GRID4EU – Winner of the ISGAN Award of Excellence 2015

Topic: Integration of Renewable Energy

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GRID4EU INNOVATION FOR ENERGY NETWORKS

Global agenda

- GRID4EU brief presentation
- Zoom on the 6 Demos
- General Work Package activities
- Dissemination activities
- To stay connected to GRID4EU

An EU FP7 Smart Grids project

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- Project led by **6 Electricity Distribution System Operators** - covering altogether more than 50% of metered electricity customers in Europe
- Overall **27 partners** from various horizons (utilities, manufacturers, universities and research institutes)
- Duration: **51 months** from November 2011 to January 2016
- Total eligible costs: €54M - requested EC Grant €25.5M

ERDF	Enel	Iberdrola
Project Coordinator	**Technical Director**	**Chairman of General Assembly**

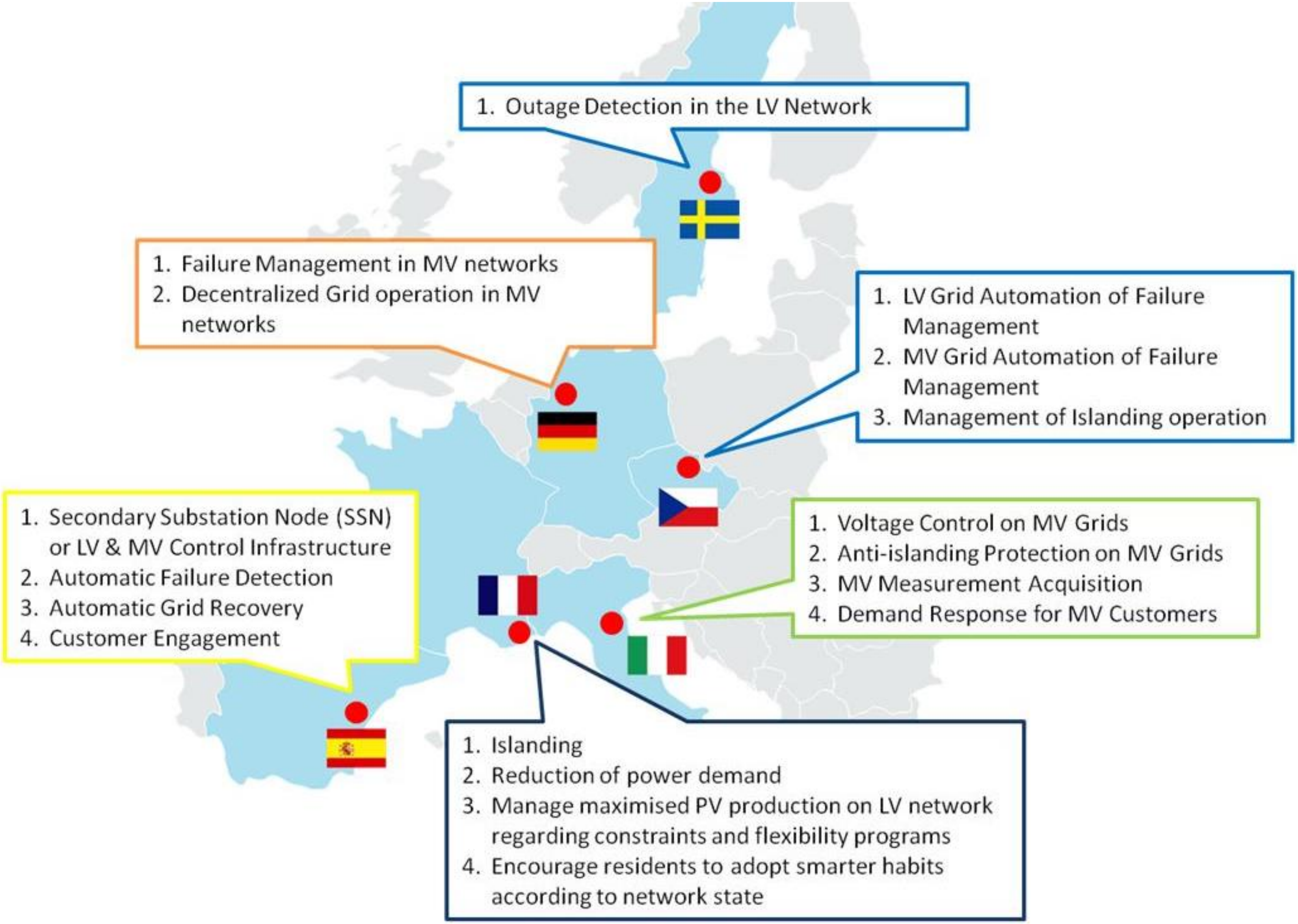
ČEZ Distribuce, RWE, Vattenfall

A project gathering 27 partners

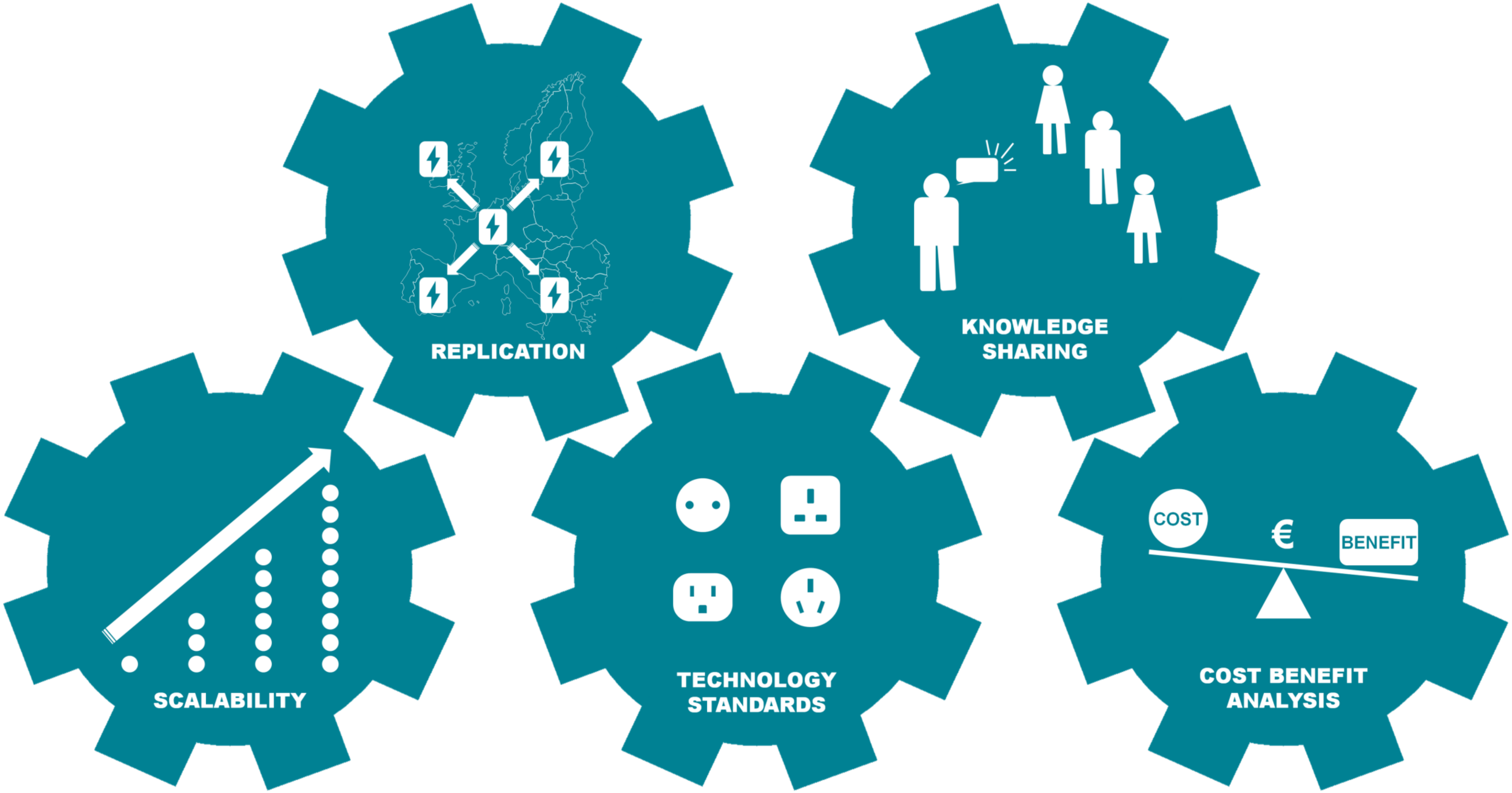
GRID4EU
INNOVATION FOR ENERGY NETWORKS

Focusing on 6 innovation streams…

…tested by 6 Demonstrators with different boundary conditions…



…to foster synergies and common work



A major focus is the integration of Renewable Energy

GRID4EU INNOVATION FOR ENERGY NETWORKS

	RWE	VATTENFALL	IBERDROLA	Enel L'ENERGIA CHE TI ASCOLTA.	CEZ GROUP	eRDF ÉLECTRICITÉ RÉSEAU DISTRIBUTION FRANCE
Distributed Energy Resources (DER)	DER			DER	DER	DER
Active Demand			ACTIVE DEMAND			ACTIVE DEMAND
Storage				STORAGE		STORAGE
Innovative Power Management at MV level	MV INNOVATION		MV INNOVATION	MV INNOVATION	MV INNOVATION	
Innovative Power Management at LV level		LV INNOVATION	LV INNOVATION		LV INNOVATION	LV INNOVATION
Micro-grid (Islanding)					ISLANDING	ISLANDING
Integration of Renewable Energy (Part of DER)	DER			DER		DER
Climate	**Moderate** *Continental*	**Cold & Stormy** *Continental / Oceanic*	**Mild** *Mediterranean*	**Dry** *Mediterranean*	**Cold** *Continental*	**Warm & stormy** *Mediterranean*
Population Density	Semi-urban	Urban	Urban	Rural	Semi-urban	Semi-urban / urban

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A project close to deliver final conclusions!

