Smart ICT - enabled Rural Grid innovating resilient electricity distribution infrastructures, services and business models

smartruralgrid.eu

This project has received funding from the European Union's Seventh Framework Programme for research, technological development and demonstration under grant agreement no. 619610.

Niagara 2016 Symposium on Microgrids
Thursday and Friday, 20-21 October 2016
Niagara-on-the-Lake, Ontario

The SmartRuralGrid EU project: Power Router and VPP enabling coupled LV Microgrids

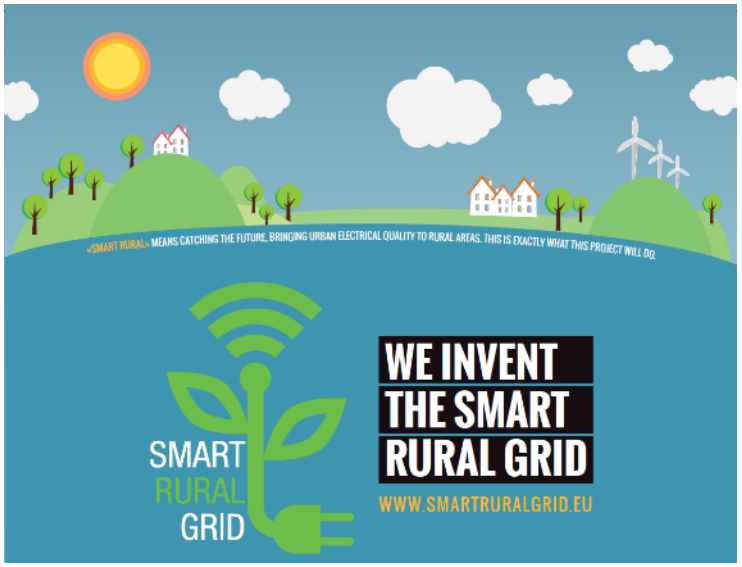
Dr. Volker Bühner
EUS GmbH (KISTERS Group)

This project has received funding from the European Union's Seventh Framework Programme for research, technological development and demonstration under grant agreement no. 619610.

Agenda

- Concept
- Intelligent Distribution Power Router (IDPR)
- Energy Management
- First results

Consortium



Estabanell Energia

CITCEA UPC Membre de: TECNIO Be tech. Be competitive

ZIV communications

SMART RURAL GRID

xarxaoberta de Catalunya

KISTERS

stadtwerke rosenheim

Smart solutions. Strong relationships.

smart innovation østfold

Concept

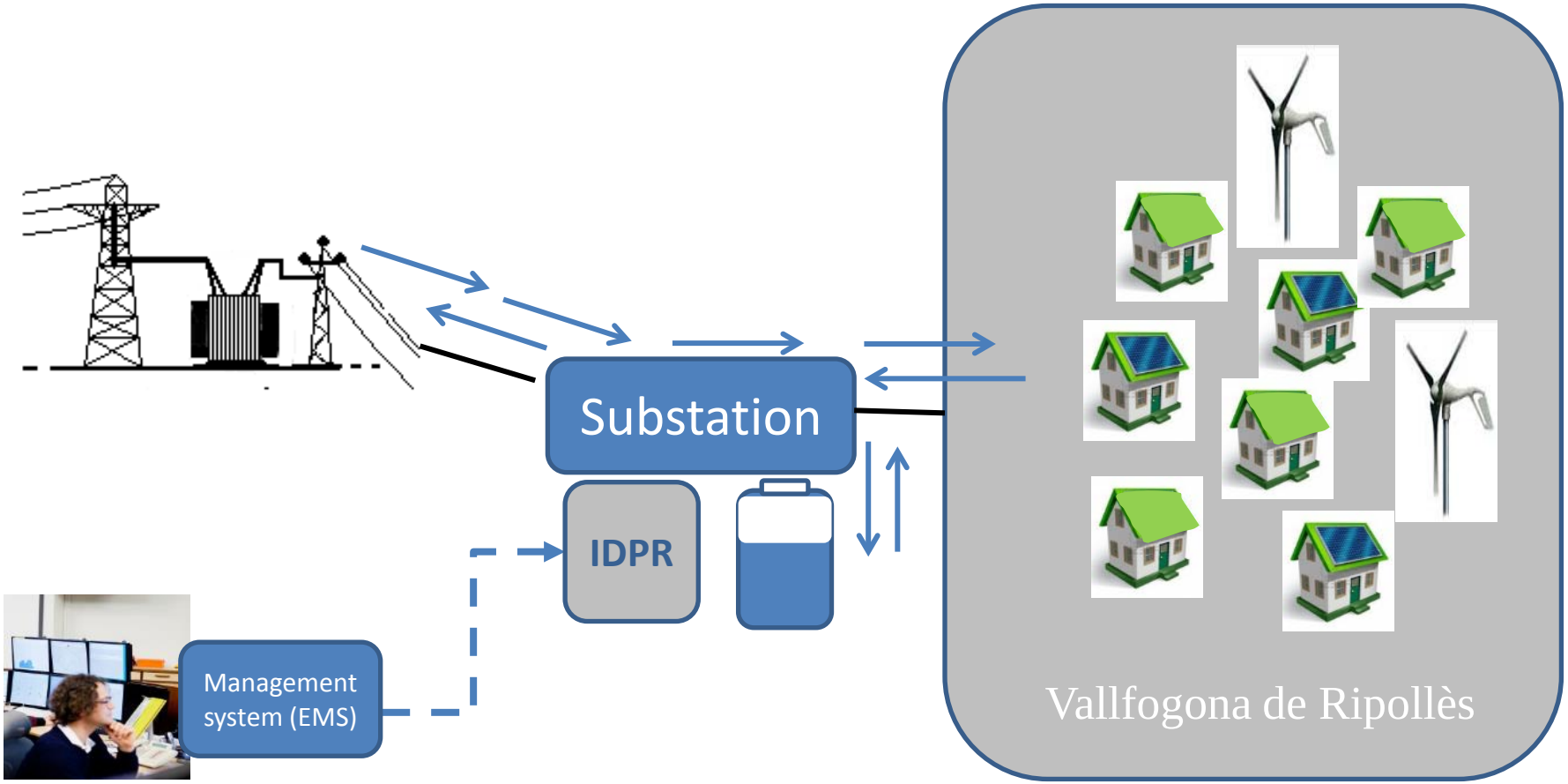
Integration of RES and DER (DG) and energy storage capacity

