Technical University of Denmark

SYSLAB – lab for research on distributed smart grid infrastructure

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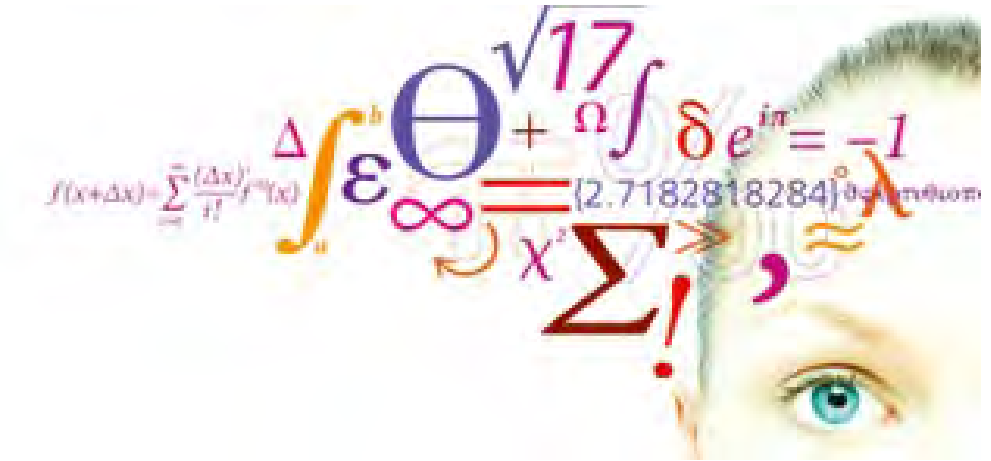
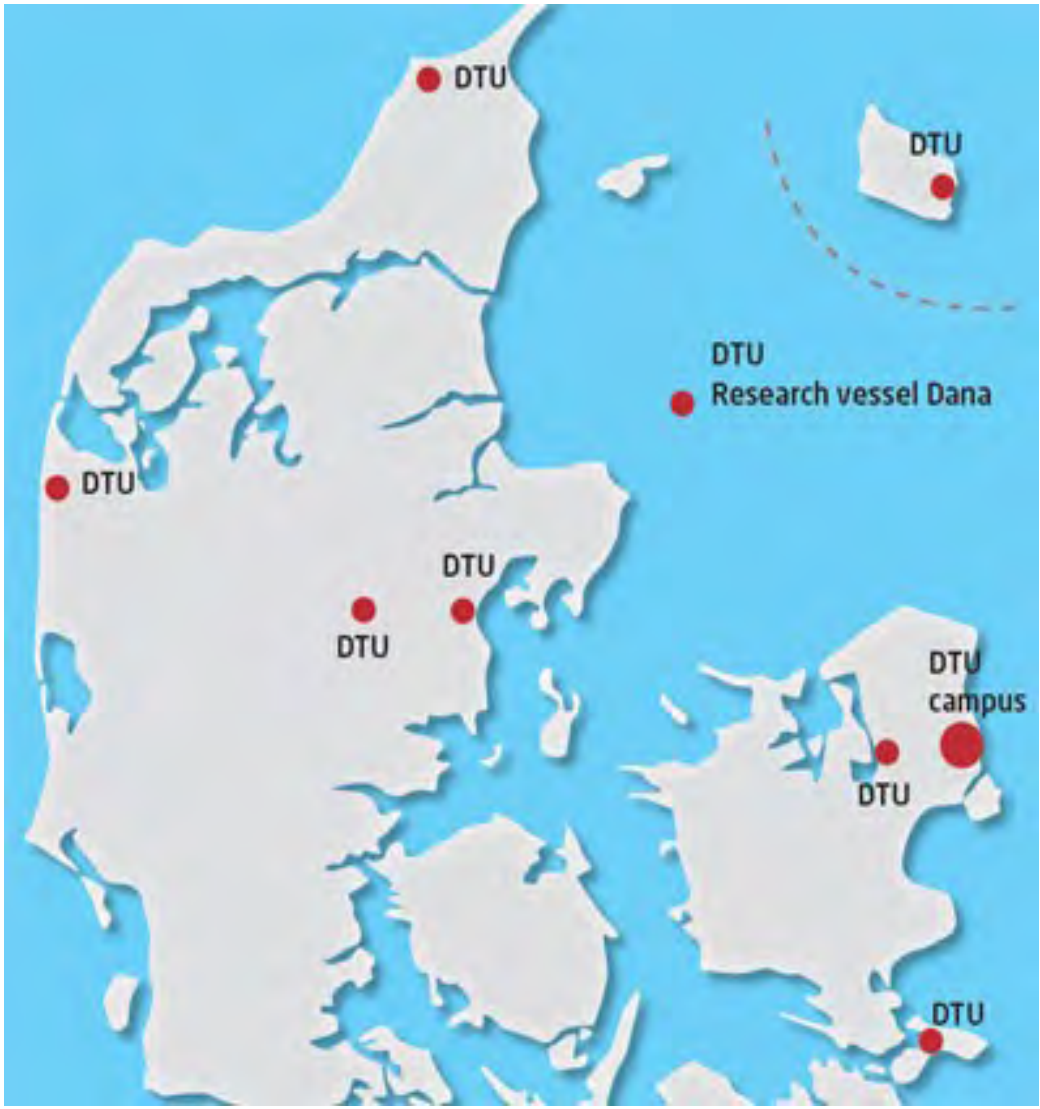