GRID4EU German Demo

Integrating Renewable Energy using an autonomous Medium Voltage control system

Lars JENDERNALIK, Westnetz GmbH
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INNOVATION FOR ENERGY NETWORKS

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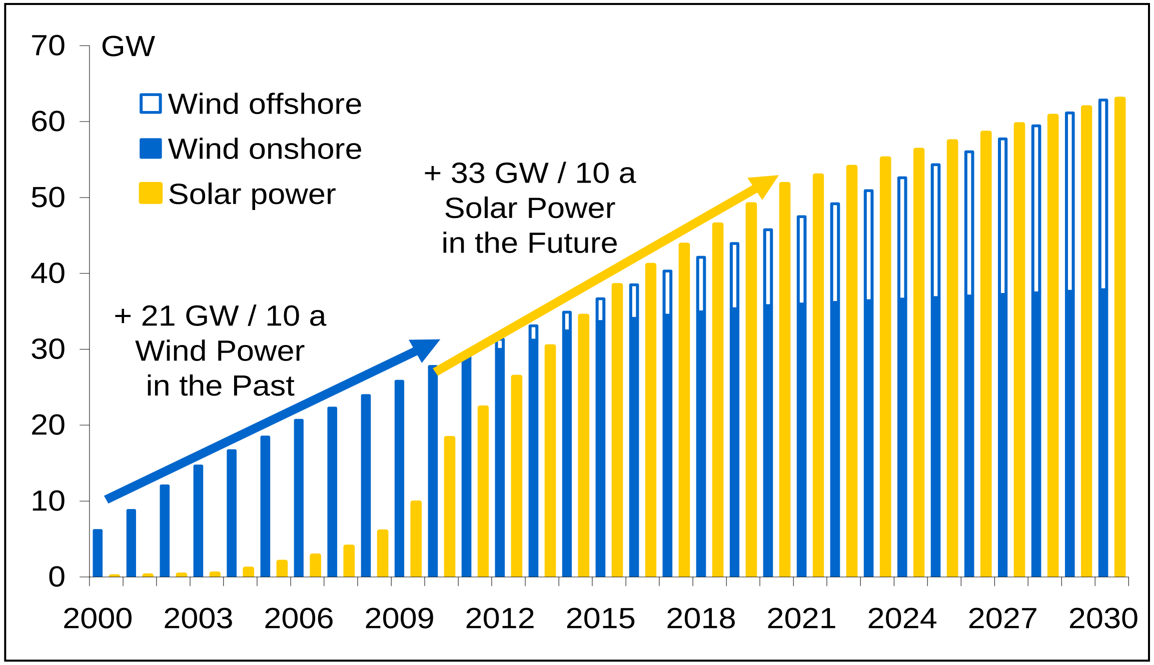
The German Demo

Renewable Energy in Germany



Renewable Energy in Germany

(figures end of 2014)

- Photovoltaic: 38.2 GW
- Wind (onshore): 38.1 GW

… and still increasing!

The situation today

- Massive increase of decentralized generation requires huge grid investments
- Power flow becomes less predictable (even reverse power flow becomes reality), grid operation and observation become more complex

The German Demo
Overview

Objectives

- Integration of an increasing number of decentralized energy resources (windmills, solar panels…) in the medium and low voltage networks
- Avoiding „classical“ network expansion measures
- Achieving higher reliability, shorter recovery times after grid failures
- Increasing the surveillance and remote-control level in MV networks to achieve better overload and failure management
- Loss reduction due to optimized switching situation for each scenario

Basic idea

- Extension of the automation level of MV networks based on an autonomously acting multi module system as an industrial solution for network operation

Partners

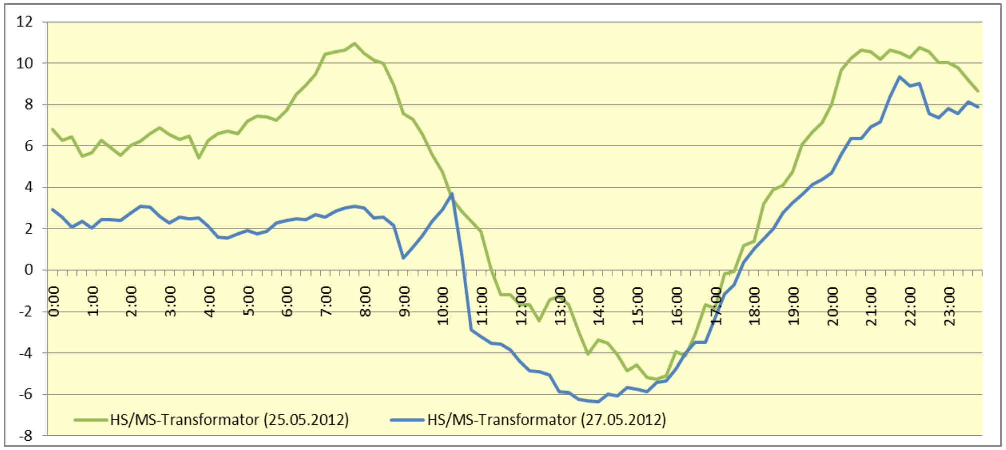
ABB

technische universität dortmund

RWE The energy to lead

The German Demo
Boundary conditions

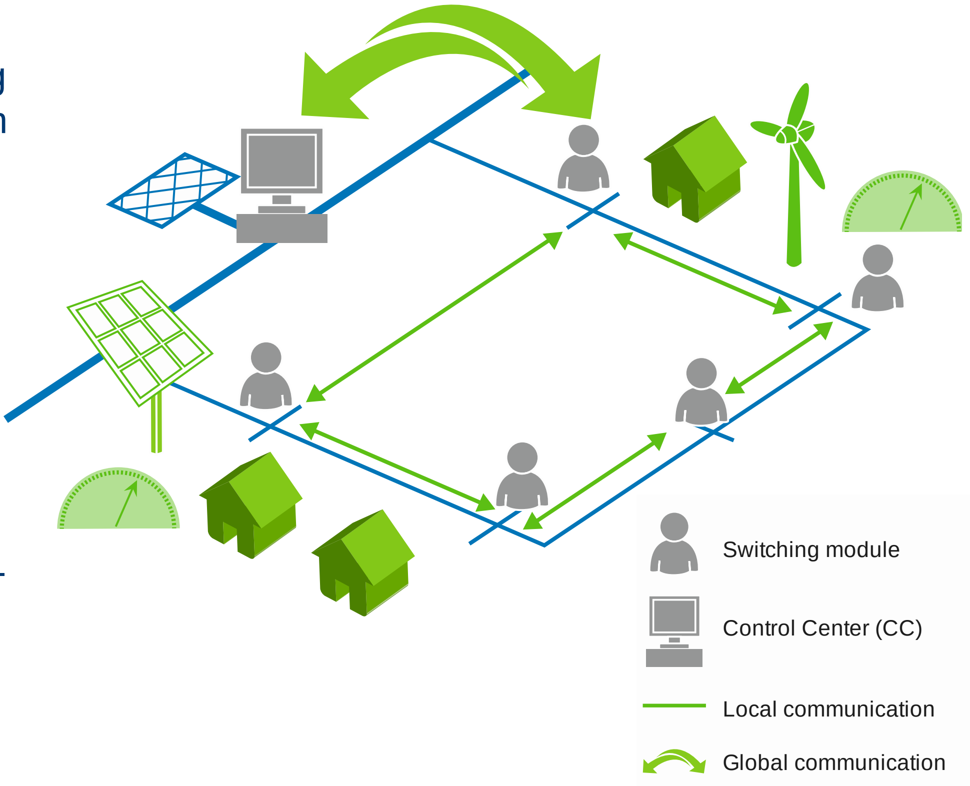
- Located in Germany, North-Rhine Westphalia, area of the municipality of Reken
- Semi-urban area with moderate continental climate conditions
- MV grid with approx. 100 secondary substations, (7 switching modules, 11 measurement modules)
- Ratio between maximum load and Decentralized Generation (DG) almost balanced
- Massive increase in DG expected



The German Demo
Principle concept

Concept

- Approach is based on autonomously working modules and a lean control center (located in primary substation)
- Modules communicate amongst each other and can act on remote-controllable switches in order to adjust grid topology to current state of grid
- Derivation of decisions based on measured operating parameters
- All relevant information (alarms, grid topology) is to be sent to the central SCADA-system



Multi module system can be …

- Pre-stage of MV/LV SCADA system
- Part of an existing MV/LV SCADA system to minimize central tasks

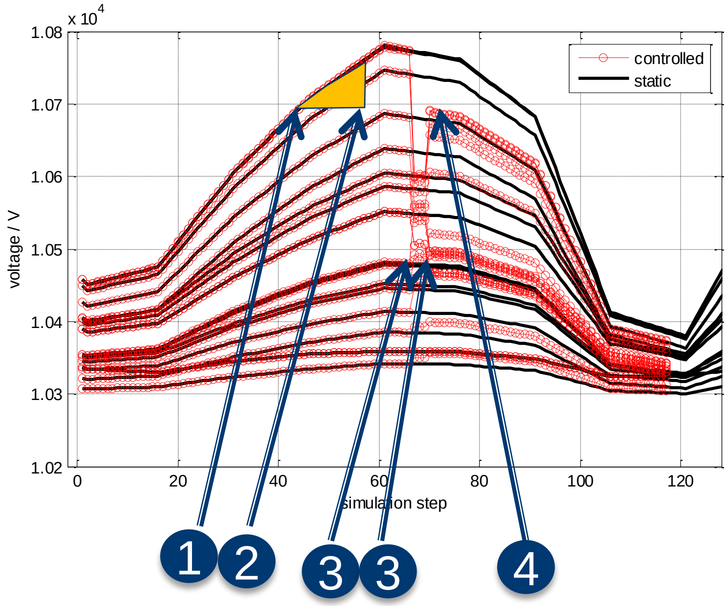
System acts and optimizes locally!