Each rural region and village self-contained with energy

Creating a resilient (rural) distribution grid

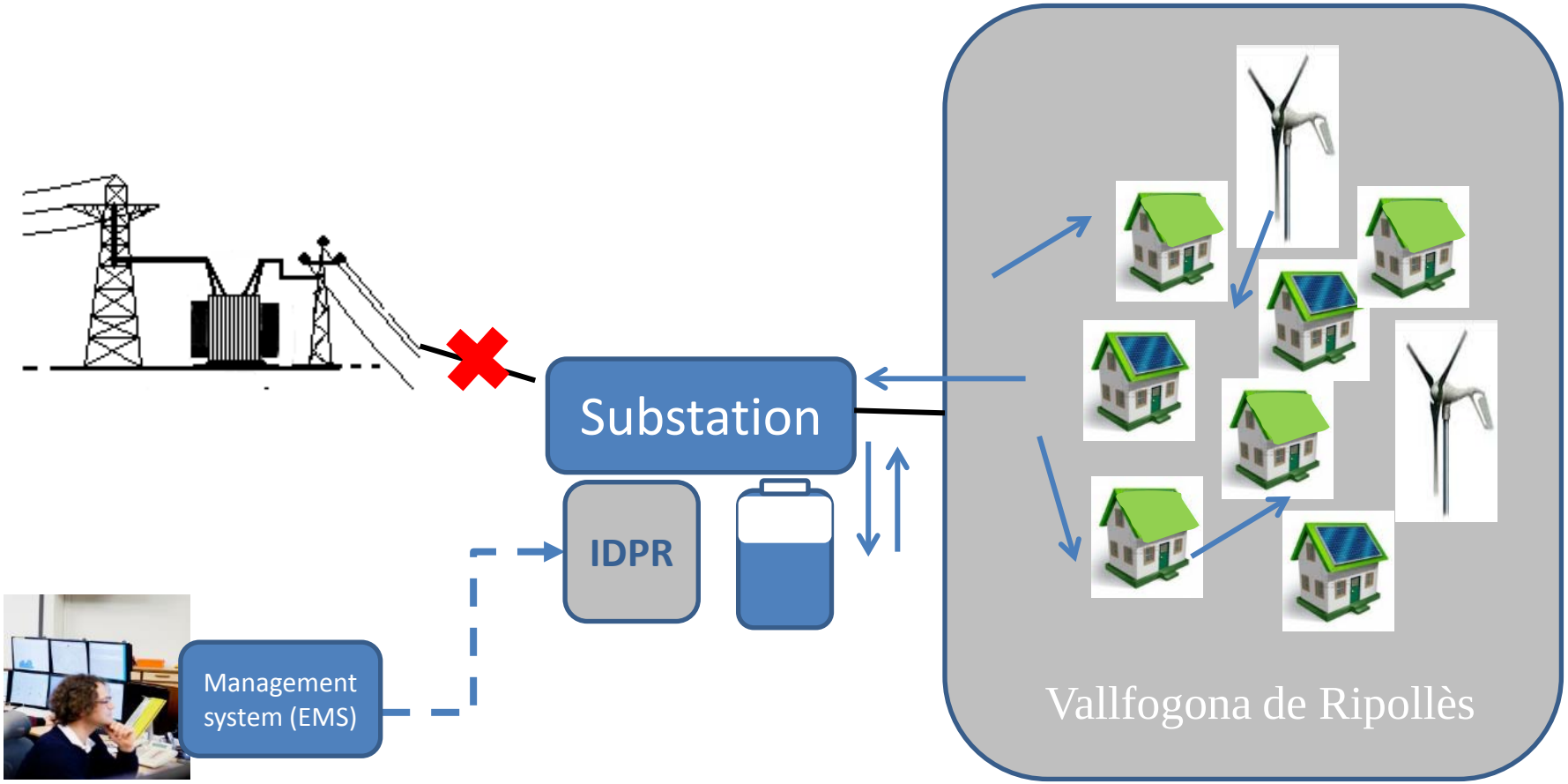
Connected

IDPR: Intelligent Distribution Power Router

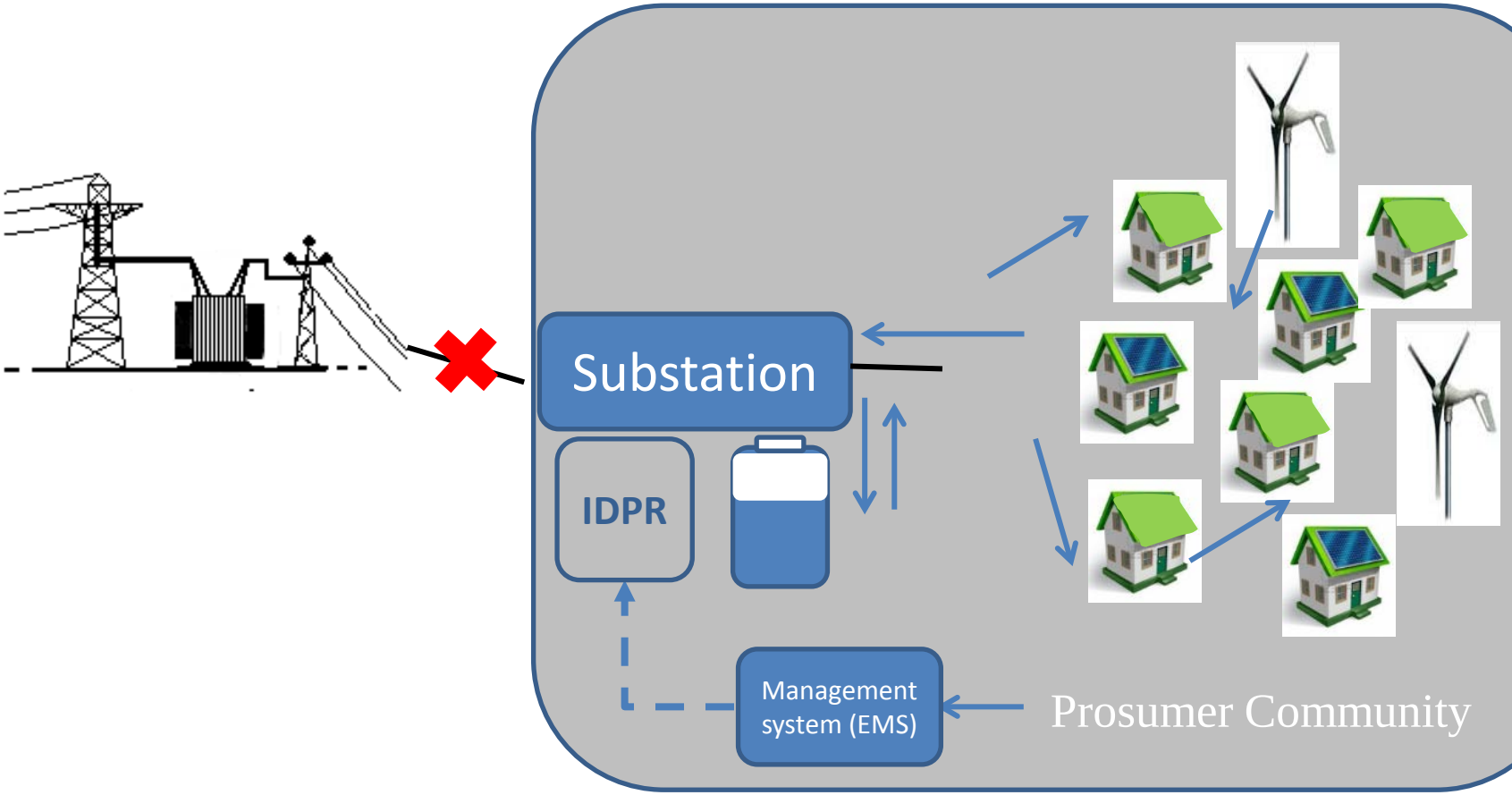


Islanded

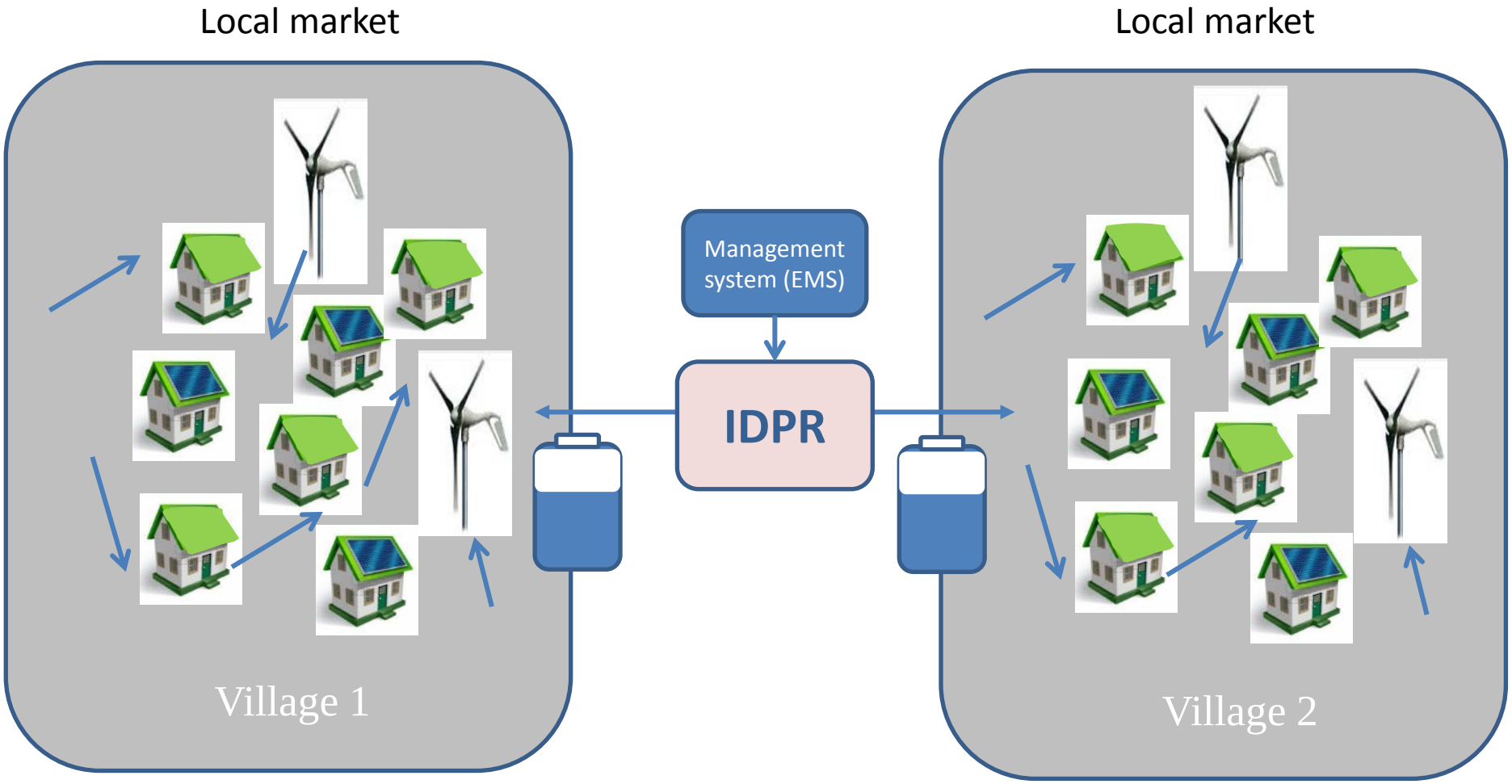
IDPR: Intelligent Distribution Power Router