DTU Electrical Engineering
Department of Electrical Engineering

SYSLAB

SYSLAB is DTU Electrical Engineering, Risø campus laboratory for intelligent distributed power systems.

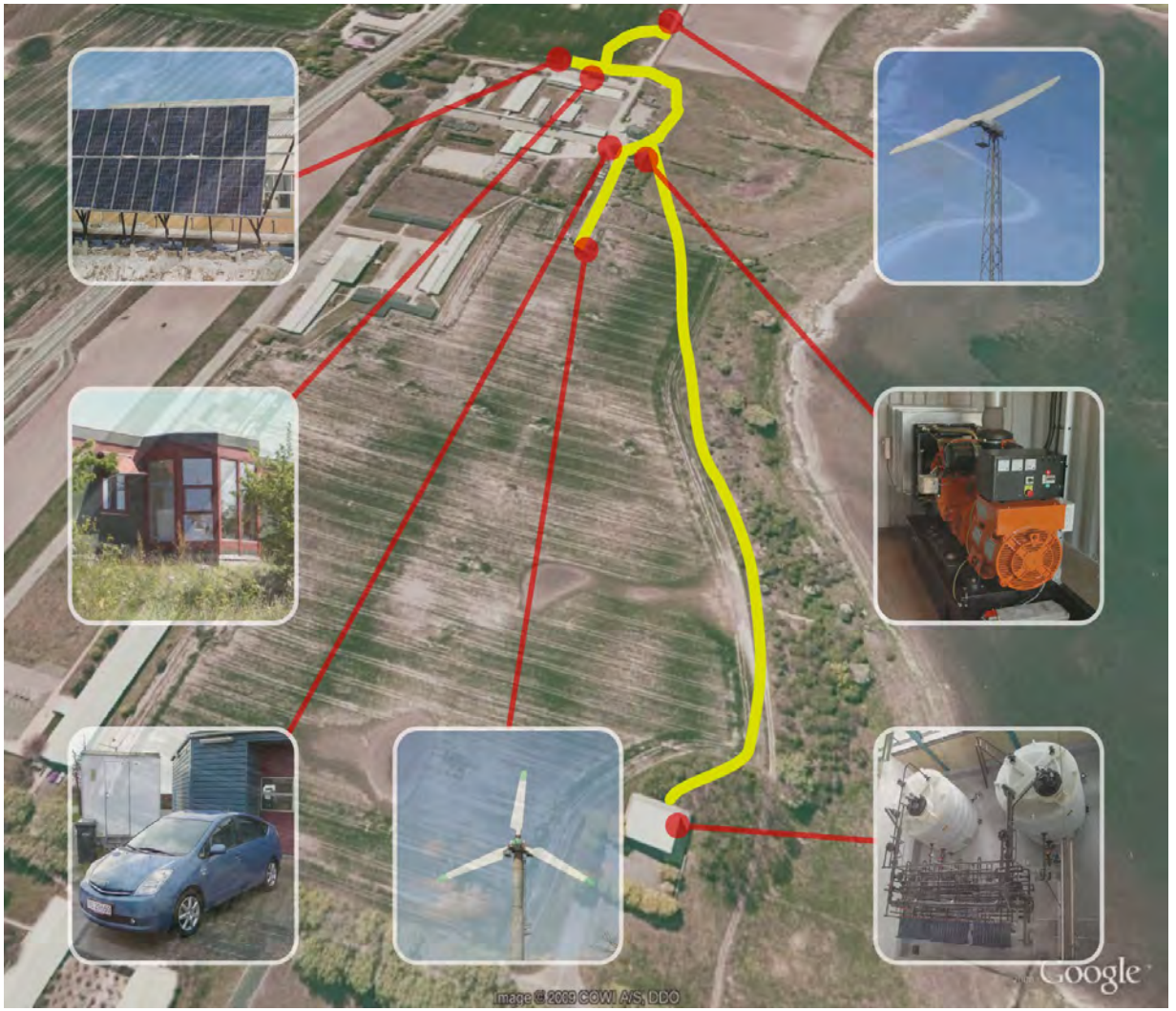
SYSLAB enables research and testing of control concepts and strategies for power systems with distributed control and integrating a number of decentralized production and consumption components including wind turbines and PV plant in a systems context.



