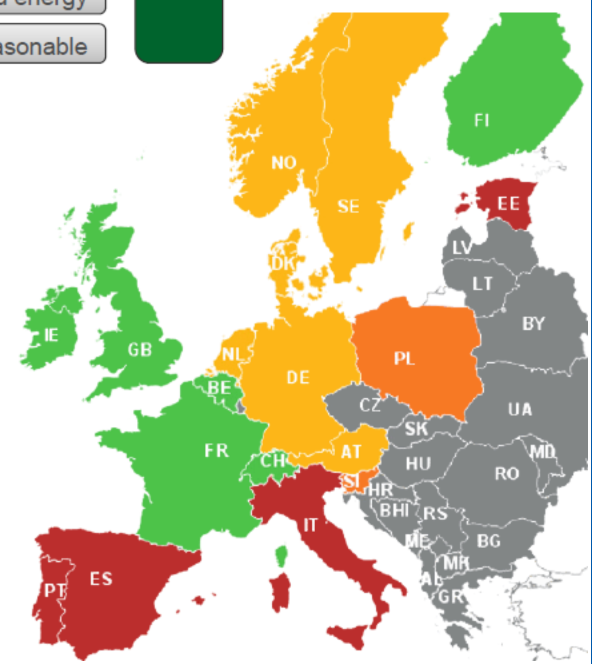
Involvement of customers: evaluation of Demand Side Response

Low	Level of consumer participation	High
All hours	**Resource availability**	Critical hours only
Arbitrary	**Event trigger**	Needs-based / transparent
Instantaneous	**Advanced notice**	Minutes / hours
Unlimited	**Event duration**	Fixed / short
None	**Event limits**	Daily / annual limits
Overly complex	**Technology requirements**	Adequate / reasonable
Complex / biased	**Baseline**	Simple / accurate / fair
None	**Aggregation**	By total portfolio
Energy only	**Payments**	Availability and energy
Severe	**Non-compliance penalties**	Reasonable