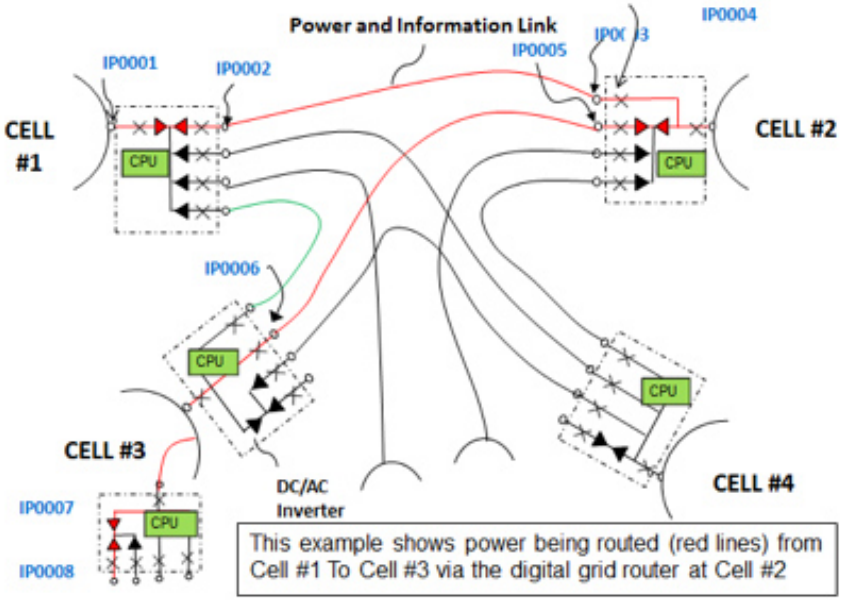
Who takes control?
Ownership determines business models and social benefits



“Bottom-Up” development



Digital Grid?



digital grid

電力のインターネット化 - デジタルグリッド

Internet of Energy

Source: www.digitalgrid.org

FOR MORE INFORMATION: WWW.SMARTRURALGRID.EU ALSO AVAILABLE ON:

NEWSLETTER #01 2015 PAGE 6

TAG MEMBER SPEAKS OUT - MEET PROFESSOR PROFESSOR DR. RIKIYA ABE

Dr. Rikiya Abe is a professor and Presidential Endowed Chair of Electric Power Network Innovation by Digital Grid at the University of Tokyo in Japan.

Professor Abe is a well-known educator, scientist and speaker. He has had a significant influence on energy systems development over the years and has been featured at many distinguish events, including the World Economic Forum and technical meetings like IEEE and ISPE International. In 2012 he was featured in the IEEE Spectrum, a world leading magazine on the latest technology news. Professor Abe has pioneered the Digital Grid. The Digital Grid is constituted by several cells, which are connected to each other asynchronously, via IP addressed converters. The Smart Rural Grid is relating to this concept through the development of its intelligent power router.

We are honored to have Professor Abe as a member of our TAG. He is a great supporter of the Smart Rural Grid and his encouragements mean a lot. With his permission we publish a quote about the Smart Rural Grid that he made at the end of last year:

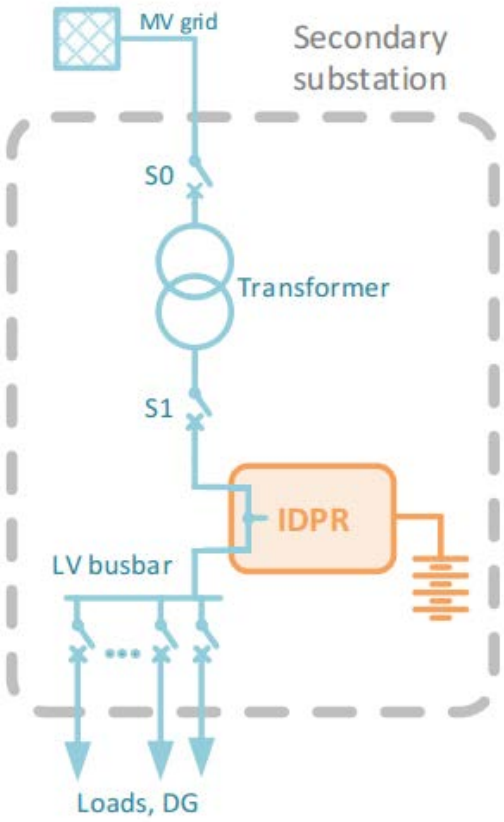
"Conventional grid architecture was designed more than one hundred years ago. It expands gradually and supplies reliable electric power to almost half of the world. For the rest of the world, however, 1.3 billion people have no access to the electricity and 2 to 4 billion people has very weak access to the grid. The Smart Rural Grid concept is becoming very important for the people who live in these weak grid and off-grid areas.

Yet, this concept may become important in advanced countries, too. In Japan, a new feed-in tariff program was introduced in 2013 and 70 GW PV installation plan was approved in almost one year. This amount was more than 40% of Japanese maximum demand of 160 GW. It is very difficult to accept such unstable PV power in the current grid. Power companies refuse assessment for the moment. We should develop a Smart Rural Grid architecture which can absorb PV power and divide from the main grid by means of a power router. We developed Digital Grid concept, which is similar concept to Smart Rural Grid. We think this offer a good solution to the problem. •

See also this video on Professor Abe's vision for the Digital Grid: https://www.youtube.com/watch?v=IhoEvA9JTkM

Digitalize the Smart Rural Grid

- It means to segment the grid into substantially self-sustaining cells, controlling the flow of energy between those cells using controlled, scheduled energy flows thanks to IDPR.
- This segmentation can be done gradually in LV, MV or both.
- Independent cells or systems located in each secondary substation, with mutually synchronized phases and frequencies are connected using IDPR composed of power converters which exchange electric energy between selected parts of network by supplying specified energy directly through power converters to the designated end point defined by an address.

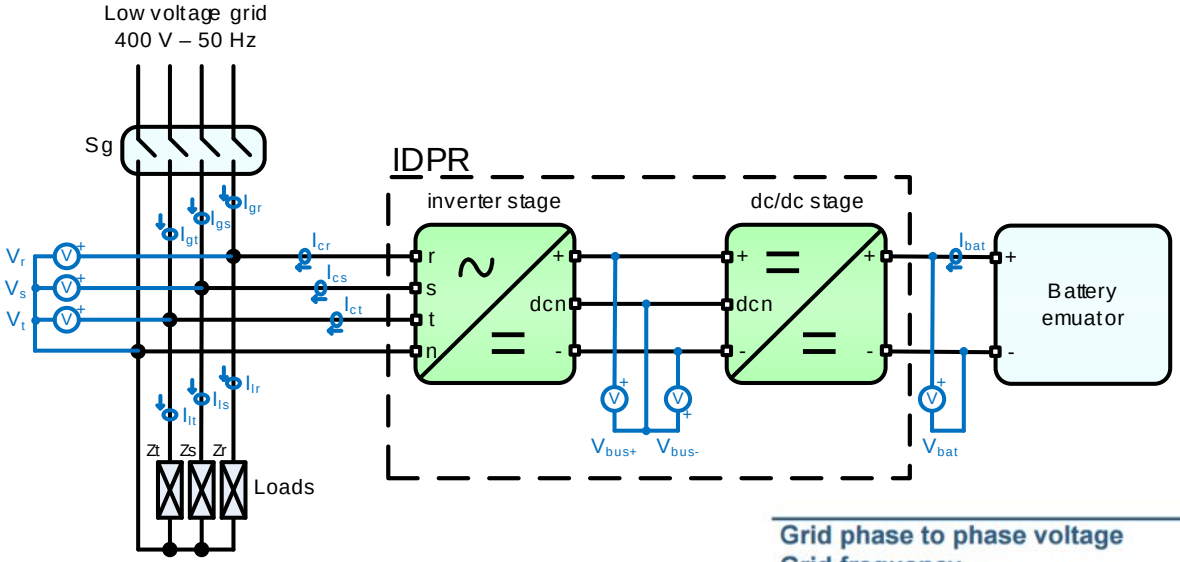


What is a IDPR?