The German Demo
Hardware implementation in Reken

- **Option 1:**
  Full replacement of old secondary substations with an intelligent compact substation
- **Option 2:**
  Replacement of existing switchgear in walk-in substation / Implementation of “intelligence”
- **Option 3:**
  Dedicated cabinet solution containing new switchgear and “intelligence” added to existing substations

The German Demo
First indicative simulation results

Reconfiguration of the network topology leads to significant **improvement of the voltage**



1. Endangered State Level 1 detected
2. Transition to the Endangered State Level 2
3. Switching execution
4. Voltage violation resolved

Higher level of automation leads to **improved network reliability**

Situation	SAIDI in min/a	ASIDI in min/a
Current state	12,8	14,9
System applied	6,1	7,5

SAIDI
(System Average Interruption Duration Index)
→ Based on No of customers

ASIDI
(Average System Interruption Duration Index)
→ Based on Apparent power / rated power of assets

The German Demo
Field test phase in 2015

Stepwise operation approach towards operational autonomy

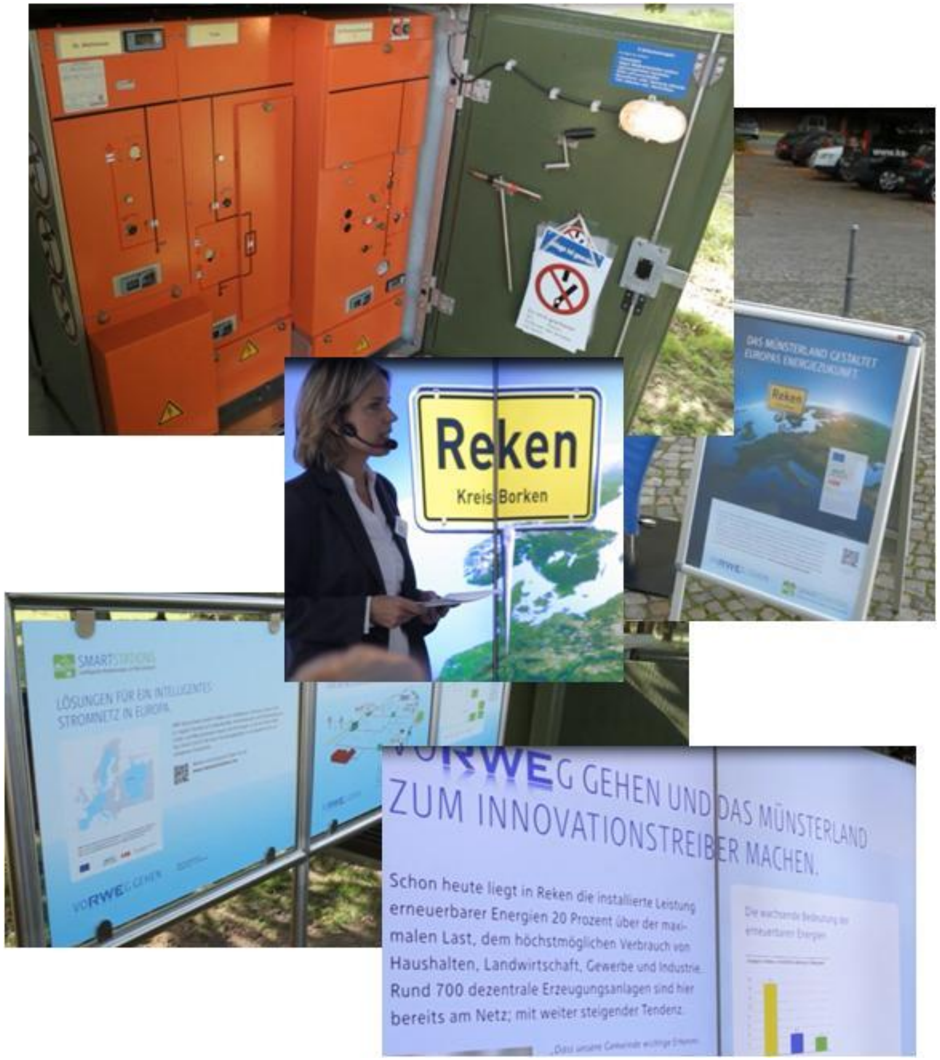
- ❑ Phase 0 – Recording of measured values and signals — “No switching”
- ❑ Phase 1 – Semi-automatic switching step 1 — “Switching via SCADA”
- ❑ Phase 2 – Semi-automatic switching step 2 — “Switching via central RTU in HV/MV substation”
- ❑ Phase 3 – Autonomous switching

Set of test cases clustered by

- ❑ Test phases 0 – 3
- ❑ Use cases (Threshold violation, FDIR, loss reduction)
- ❑ Test components (hardware, communication, software modules)

The German Demo
Conclusion

- Integrating a higher number of Renewable Energy is a key objective of the German Demo:
  - **The dynamic reconfiguration of the grid topology enables an optimum connection of time-dependent load and feed-in oriented grid sections**
- Field implementation of the autonomously acting multi module system in Reken successfully finalized
- Simulation results show the potential of an autonomous MV operating system
- 2015: Field test phase started



GRID4EU Italian Demo

Integrating Renewable Energy using an advanced control system communicating with the renewable generators, HV/MV & MV/LV substations and storage facility

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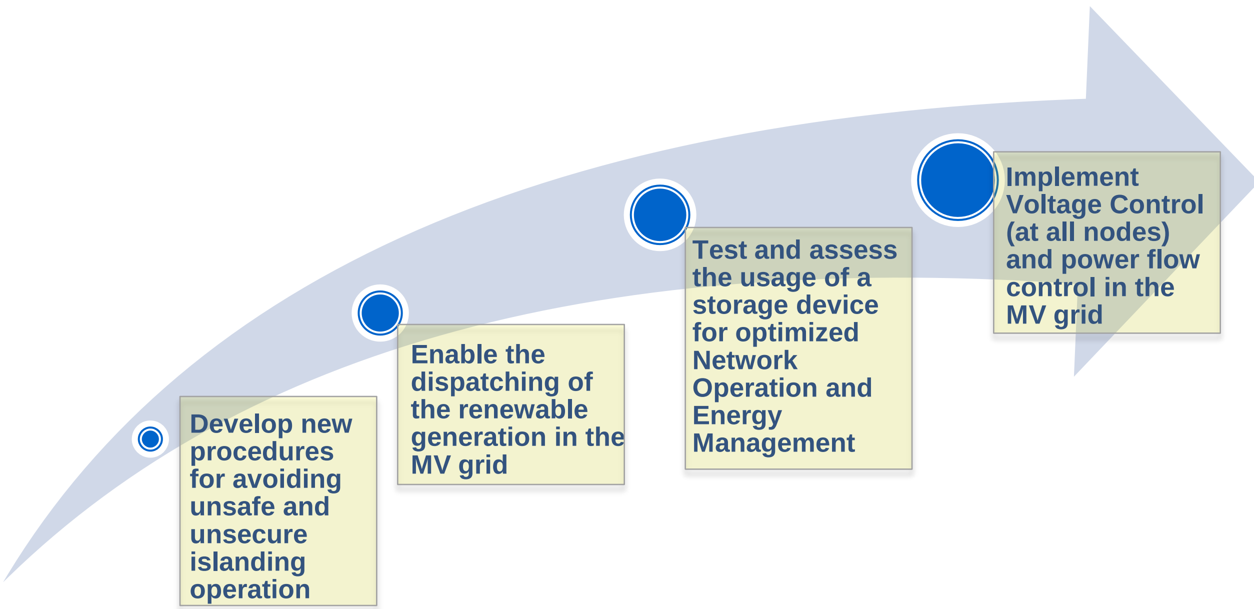
Daniele STEIN, ENEL SpA
(email address: daniele.stein@enel.com)

INNOVATION FOR ENERGY NETWORKS

The Italian Demo

Objectives

Increase the Medium Voltage (MV) network's hosting capacity for Distributed Energy Resources (DER, in particular solar), introducing Active Control and Demand Response of MV generators, controllable loads and storage

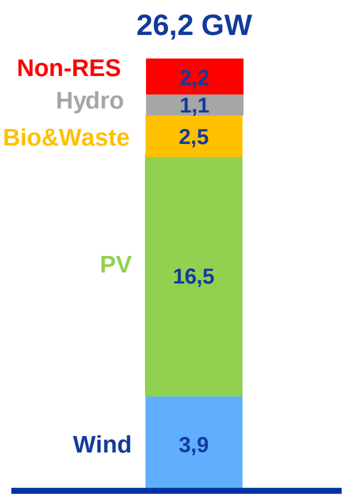


MV network Hosting Capacity

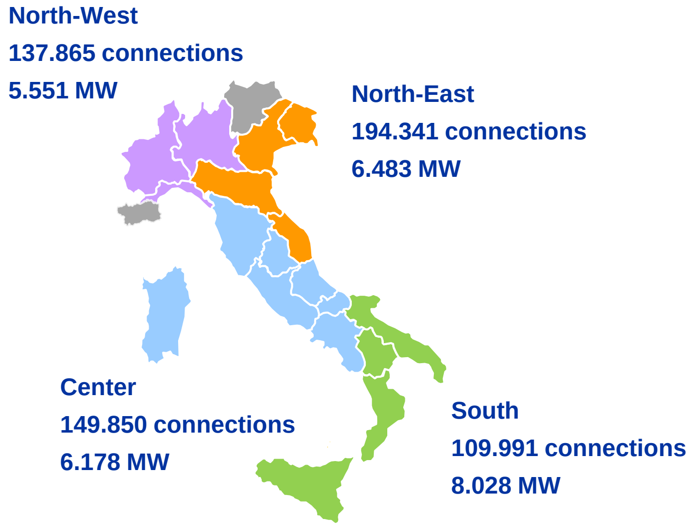
The Italian Demo

Distributed generation: an exponential growth

Connections to Enel Distribuzione's Network (up to Dec 2014)



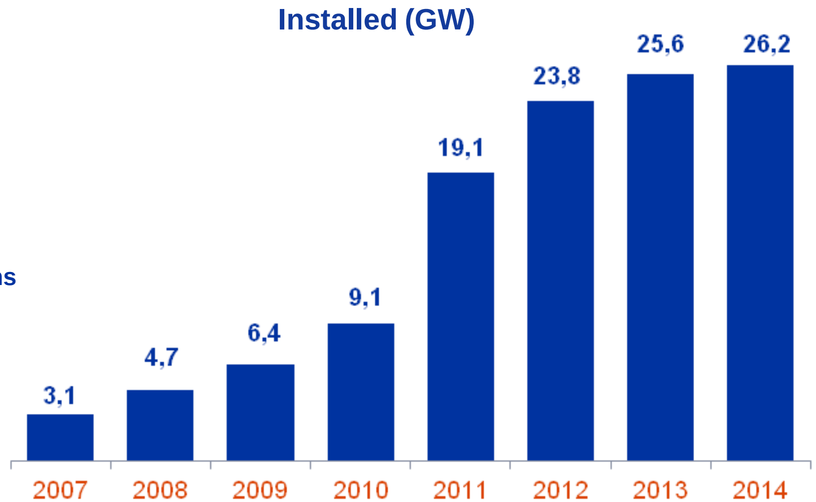
Connections 31.12.2014



TOTALE NAZIONALE

591.967 connections

26.240 MW

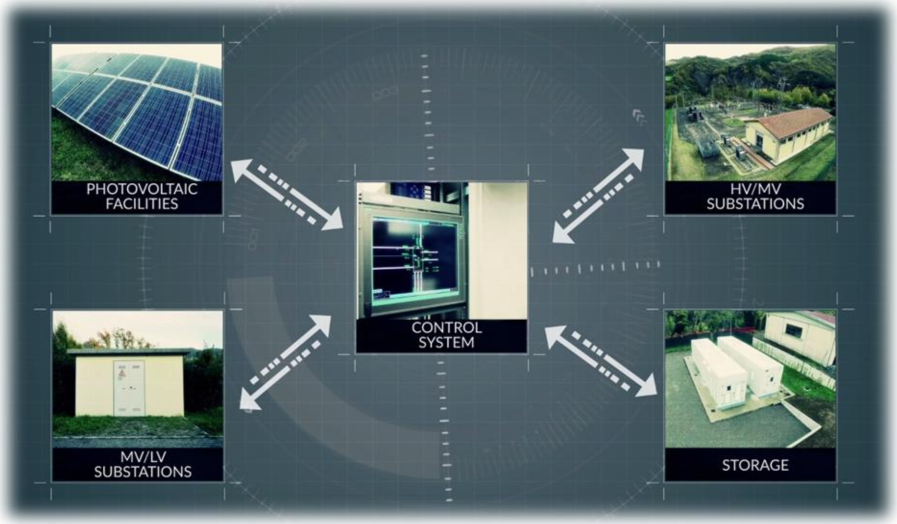


Most RES-Power is connected to MV network

The Italian Demo

The system: basic concepts

Realization of an **advanced control system** communicating with the renewable generators, HV/MV & MV/LV substations and storage facility.