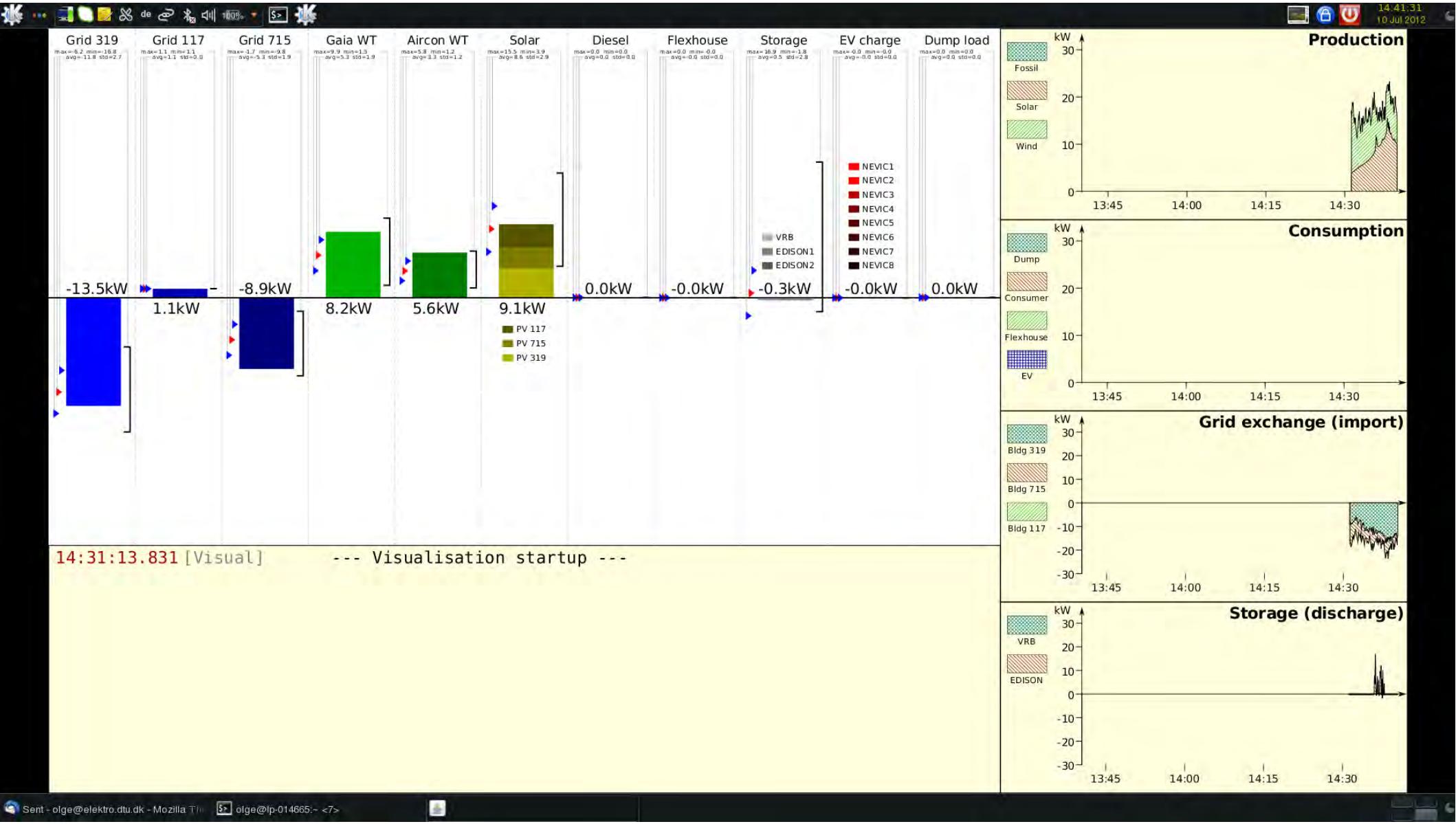
SYSLAB / Hardware platform

- 2 wind turbines (10+11kW)
- 3 PV array (7+10+10kW)
- Diesel genset (48kW)
- Office building (20kW)
- Dump load (75kW)
- 3 mobile loads (3x36kW)