- A four-wire parallel active filter that is enhanced with and by distributed intelligence. The aim is to optimize the use of distributed resources in any operation mode allowing to route the energy according to the needs of unbalanced grids and to improve quality of power / service

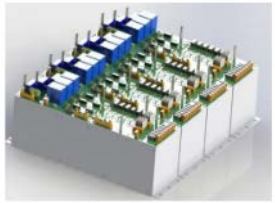
- **Grid-connected mode:**
  - 4 quadrant P/Q dispatching
  - Grid side current balancing / minimizing losses
  - Current harmonic content compensation
- **Grid-disconnected mode:**
  - Generation of a controllable voltage per phase
- **The storage system:**
  - Active Power regulation in grid-connected mode
  - Permits operation in grid disconnected mode

IDPR: Specifications



Operation features (1 cell: DC/DC + DC/AC):

Grid phase to phase voltage	400 V ± 10 %
Grid frequency	50-60 Hz
Grid grounding scheme	3P + N, TN or TT
Battery side voltage (optimal range)	350..600 V
Isolation	Low frequency isolation (optional)
Cooling	Forced air
Degree of protection	IP-55
Operating ambient temperature	- 20 .. 40 ° C
Communications	Modbus over RS-485
Rated power	20 kVA
Rated current grid current	30 A
Battery side rated current	50 A



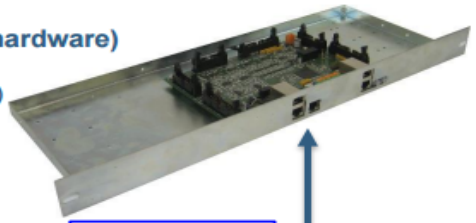
Up to 5 cells can be paralleled
100 kVA

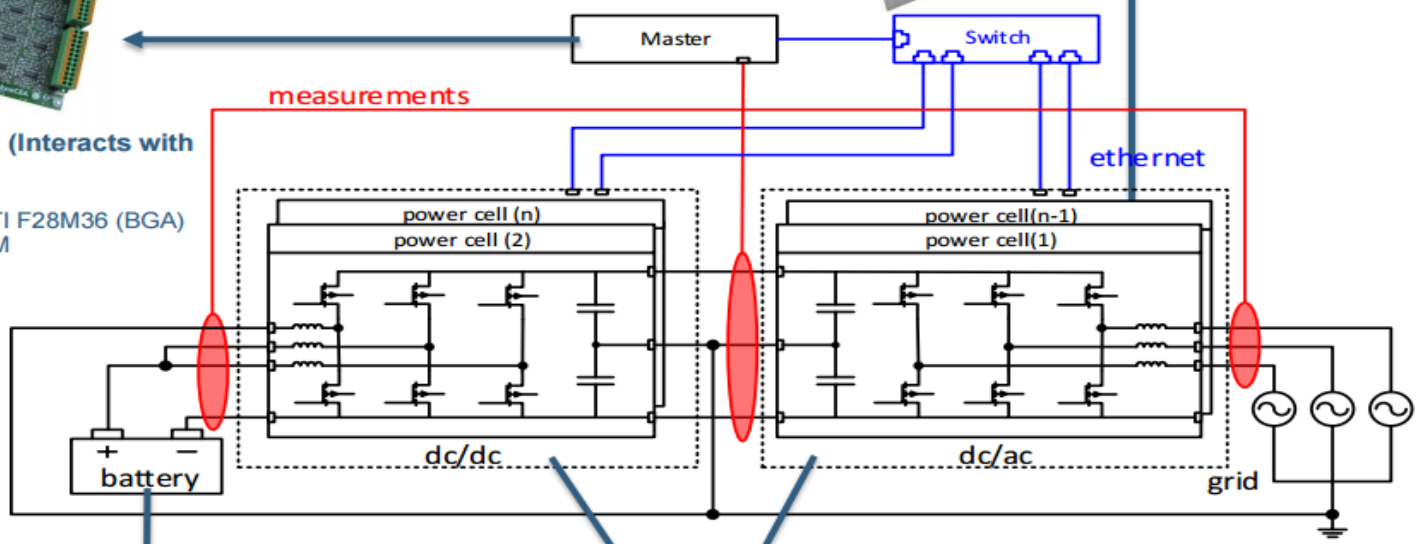
IDPR: Specifications

Full IDPR

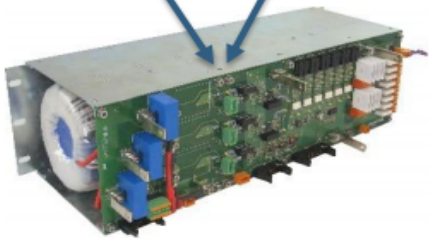
Master control board (Interacts with an external EMS)
- 1 per each IDPR
- Based on DSP from TI F28M36 (BGA)
- Two cores: DSP+ARM

Slave control board (Controls the IDPR hardware)
- Each one manages 2 power cells
- Based on DSP from TI F28M35 (HTQFP)
- Two cores: DSP+ARM