Deter ← → Encourage



Source: Osservatorio Rinnovabili

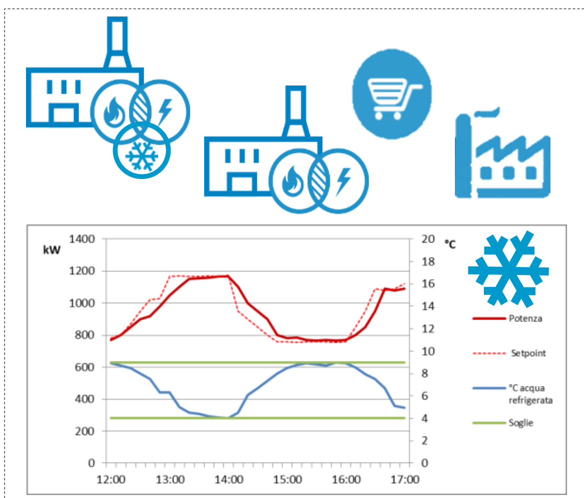


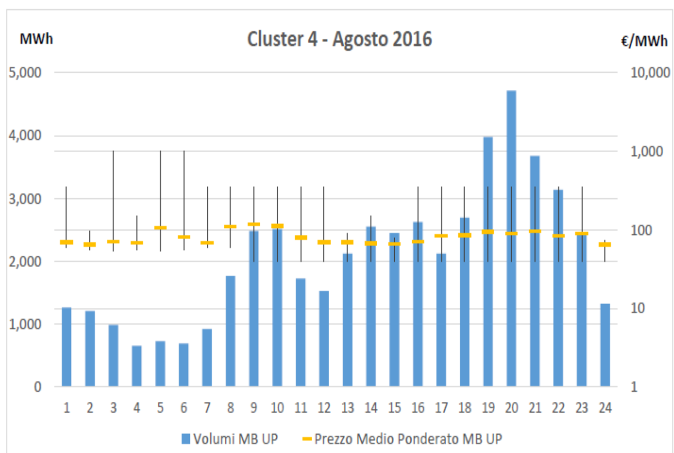
A new ancillary service market

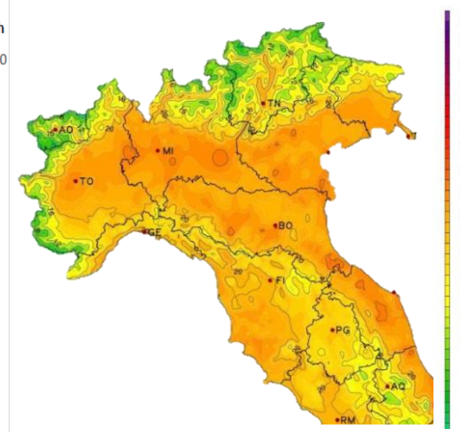
Resources availability

Resources value

Resources Forecasting

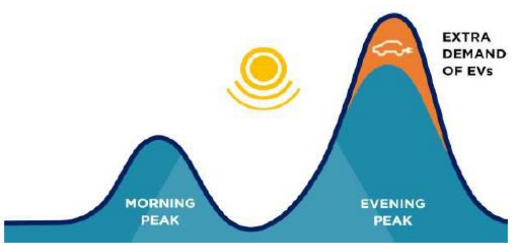






Potential impact of the Electric Vehicle on the grid and on the system adequacy can be mitigated through VGI Services

Uncontrolled Charging

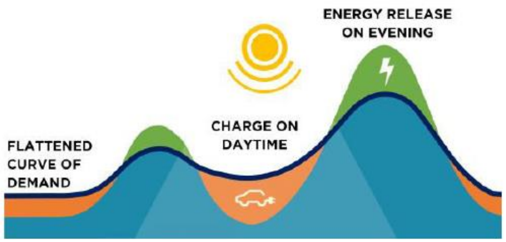


- Charging driven by need of immediate capacity
- Risk of high peak loads especially in the evening hours
- Less compatible with RES generation profiles

V1G

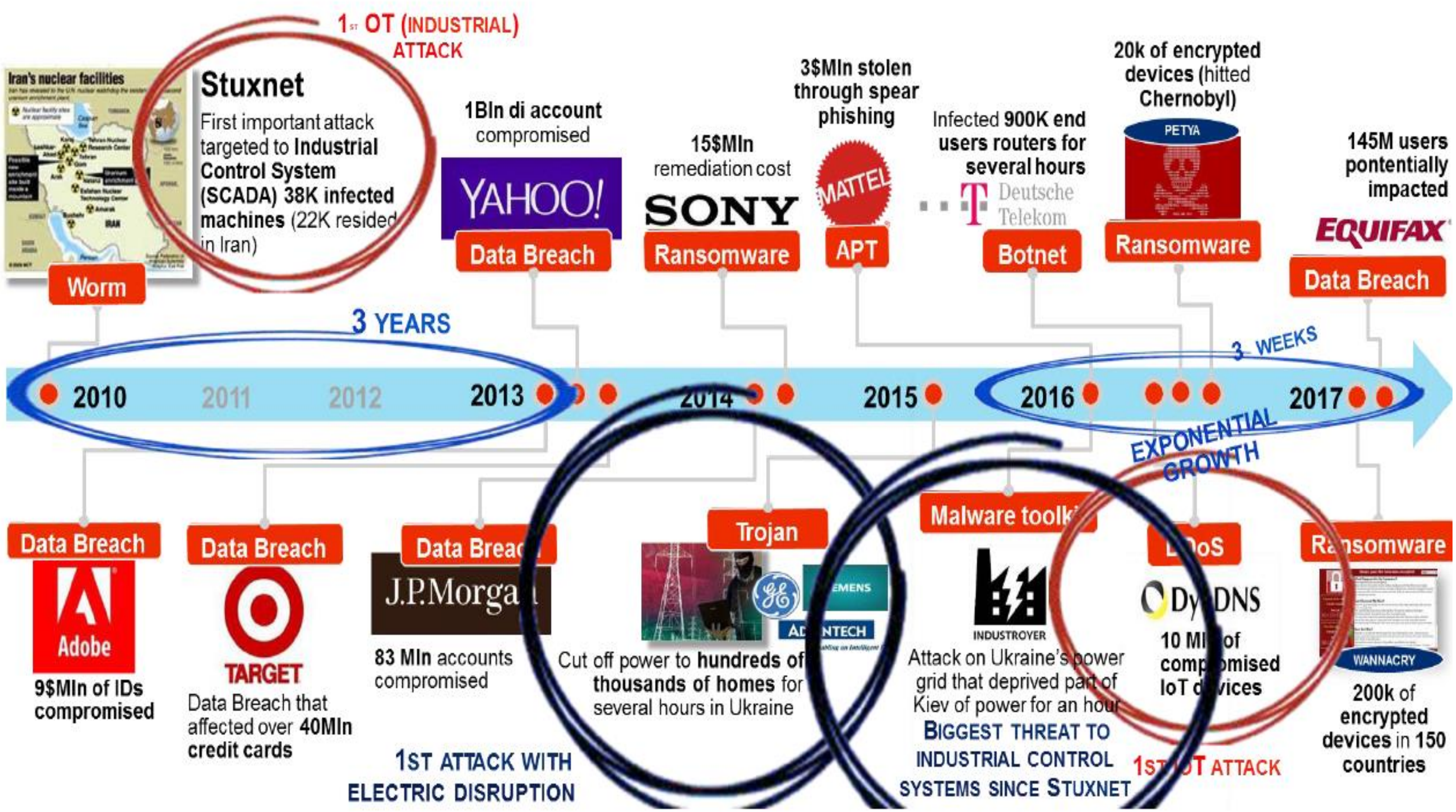
- Smart optimized controlled Charging
- Possibility to time-shift of peak loads
- Can follow RES generation patterns