- Flow battery (15kW)
- B2B converter (104kW)
- 3 NEVIC EV Charging post
- Machine set (30kW)
- Battery testing bays (300+50+50kVA)

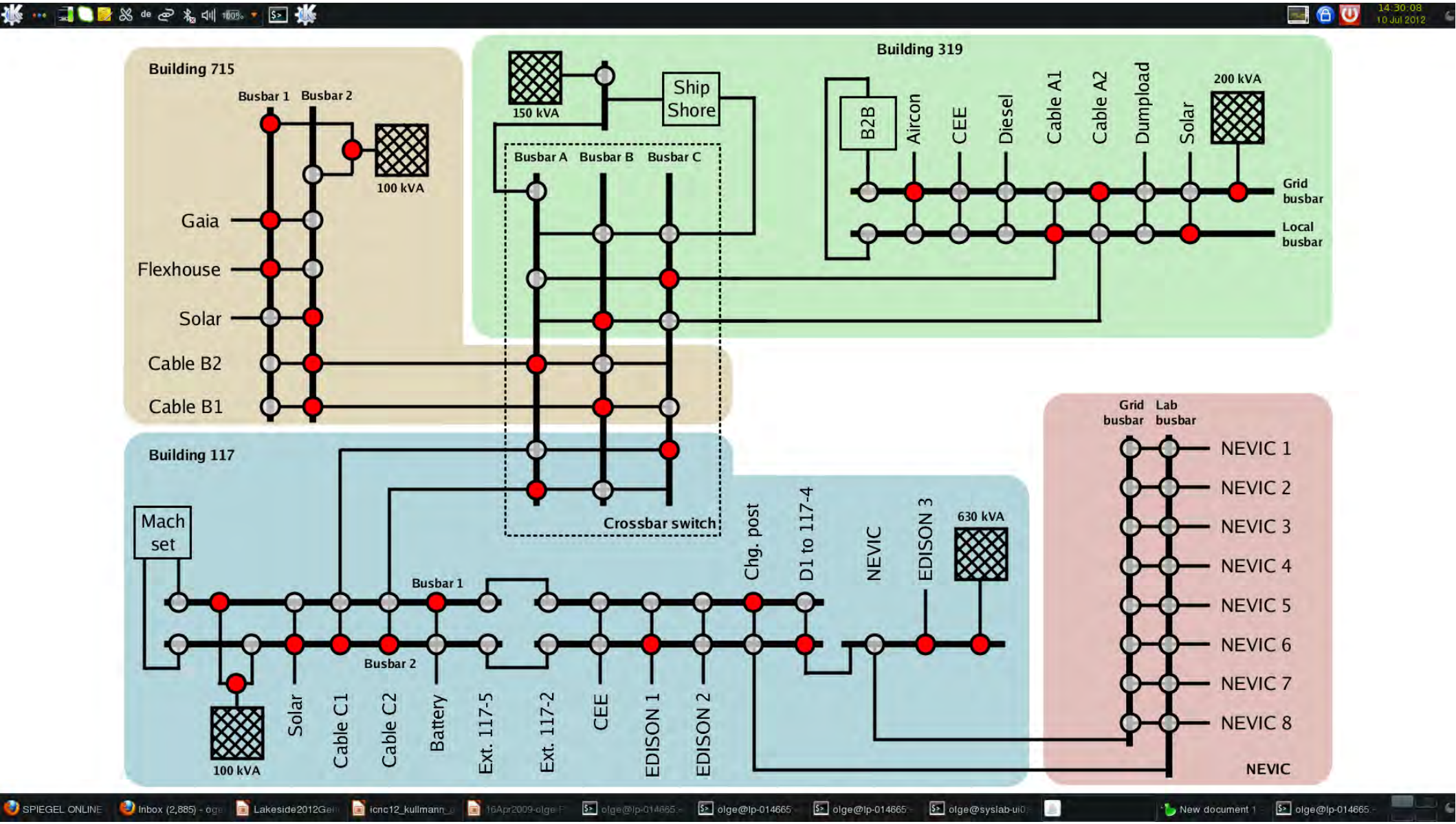
Small “real-world” power grid on Risø's premises