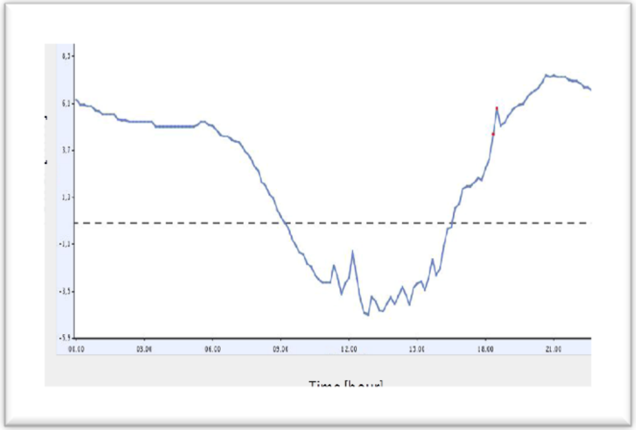


Realization of an **"always on", IP standard-based communication** solution connecting all the relevant nodes in the network (wireless, wired and PLC).

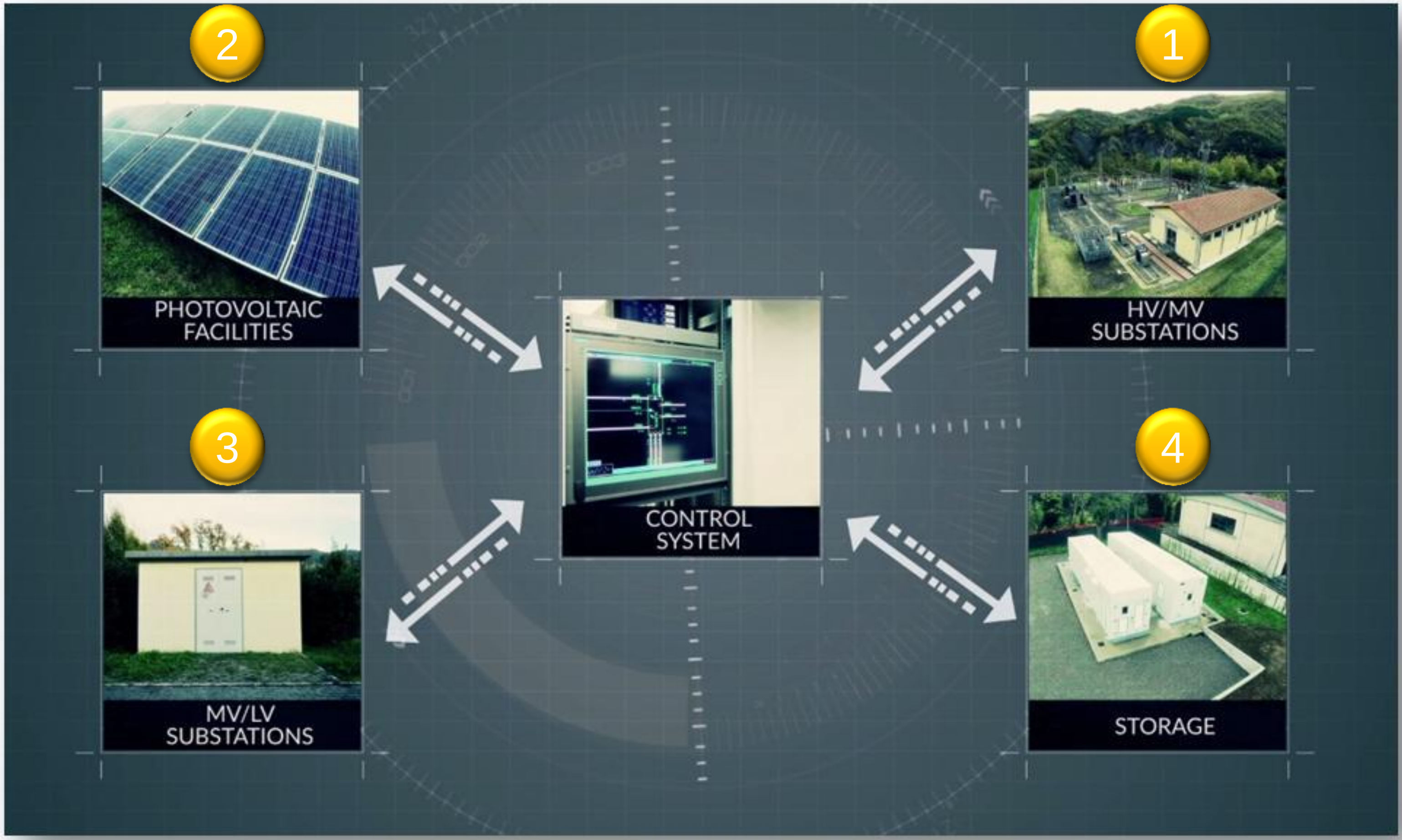
Installation of a **storage facility** (1 MVA / 1 MWh)

The Italian Demo
Site description

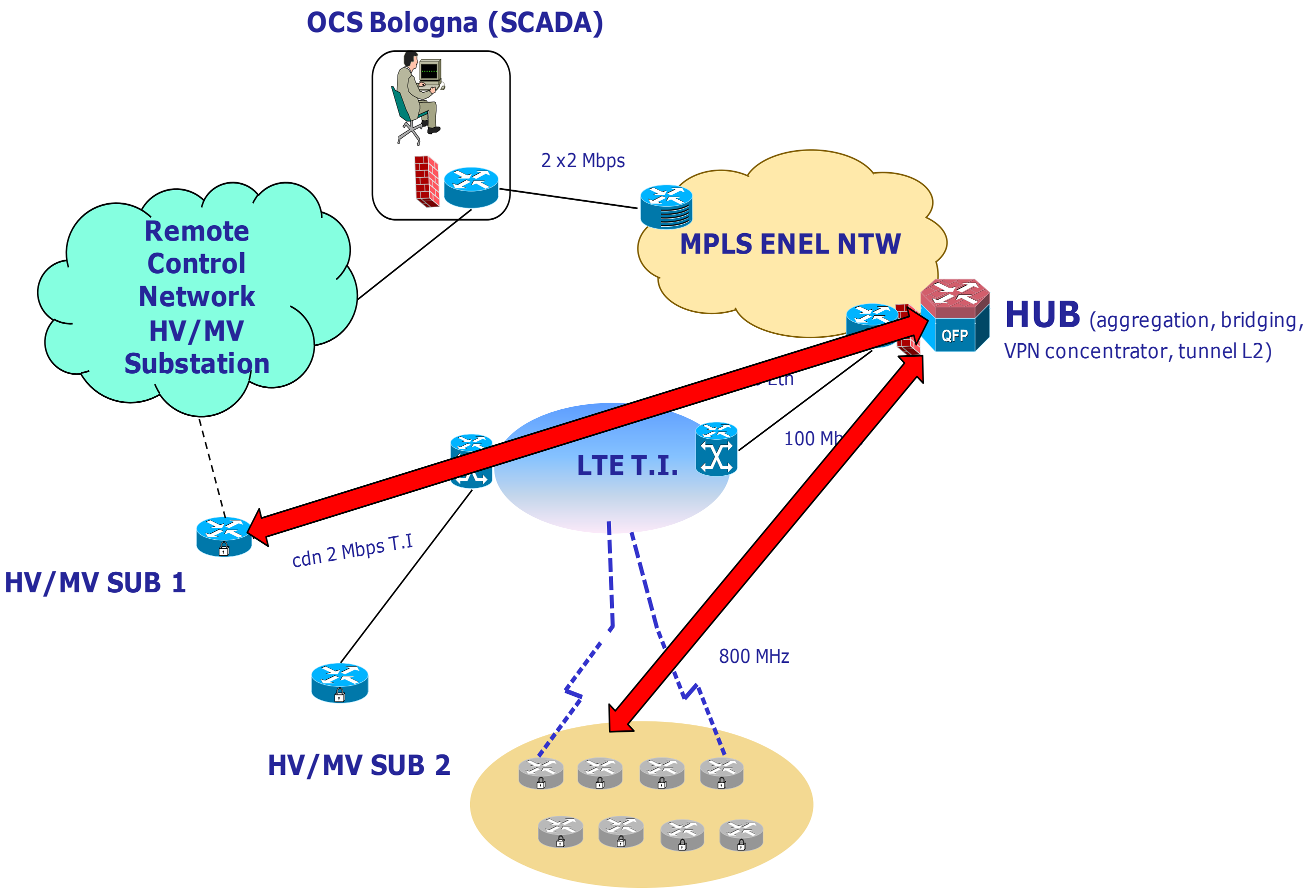
- Project is located in Forlì – Cesena (Emilia Romagna, Italy)
- 2 HV/MV substations, over 20 MV lines, 100+ MV substations and about 35,000 LV customers impacted
- High penetration of RES, mostly photovoltaic
- Low consumption area
- **Back-feeding phenomenon from MV to HV**