V2G



- Smart optimized controlled Charging and possibility to reverse flow
- Possibility to time-shift of peak loads and load following
- Takes advantage of peak RES generation

Decentralization and exponential increase of access points place grids under a continuous cyber-threat



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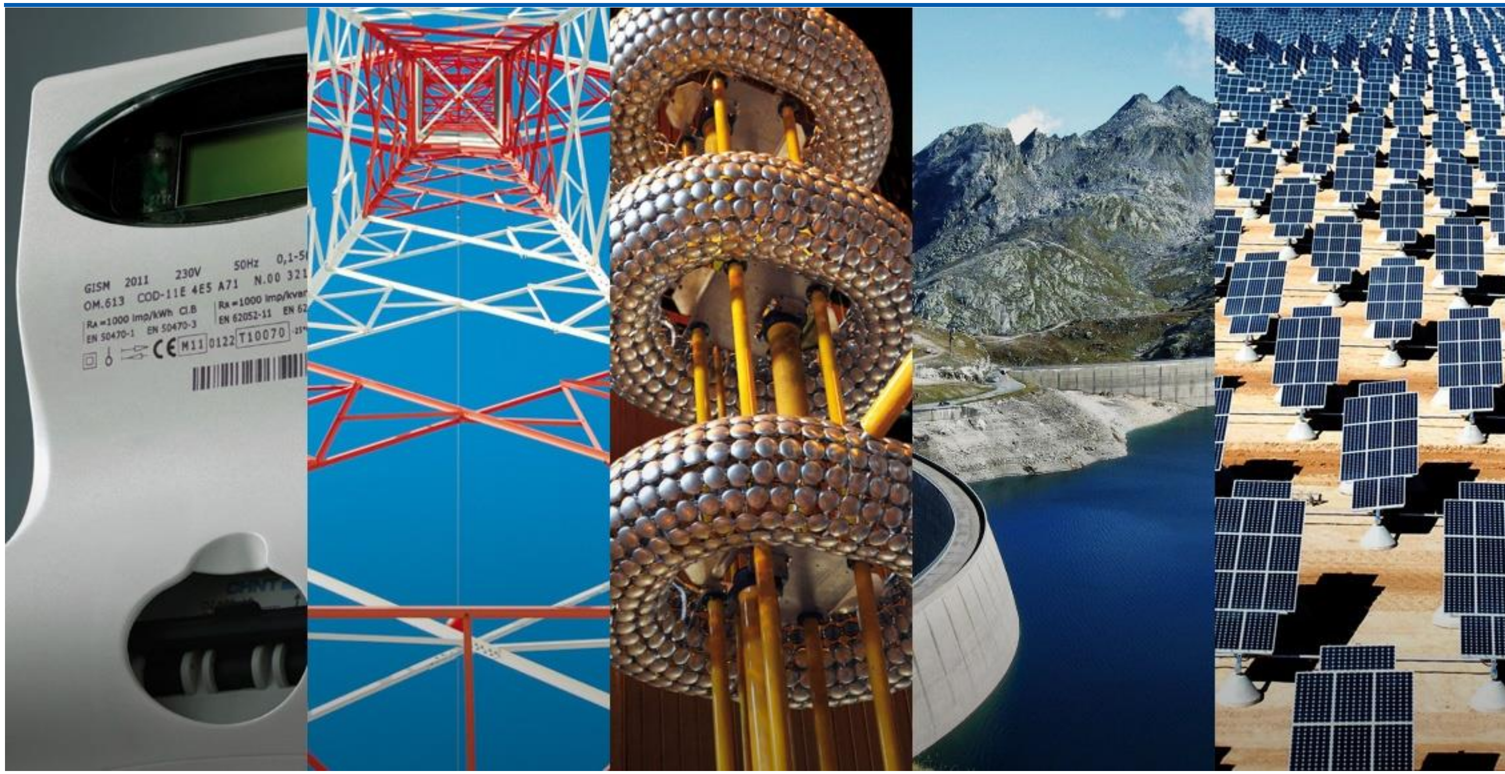

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