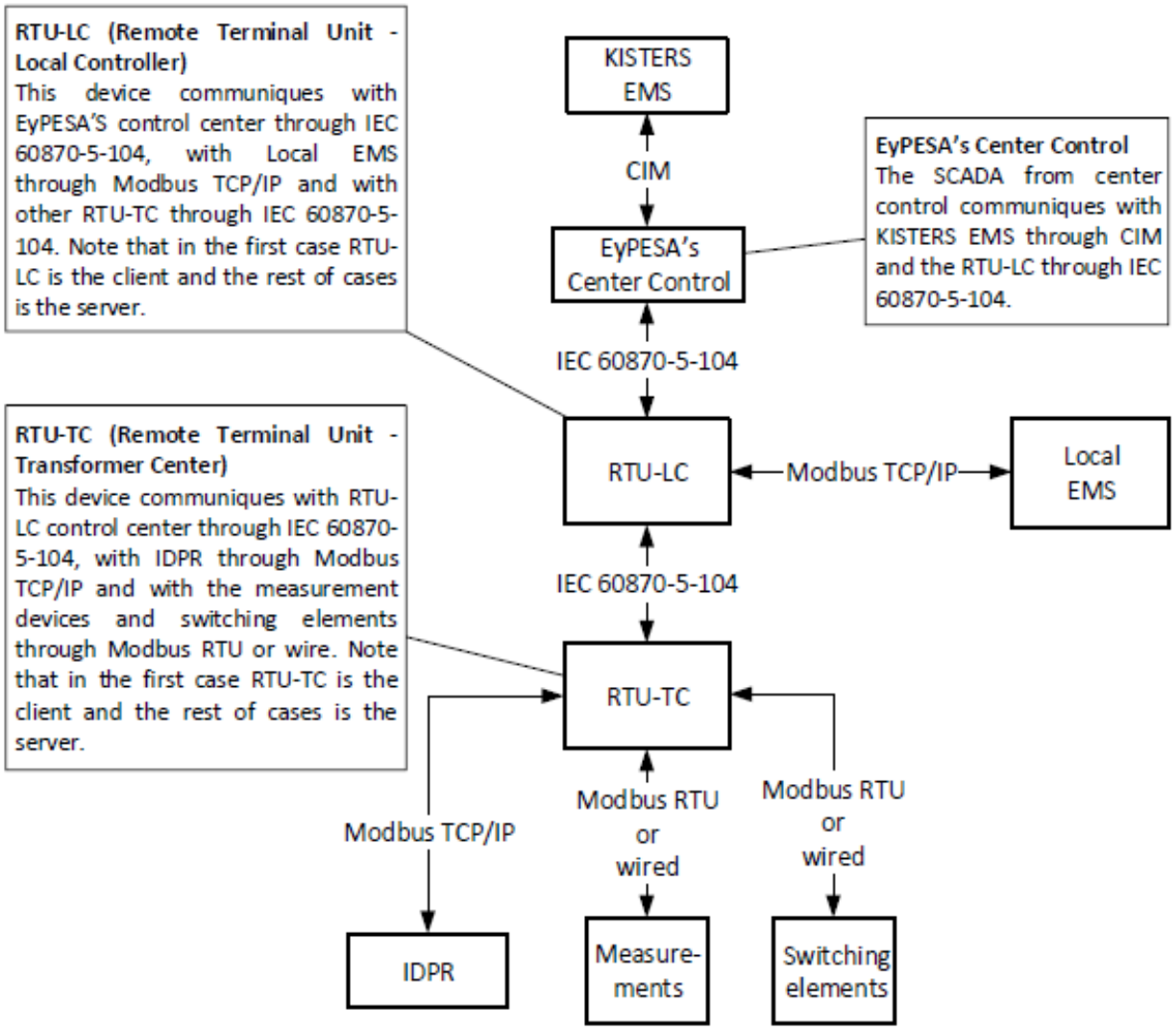


Battery
- LiFePO4 battery
- 320 V-60 Ah
- BMS RS-485
- 320 x 809 x 1178 mm



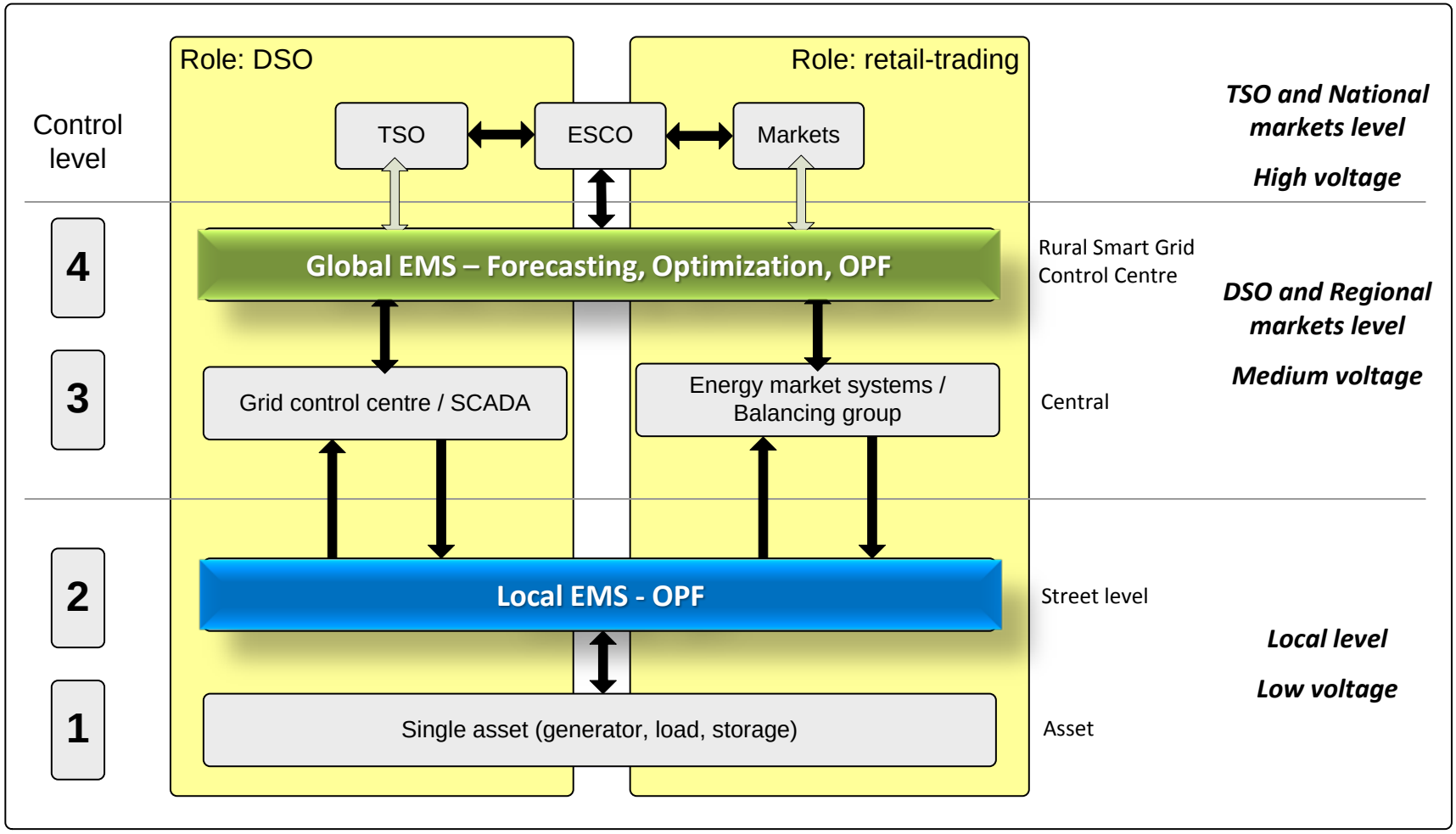
IDPR: Specifications

System architecture

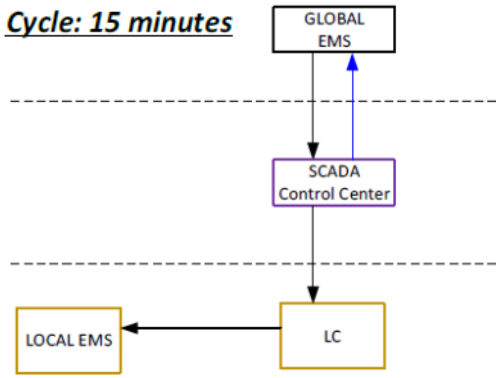


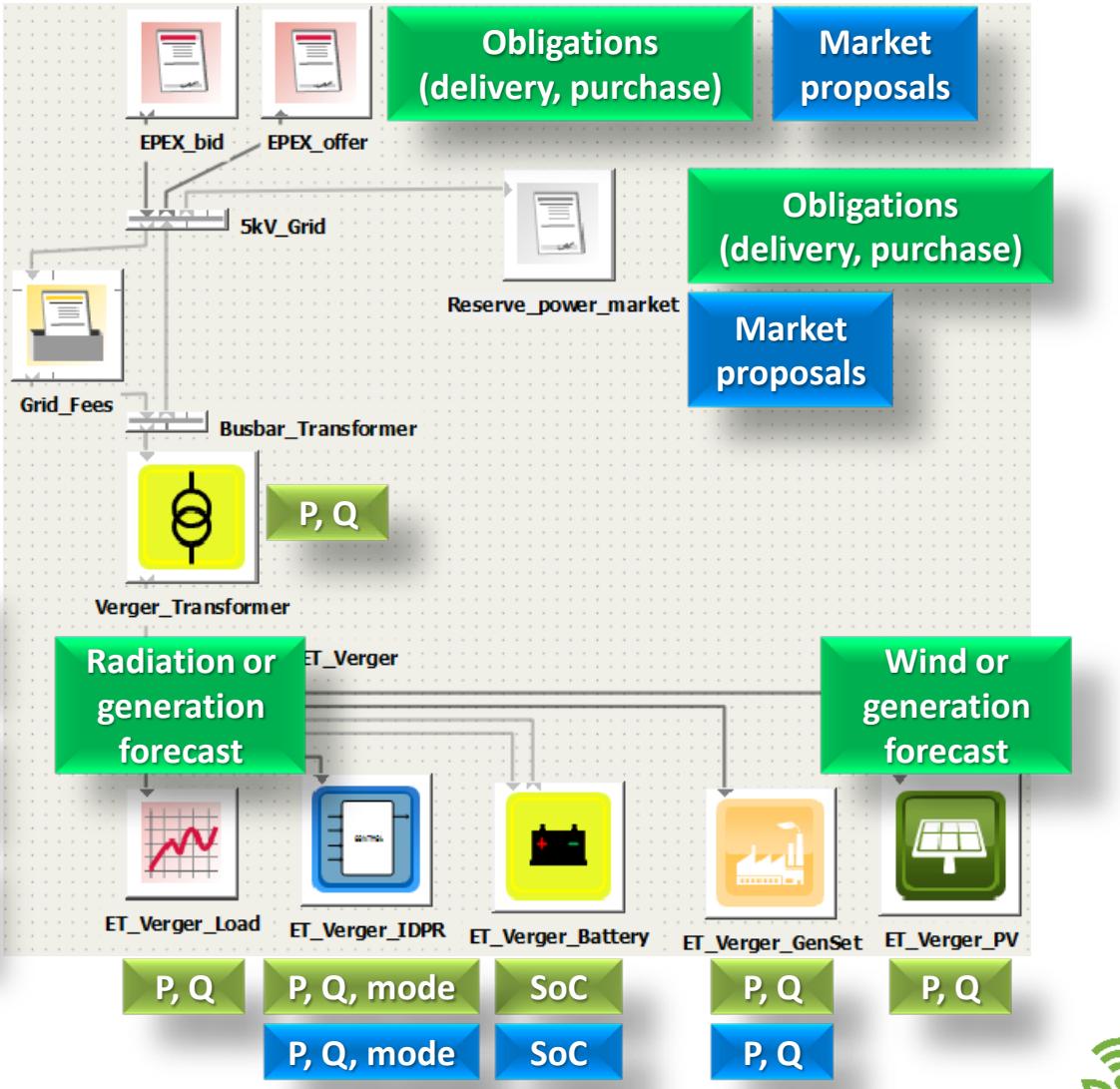
The Energy Management System(s)

- Local EMS: One per grid cell / IDPR, look at direct neighbors
- Global EMS: Orchestrating all local EMS, taking topology and markets into account
- Open concept that uses already existing SCADA