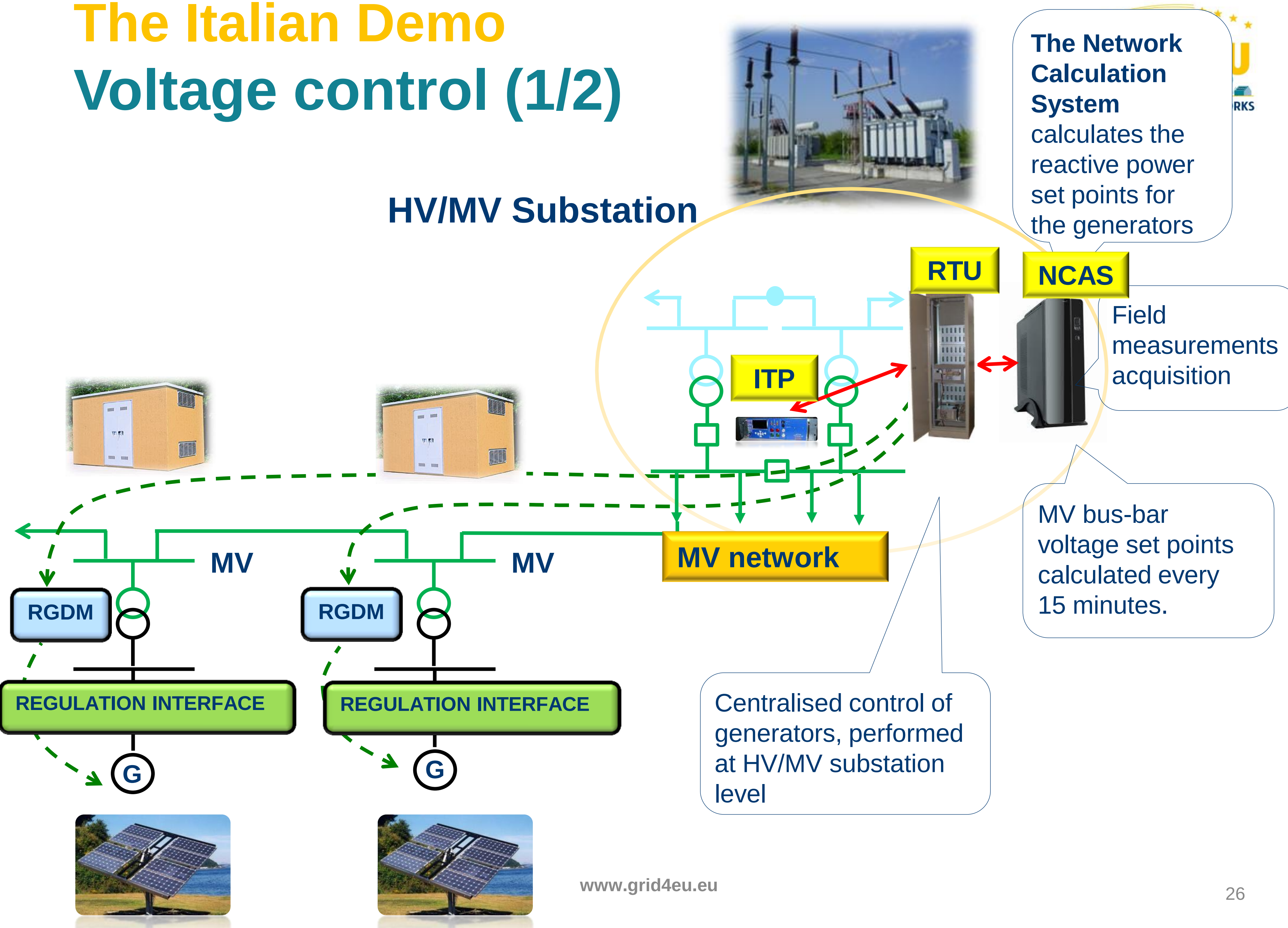
The Italian Demo
Field installations



The Italian Demo
Wireless telecommunication infrastructure
4G – LTE (Long Term Evolution)



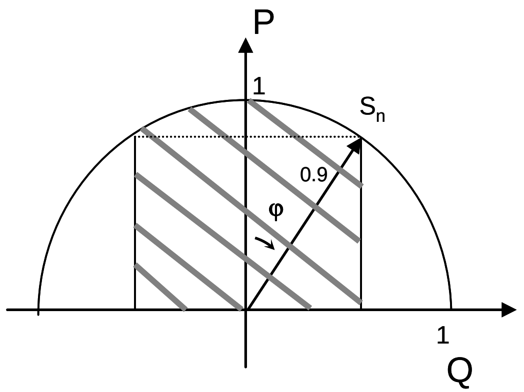
The Italian Demo
Voltage control (1/2)

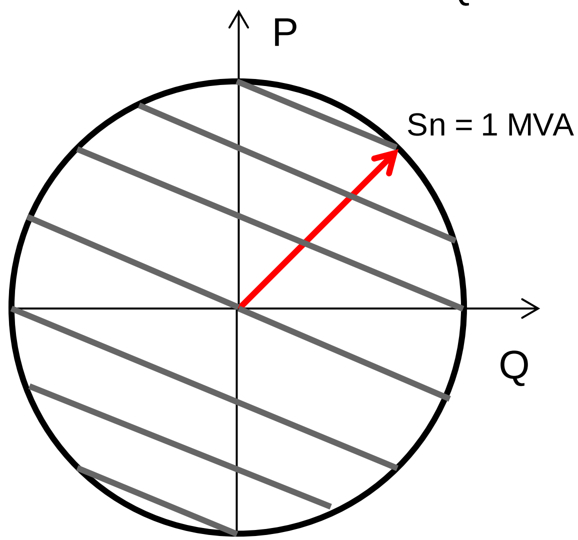


The Italian Demo
Voltage control (2/2)

Voltage control function achieved through Distributed Generation participation and the use of an Electric Energy Storage System (EESS).

- Every 15 minutes or in case of voltage limits violation the Voltage Regulation algorithm is triggered and sends optimized set points to:
  - HV/MV transformer tap changer
  - Generators local control systems for reactive power modulation (the algorithm takes into account the capability curve of each generator and the active power injected is not modified; nevertheless, active power modulation is possible, but it will not be tested in field)
  - Storage control system for active and reactive power modulation





The Italian Demo
Lessons learnt so far

- According to the first project results the most beneficial resource -for voltage regulation and for increasing the Hosting Capacity- is the On Load Tap Changer of the HV/MV transformer;

- Also the use of reactive modulation from generators can be an effective resource, but –in some cases – it may lead to losses increase;

- The Electric Energy Storage System (EESS) is able to contribute effectively to the voltage regulation; it can help HV-MV power flow control too (according to EESS capacity);

- For the usage of the EESS, the optimization horizon can cover from minutes to several days (key is the reliability of forecast), with a reasonable computation time;

- The Smart Grids systems rely very much on telecommunication systems, therefore it is important and necessary to foster “convergence” between electric distribution and communication infrastructures.

GRID4EU French Demo

Integrating Renewable Energy using residential, industrial and grid flexibilities (including storage)

Thomas DRIZARD, ERDF
(email address: thomas.drizard@erdf.fr)

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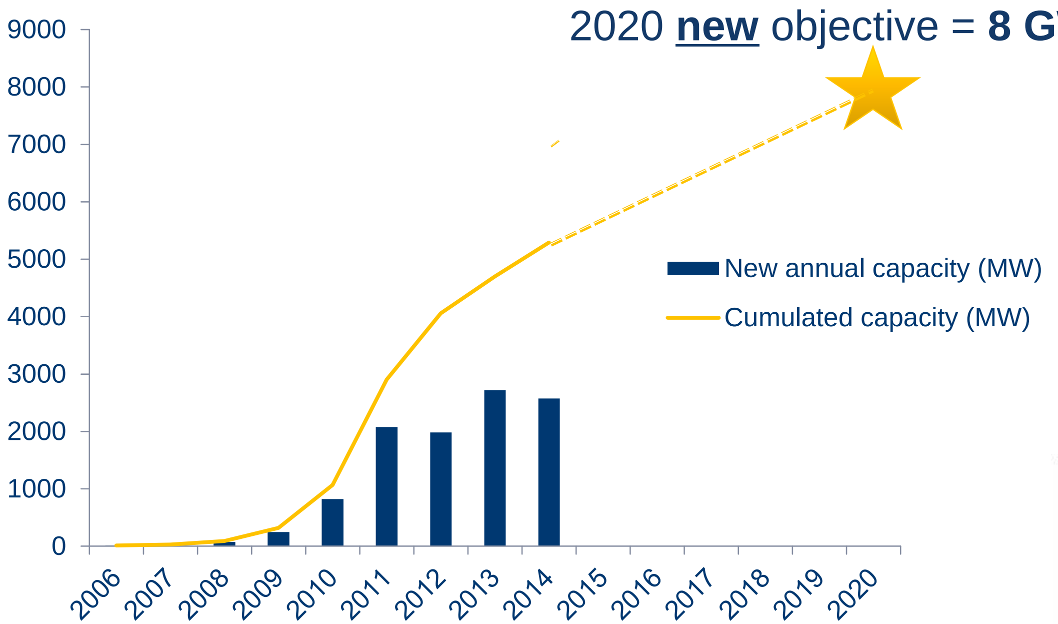
The French Demo
Photovoltaic energy in France

2020 **new** objective = **8 GW**



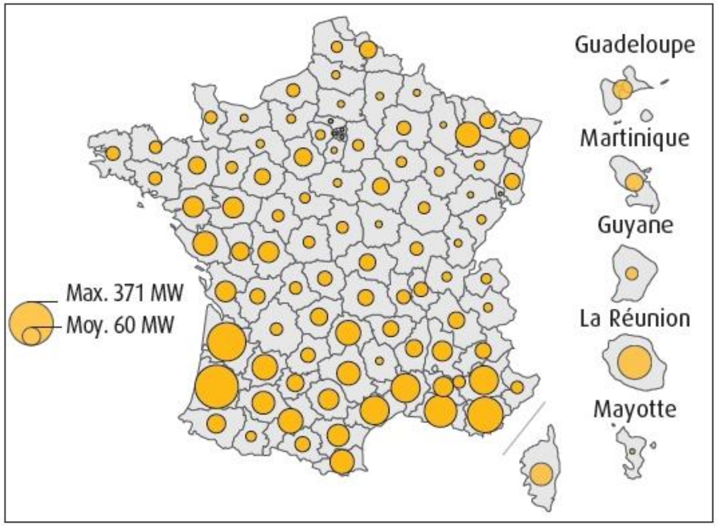
Renewable Energy in France
(figures end of 2014)

- ❑ Photovoltaic: 5,9 GW
- ❑ Wind (onshore): 9,9GW

… and still increasing!