Live SYSLAB state

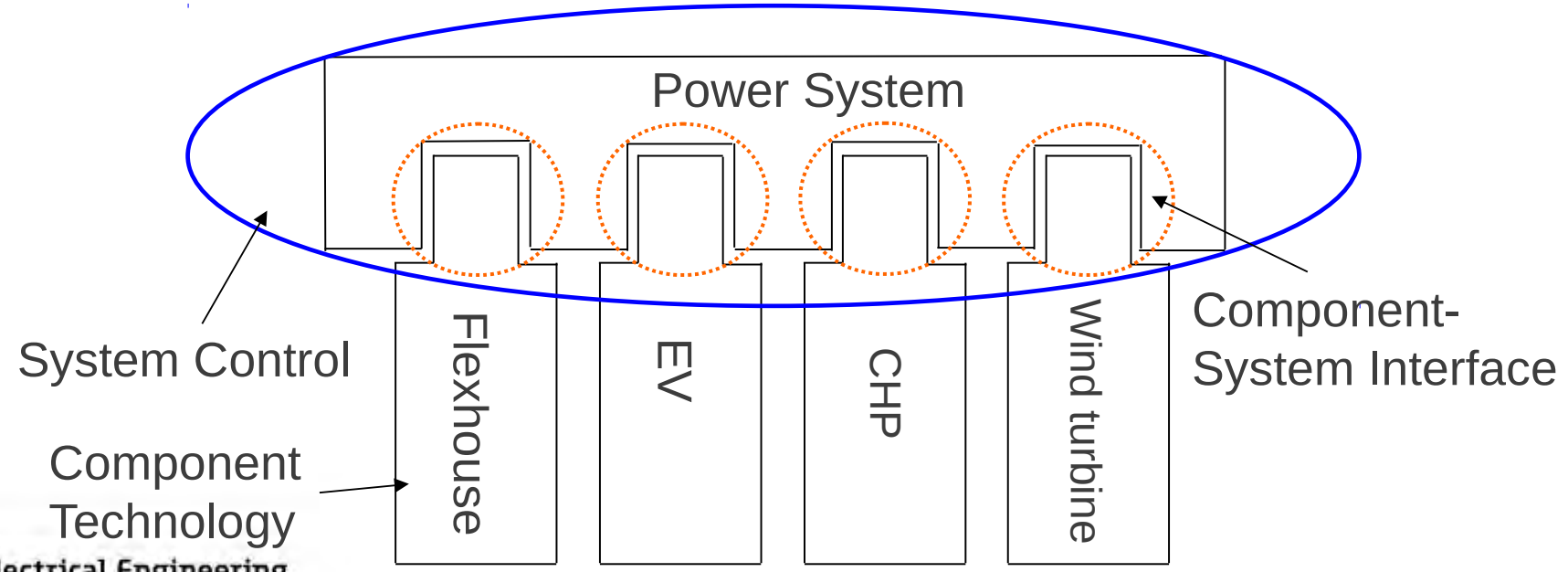


Live SYSLAB state



What can SYSLAB be used for

- System control concepts
  - Distributed and decentralised control: VPP, micro grids, agents
  - Implementation and utilisation of demand response/demand side management
  - Communication – what has to be communicated, what happens when the communication is interrupted
- Interaction between components in a heterogenoues system
  - Wind, Solar, Electrochemical Storage, Hydrogen system, Conventional production, Loads etc.
- Testing of components
  - Characterisation
  - System properties



iPower

Strategic Platform for Innovation and Research within Intelligent Electricity (SPIR)