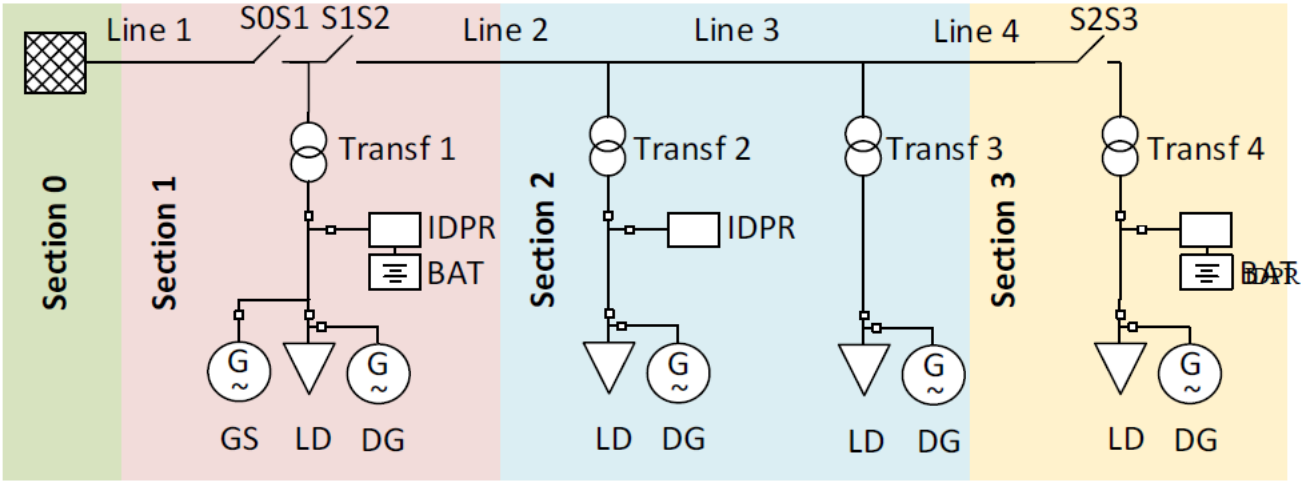


Optimization: Global level





Demo site



PILOT AREA

Normal

- Connected to the main grid
- Isolated by planned tasks

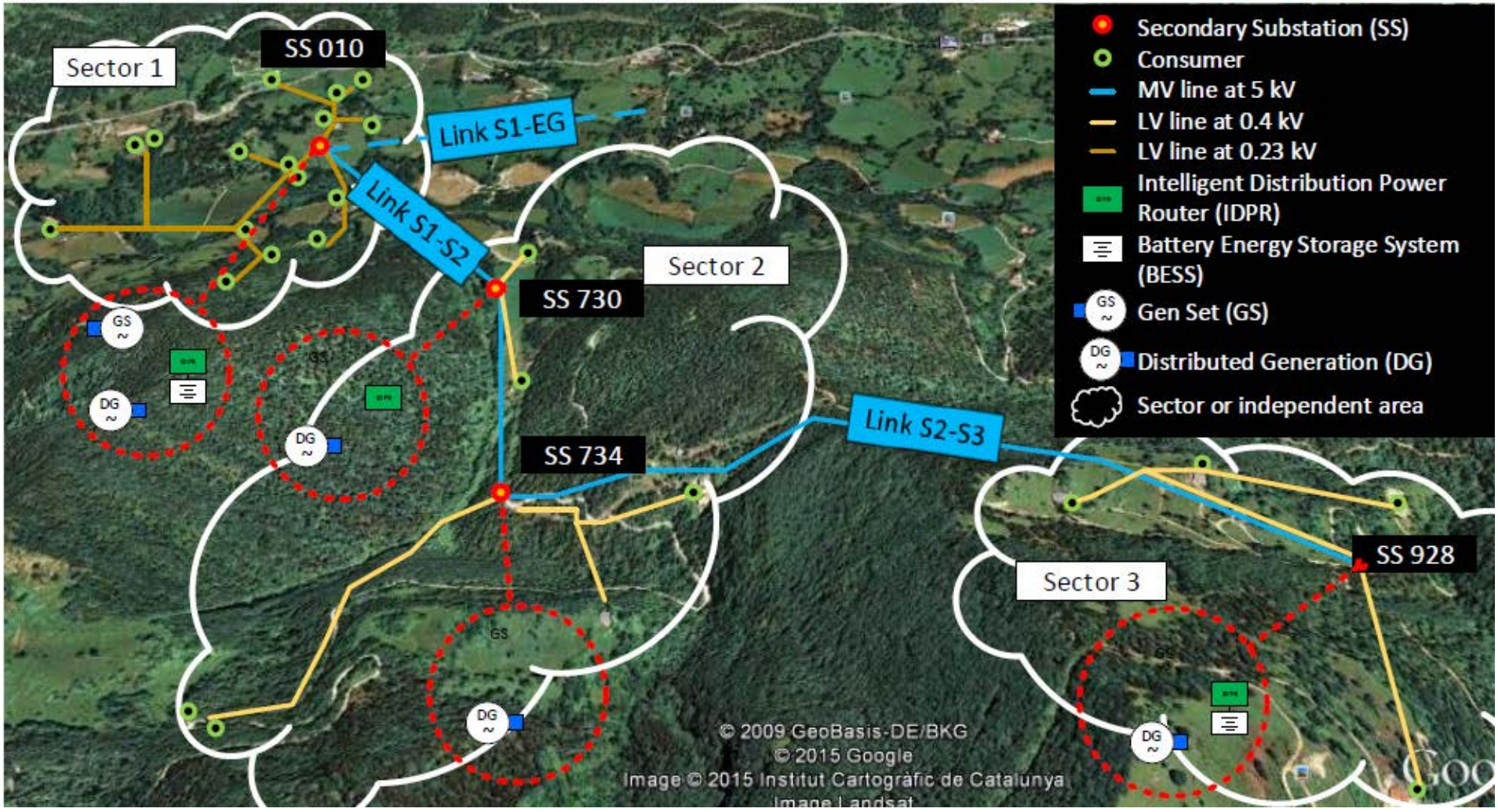
Emergency

- When the main grid is not operative
- When there is/are inoperative internal sections

Feasible possibilities

- Grid-connected
- Grid connected + One island
- One island
- Two islands

Demo site


Sector 1
SS 010
Link S1-EG
Link S1-S2
Sector 2
SS 730
SS 734
Link S2-S3
SS 928
Sector 3
GS
DG
Secondary Substation (SS)
Consumer
MV line at 5 kV
LV line at 0.4 kV
LV line at 0.23 kV
Intelligent Distribution Power Router (IDPR)
Battery Energy Storage System (BESS)
Gen Set (GS)
Distributed Generation (DG)
Sector or independent area
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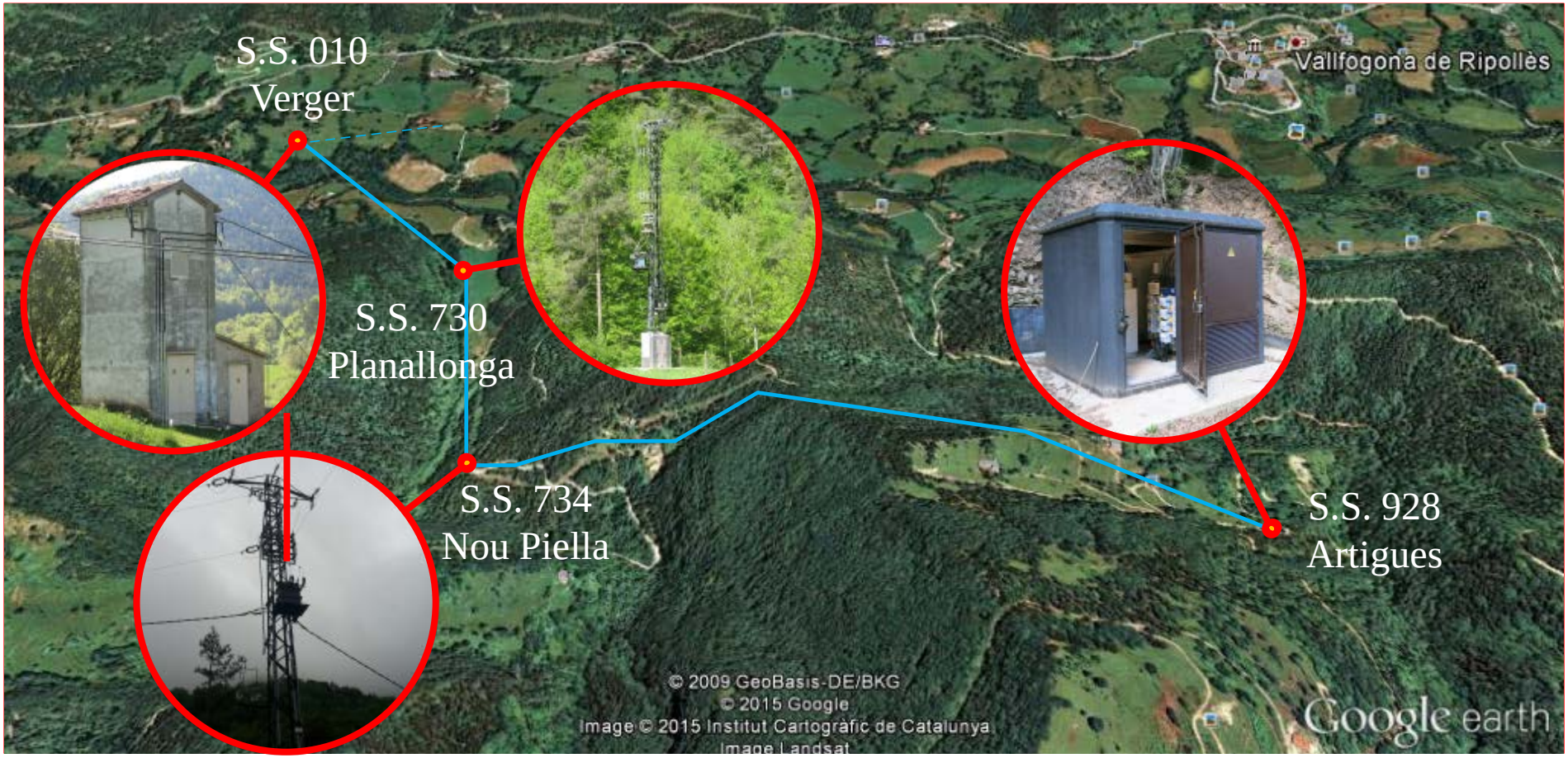
Demo site