The situation today (June 2015)

- ➢ 355 979 installations
- ➢ 6 GW



The French Demo
Overview

4 Use Cases

- Optimize massive PV integration in the distribution grid
- Test islanding on a low voltage district
- Test a 3,5 MW load management in winter
- Give the customer a new role within the grid: prosumer

Main figures

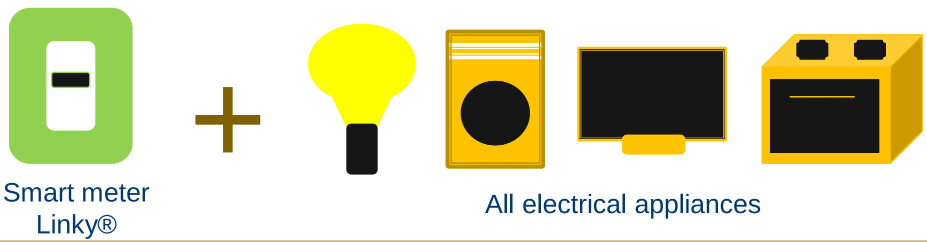
- **4 years** project
- **30M€** budget
- **300** participating clients
- **1, 3 MW** grid storage
- **80 kW** residential storage
- **2 to 3 MWp** installed PV capacity

Consortium

erdf, saft, EDF, ALSTOM, socomec, NetSeenergy, ARMINES, nke Watteco, DAIKIN

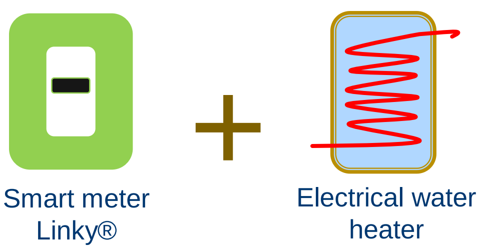
The French Demo
Three types of residential flexibilities

SOLAR BONUS (SBO)



- Extra off peak hours between 12 AM and 4 PM
- SMS warning

SMART WATER TANK (SWT)



- Water heater switched on between 12 AM and 4 PM
- Extra off peak hours accordingly
- SMS warning

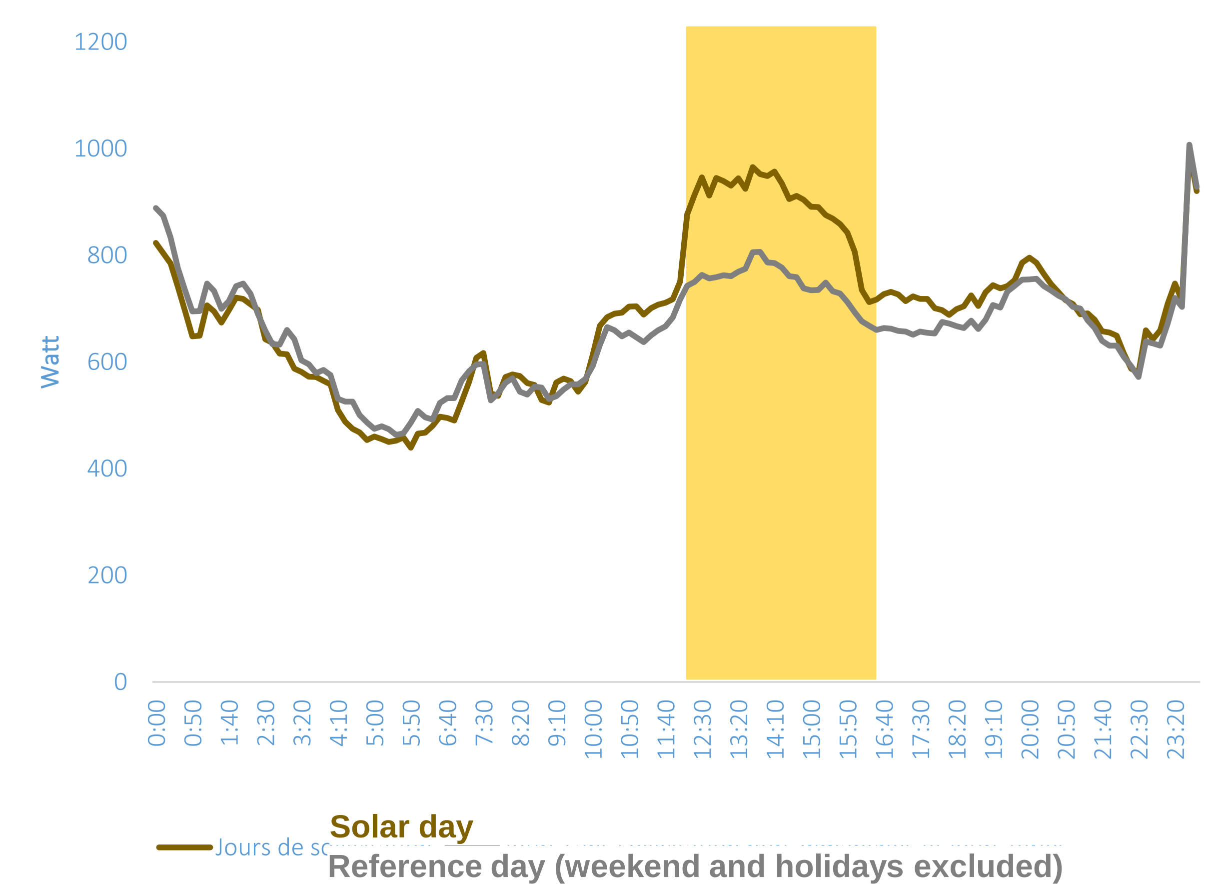
SMART STORAGE (SST)

- Remotely controled batteries
- Extra off peak hours
- SMS warning

The French Demo

2015 results: solar bonus

Average load curve on a solar day for 36 clients with solar bonus offer considered from June 1st 2015 to July 31st 2015 (W)

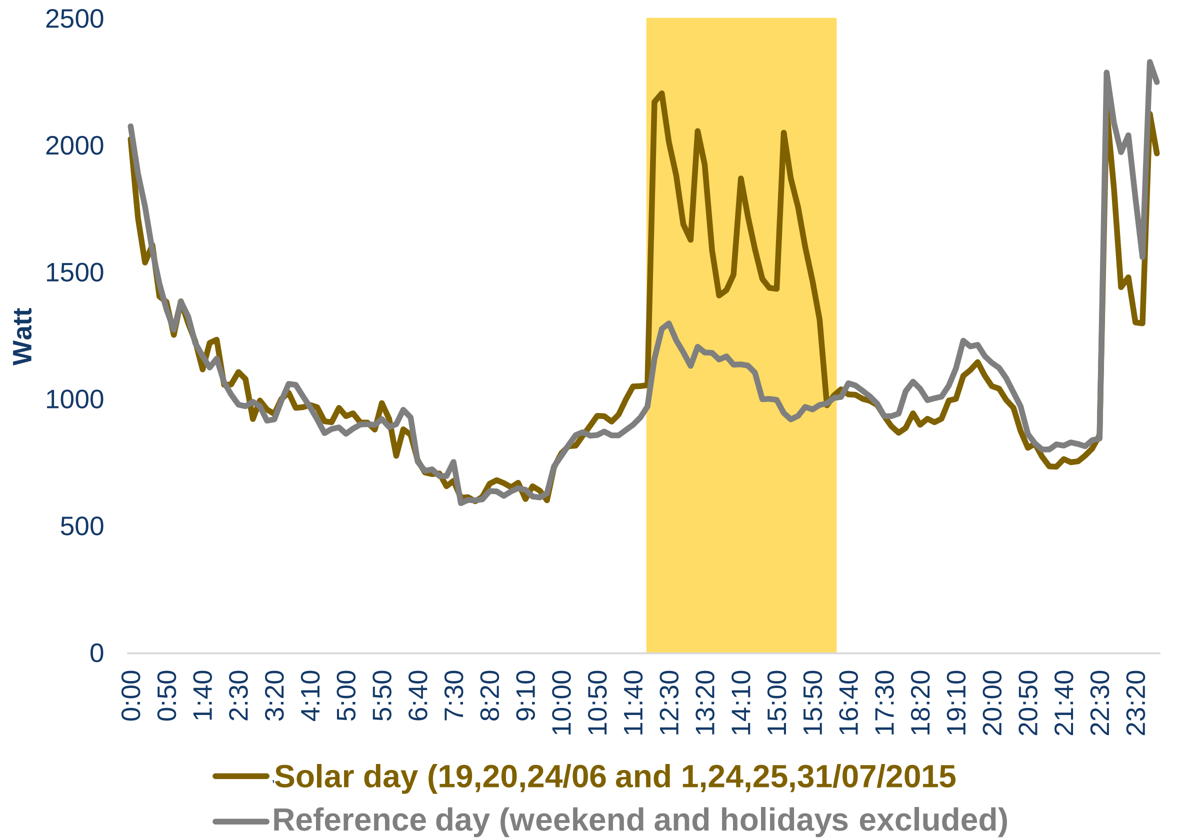


- **20% more consumption between 12 AM and 4 PM compared to a reference day (0.6 kWh).** *2014 results was 12% (0.4 kWh)*
- **Overall overconsumption of 5 % during the whole day (0,7 kWh).** *2014 results was -2% (-0.3 kWh)*

The French Demo

2015 results: smart water tank

Average load curve on a solar day for 18 clients with smart water tank (cascade version) considered from June 1st 2015 to July 31st 2015 (W)



