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

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

smartruralgrid.eu
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
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

Island operation

Data flow

DSO

Niagara 2016 Symposium on Microgrids | Volker Bühner - KISTERS | 20 October 2016
IDPR: Intelligent Distribution Power Router

Vallfogona de Ripollès
Islanded

**IDPR: Intelligent Distribution Power Router**
Who takes control?
Ownership determines business models and social benefits
"Bottom-Up" development

Local market

Village 1

Management system (EMS)

IDPR

Village 2

Local market
**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

---

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 distinguished 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 have 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 100 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=lhoEvA9JTtM
• 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.
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

Low voltage grid
400 V – 50 Hz

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

- Grid phase to phase voltage
- Grid frequency
- Grid grounding scheme
- Battery side voltage (optimal range)
- Isolation
- Cooling
- Degree of protection
- Operating ambient temperature
- Communications
- Rated power
- Rated current grid current
- Battery side rated current

400 V ± 10 %
50-60 Hz
3P + N, TN or TT
350.600 V
Low frequency isolation (optional)
Forced air
IP-55
-20 .. 40 °C
Modbus over RS-485
20 kVA
30 A
50 A

Up to 5 cells can be paralleled
100 kVA
Full IDPR

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

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

Battery
- LiFePO4 battery
- 320 V-80 Ah
- BMS RS-485
- 320 x 809 x 1178 mm

Battery
- LiFePO4 battery
- 320 V-80 Ah
- BMS RS-485
- 320 x 809 x 1178 mm
System architecture

RTU-LC (Remote Terminal Unit - Local Controller)
This device communicates with EyPESA’s control center through IEC 60870-5-104, with Local EMS through Modbus TCP/IP and with other RTU-TC through IEC 60870-5-104. Note that in the first case RTU-LC is the client and the rest of cases is the server.

RTU-TC (Remote Terminal Unit - Transformer Center)
This device communicates with RTU-LC control center through IEC 60870-5-104, with IDPR through Modbus TCP/IP and with the measurement devices and switching elements through Modbus RTU or wire. Note that in the first case RTU-TC is the client and the rest of cases is the server.
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

![Diagram of energy management systems](image)
Optimization: Global level

**Cycle: 15 minutes**

- **GLOBAL EMS**
- **SCADA Control Center**
- **LOCAL EMS**

- **Actual data send by SCADA**
- **Data send by 3rd party systems**
- **Setpoints / schedules**

- **Obligations (delivery, purchase)**
- **Market proposals**

- **Wind or generation forecast**
- **Radiation or generation forecast**

**Setpoints / schedules**:
- **P, Q**, **mode**
- **SoC**

**Market proposals**:
- **P, Q**, **mode**
- **SoC**

**Obligations (delivery, purchase)**:
- **P, Q**, **mode**
- **SoC**

**Niagara 2016 Symposium on Microgrids | Volker Bühner - KISTERS | 20 October 2016**
Demo site

- Connected to the main grid
- Isolated by planned tasks
- 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
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 22\textsuperscript{nd} with SmartRuralGrid
• Summary of experiences in a workshop in May 2017
Thank you for your attention - Contact us!

Dr. Volker Bühner
KISTERS AG
Pascalstraße 8 + 10
D-52076 Aachen
Germany
Phone +49 (0)2408 93 85-0
Fax +49 (0)2408 93 85-555
Volker.Buehner@kisters.de