S.S. 010
Verger
S.S. 730
Planallonga
S.S. 734
Nou Piella
S.S. 928
Artigues
Vallfogona de Ripollès
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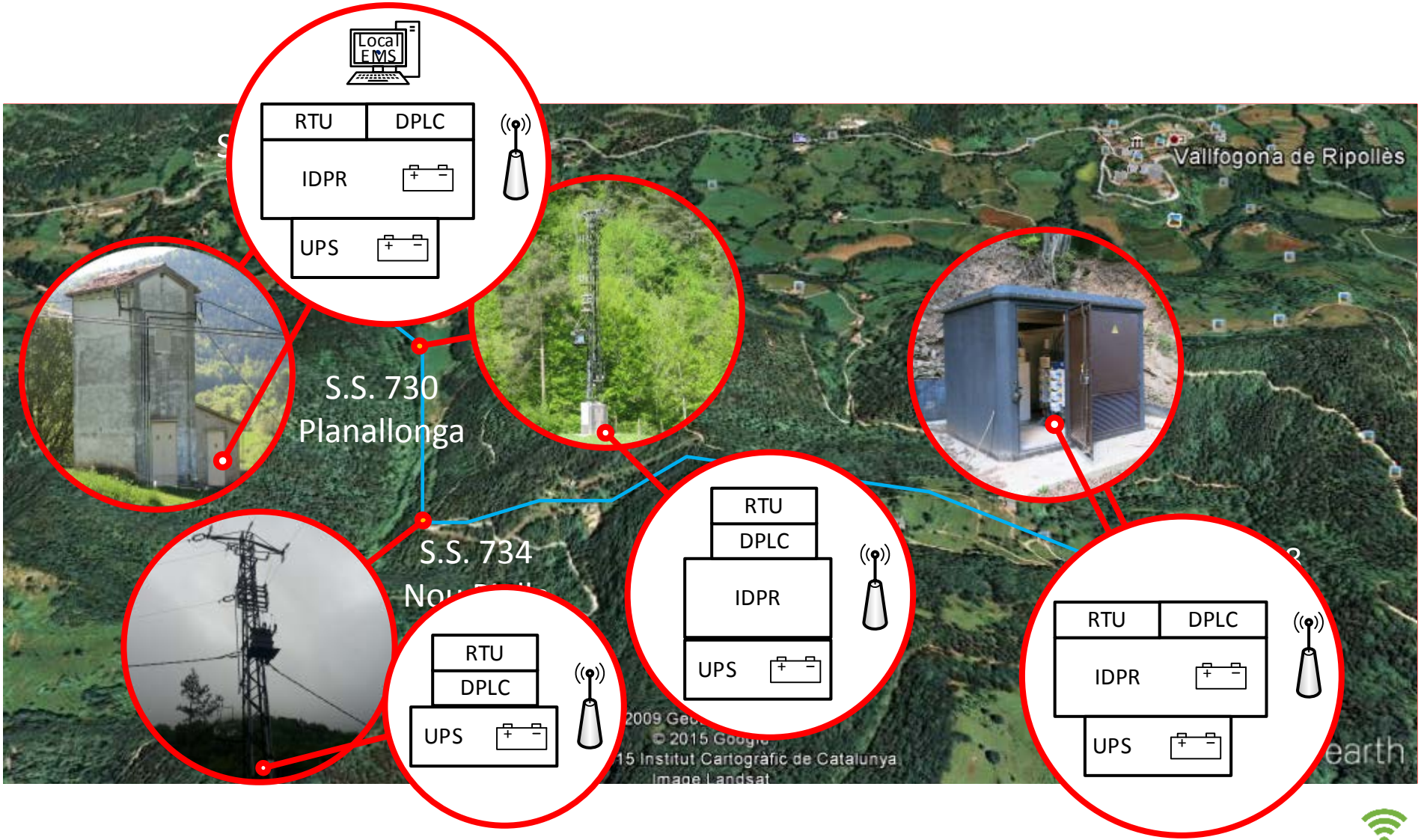
Google earth

Demo site


Local EMS
RTU
DPLC
IDPR
UPS
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RTU
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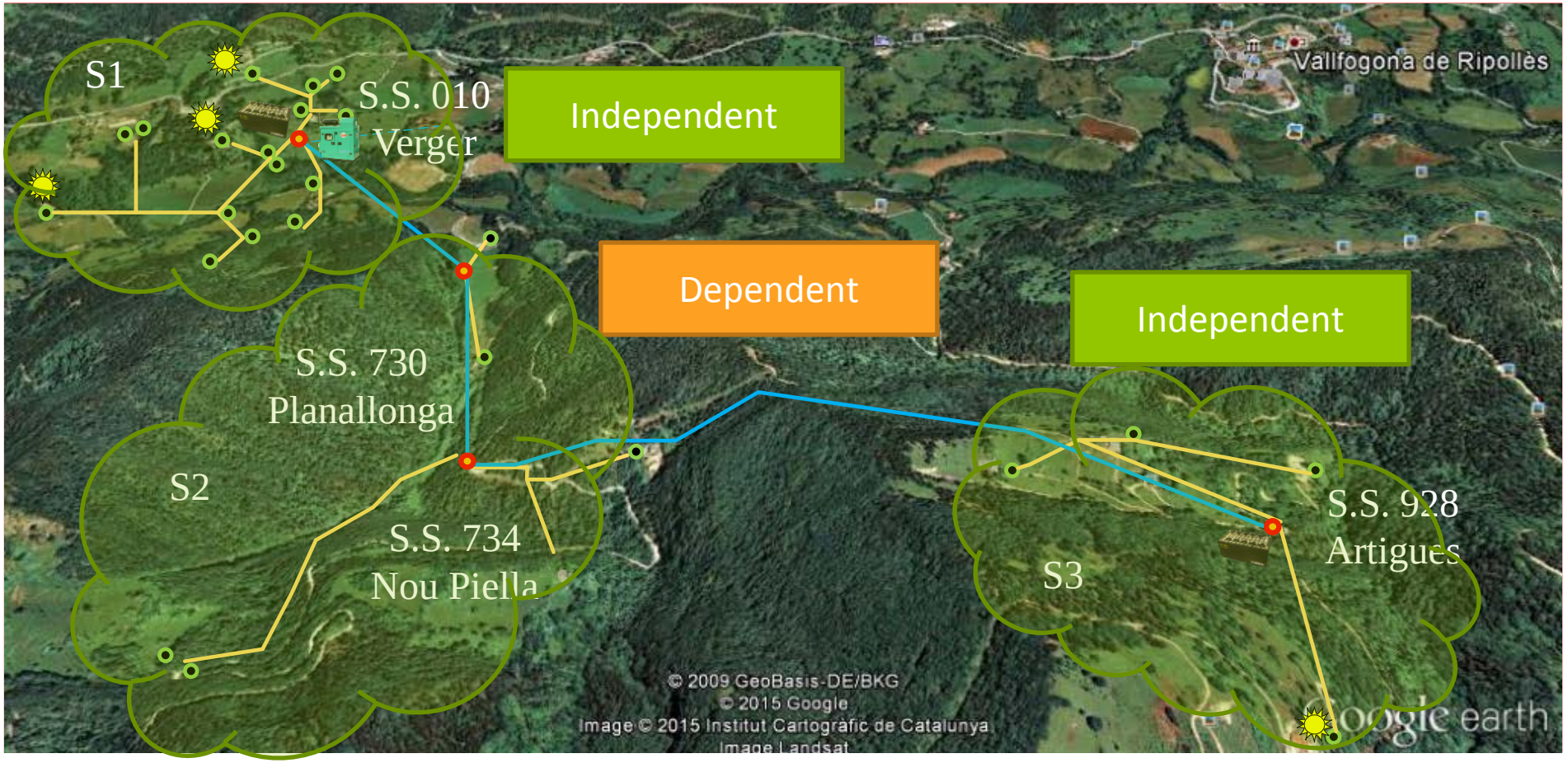
earth