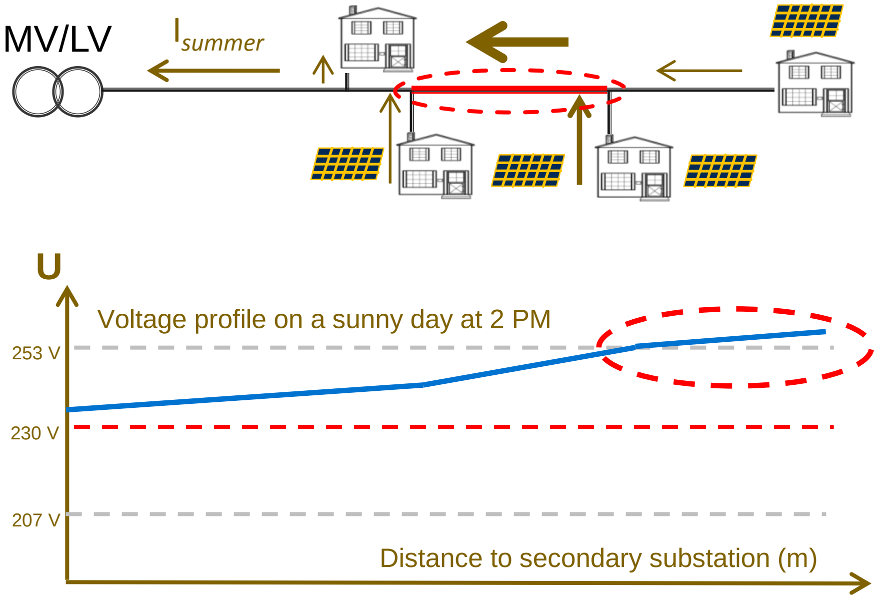
- **Smart water tank is switched on in "cascade": at 12:00, 13:00, 14:00 and 15:00 for 1 to 4 hours**
- **Overconsumption of 56% compared to a reference day (2,4 kWh).** *2014 result was 57% (2,4 kWh)*
- **Overall overconsumption of 7 % (1,7 kWh).** 2014 result was 5% (1,3 kWh)

☞ **Solar bonus is also present**

The French Demo
Solar OLTC transformer

Context

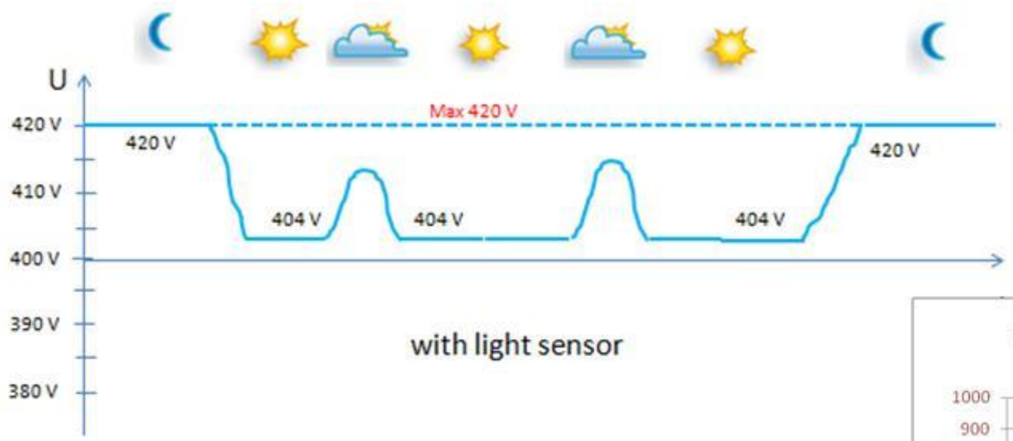
The MV grid voltage moves up or down because of DER generation and customer consumption
➔ ERDF connecting rules allow no more than 4% of increase of voltage on LV network, to prevent overvoltage downstream at any time
➔ An On Load Tap Changer Transformer (OLTC) allows for changing dynamically the voltage ratio of a secondary substation

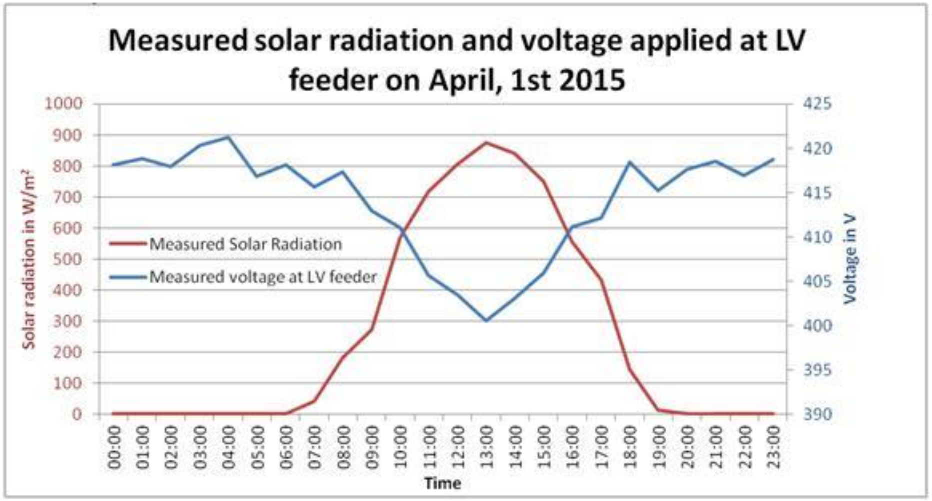


The French Demo
Solar OLTC: principles and results

Principles

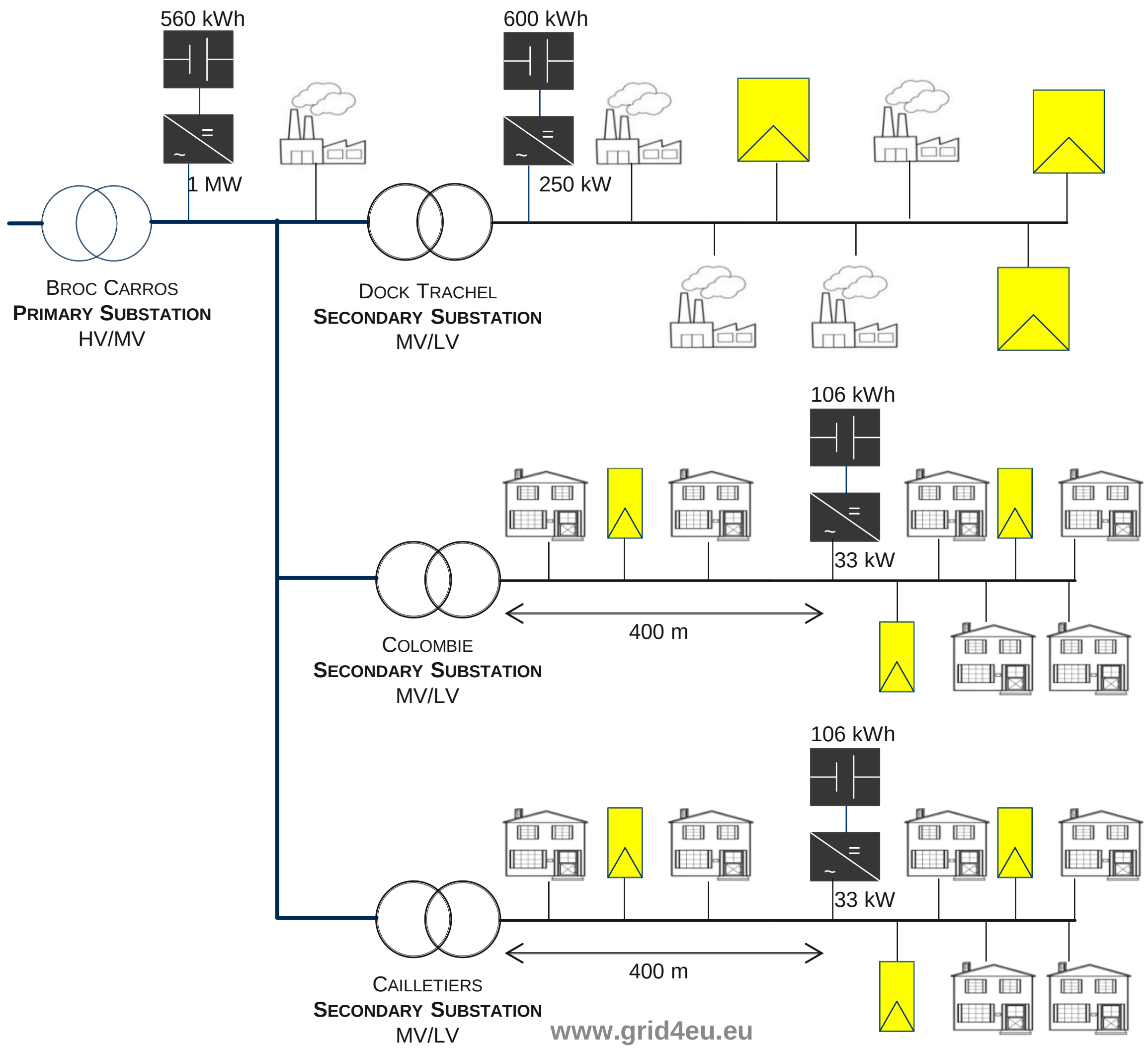
- The solar transformer is first an OLTC transformer, with a voltage setpoint of 232 V (or 404 V)
- PV generation is almost the only DER at this level
- At night or in winter, there is no PV generation and it is a peak period with risks of voltage drops





The French Demo

Grid batteries involved in PV integration



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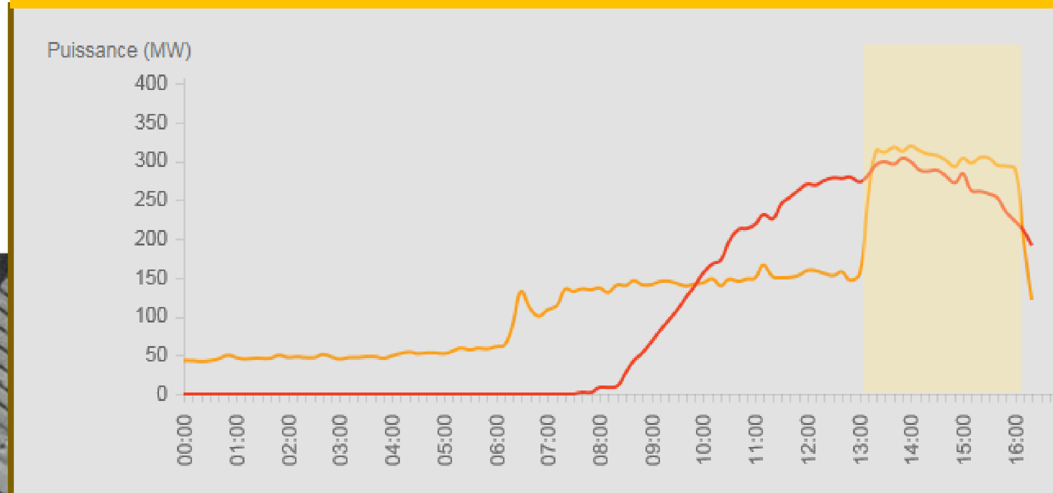
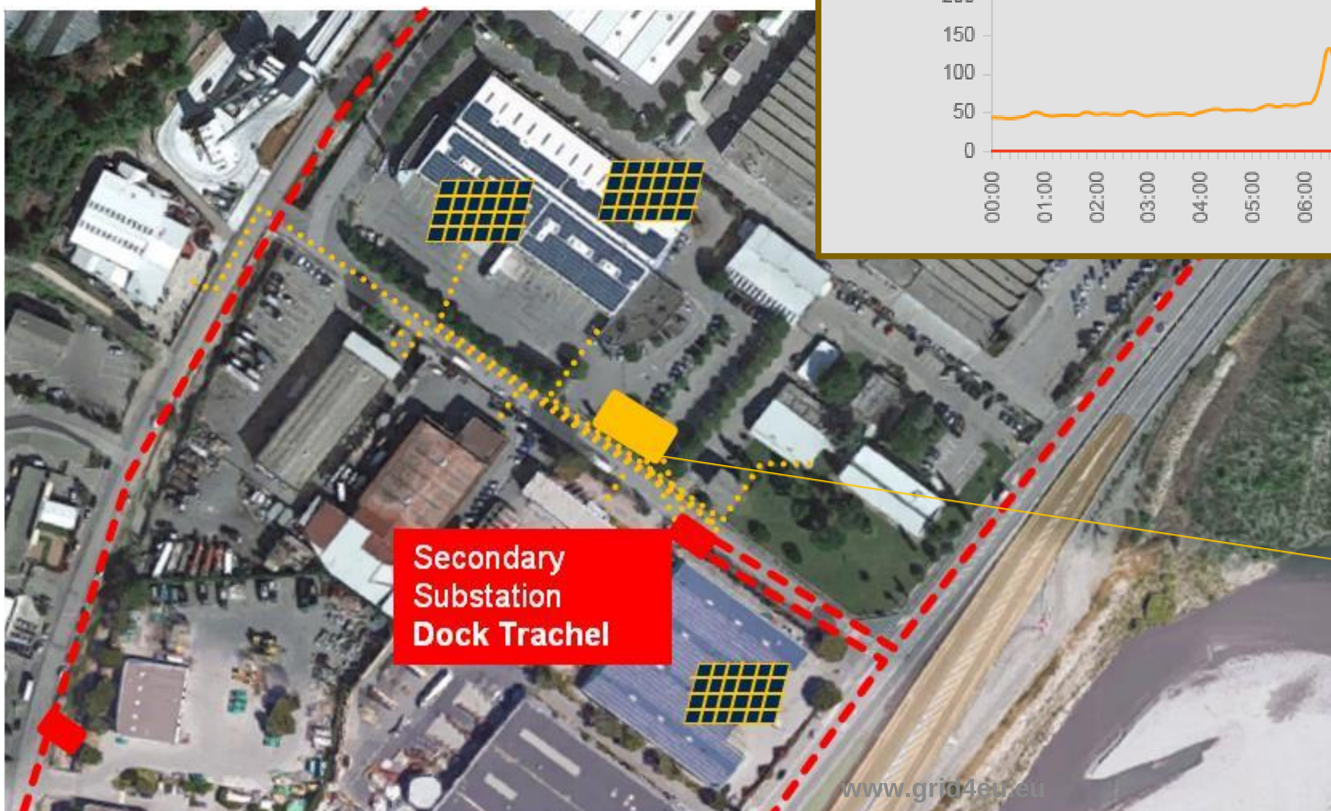
The French Demo
Effect of batteries: current constraints

Principles

- Reverse power flow at secondary substation level
- Use storage to limit exported PV power

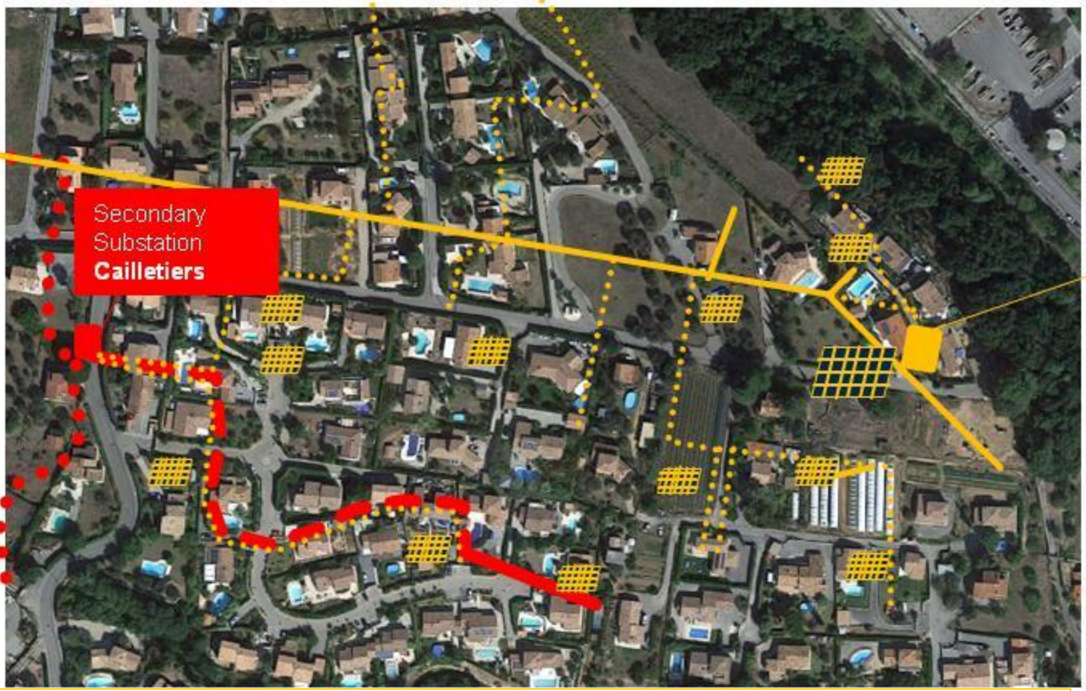
Consumed (yellow) and generated (red) power (MW)



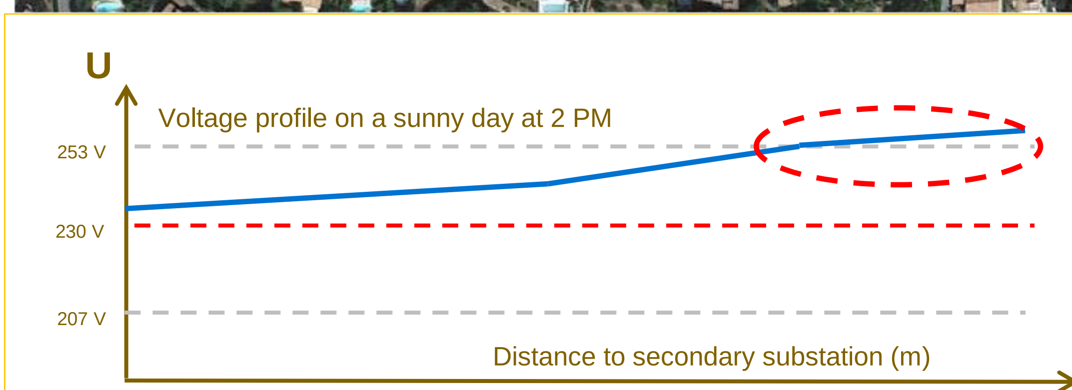


250 kW / 600 kWh Storage System

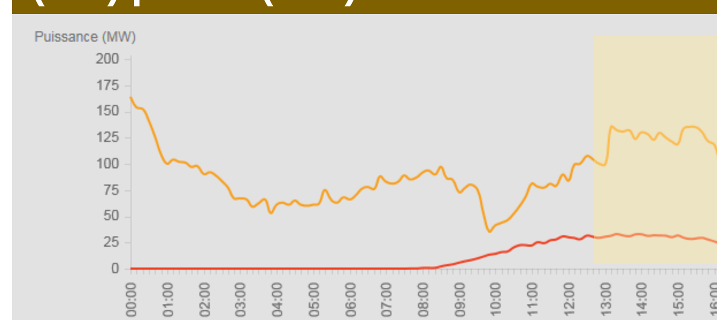
The French Demo
Effect of batteries: current constraints



33 kW / 106 kWh
Storage System



Consumed (yellow) and generated (red) power (MW)



The French Demo
Conclusions and perspectives

- Residential clients results are preliminary, and have to be consolidated at the end of summer
- Evolved smart water tank will allow for limiting the peak and extending the charging duration
- Smart transformer is a « plug and play » solution and works dynamically
- Grid storage is responsive and efficient, but acts on the three phases with the same manner, whereas LV grid are desquilibrated
- Real time storage management to be implemented by 2016 (light sensor)
- Secondary substation able to perform islanding for a few hours: successful tests in december

Overall perspectives

- To ease the replication of promising approaches developed and tested in Demos, GRID4EU put the emphasis on transversal activities
- In particular, concerning Replication and Scaling-up:
  - Accounting for more than 50% of the European metered Energy, GRID4EU relies on a consistent playground for scaling-up and replication
  - The Scalability and Replicabilty Analysis performed within the project already started benchmarking quantitative technical outcomes and is currently carrying a wider quantitative analysis including social and regulatory aspects
- Final results will be presented in the final deliverables and during the GRID4EU final event on January 19th, 2016 in Paris

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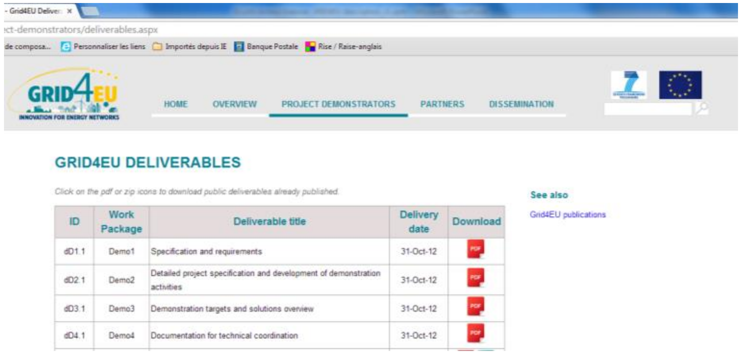
Have a look on GRID4EU videos:
https://www.youtube.com/channel/UCkCfcwCz4Nze5j6idG-5aWg/videos

All public deliverables are available on the GRID4EU Website:

http://www.grid4eu.eu/project-demonstrators/deliverables.aspx



For more information: **question@grid4eu.eu**