Demo site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Nou Piella
S3
S.S. 928
Artigues
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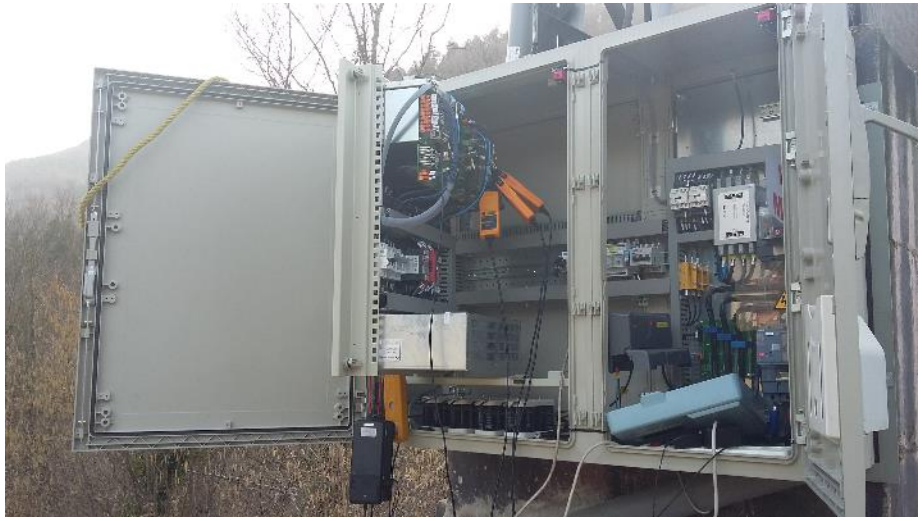
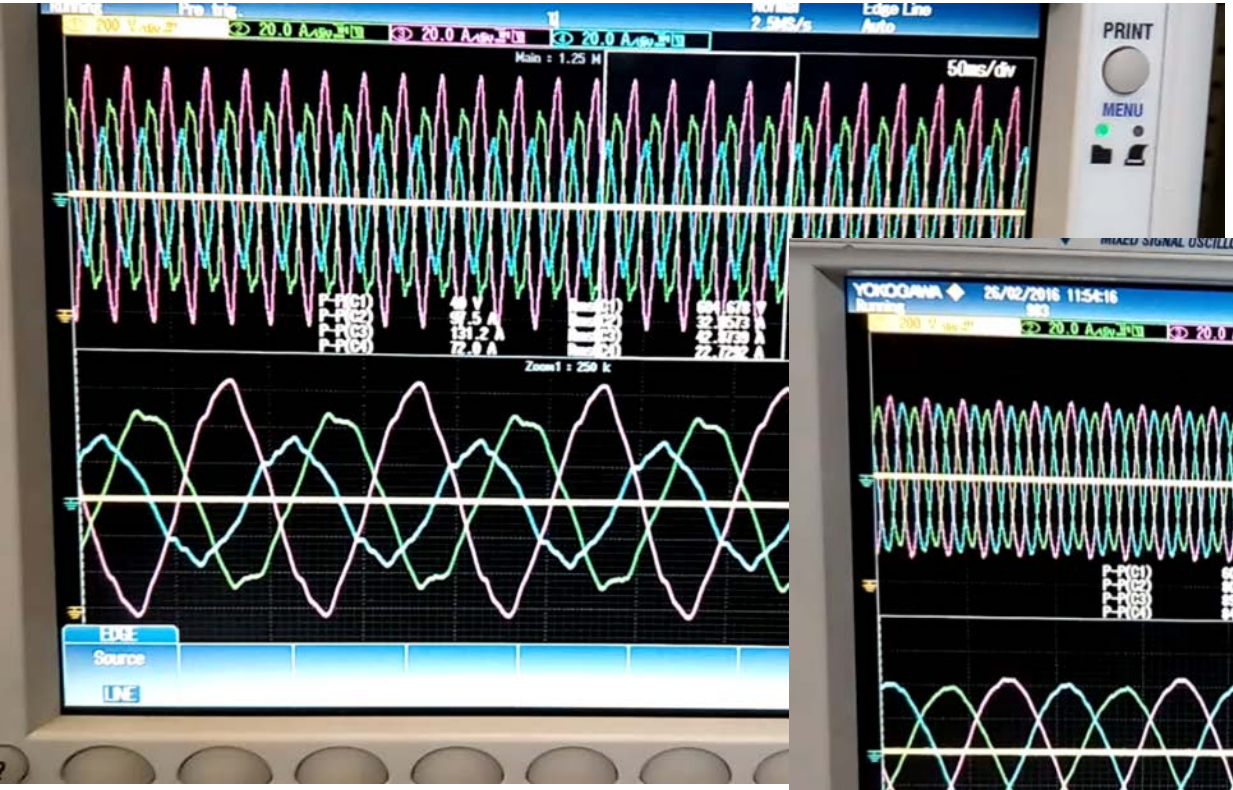
IDPR start up

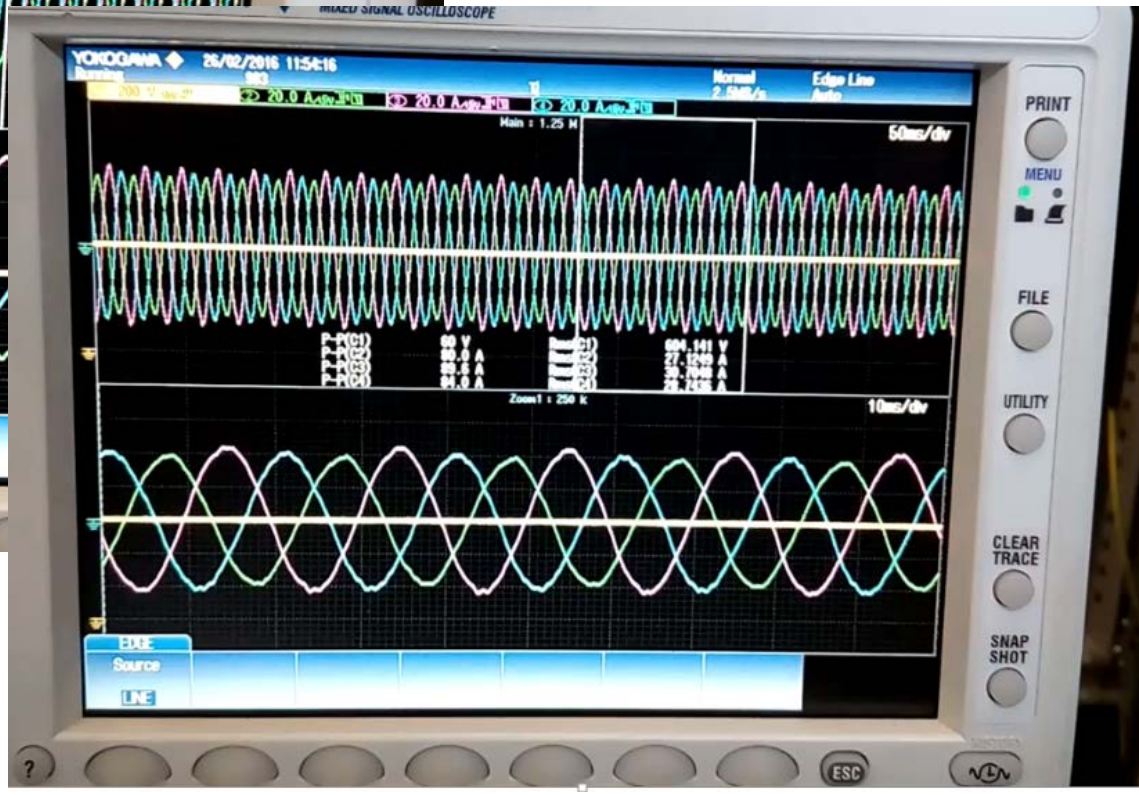


IDPR start up

- Without IDPR



- Active IDPR



Conclusions

Business cases

- Postpone or even avoid grid reinforcements due to renewables
- Reduction of peak loads, improvement of the power quality
- Enabling local markets

Field tests

- Field tests are running
- Grid connected mode successfully tested in the pilot with 2 parallel connected IDPR
- Island mode tested in lab conditions
- Island mode in the field in near future
- First reconnecting of islanded cells was successfully (in lab conditions)

Next steps

- IEEE Webinar coming up November 22nd with SmartRuralGrid
- Summary of experiences in a workshop in May 2017

Thank you for your attention - Contact us!

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