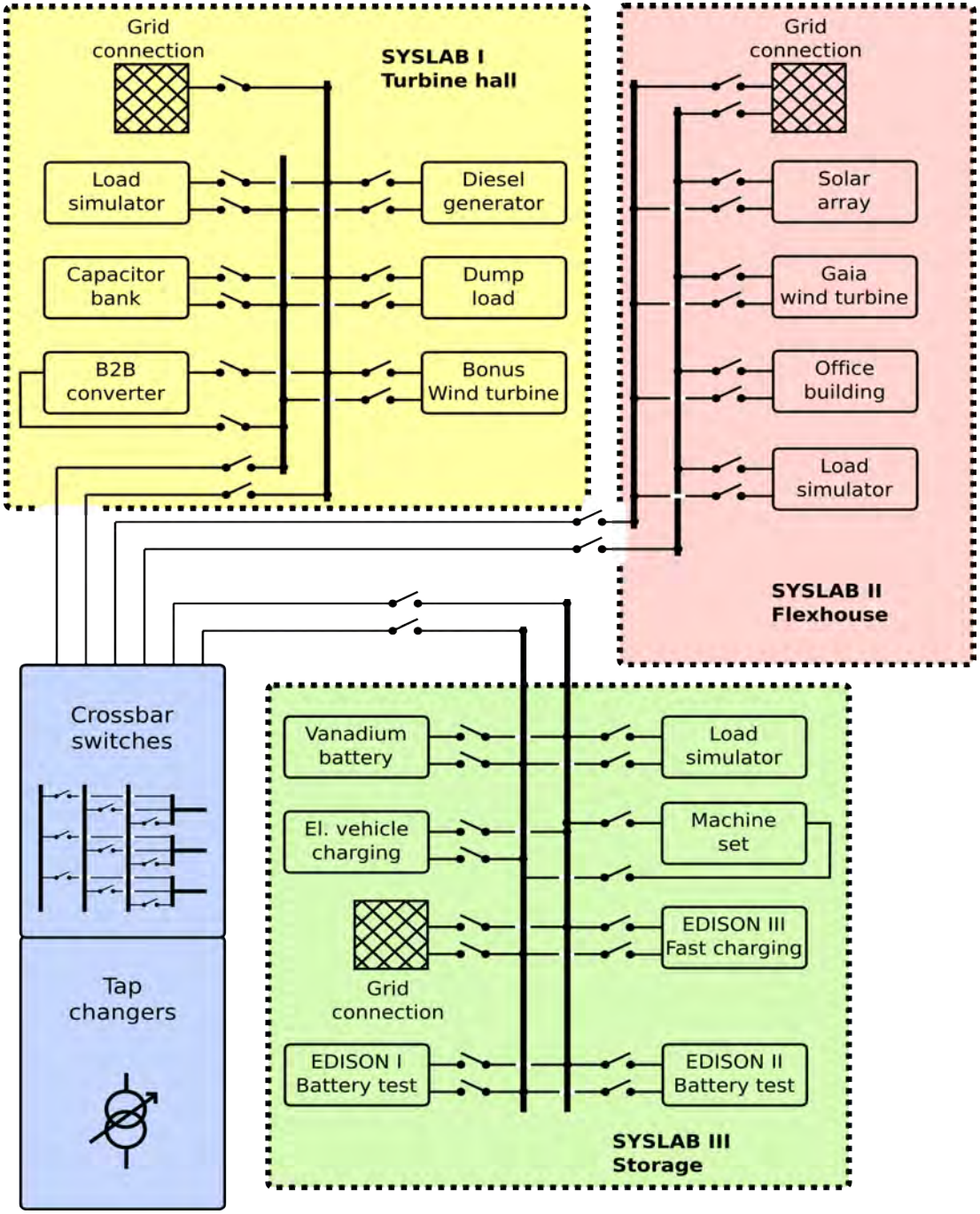
The five year vision of the iPower platform is to develop an intelligent power system where production controlled demand replaces and supplements demand controlled production.

Scientific work packages:

- Domestic/Commercial Demand response
- Distribution grid operation
- Control and market operation
- Socio-economic and investor evaluation
- Consumer behaviour

SYSLAB / Hardware platform (II)

- Three “substations” in different buildings, several hundred meters apart
- The energy resources can be combined in many different ways, as a big system or small islands
- The power system can run isolated or exchange energy with the public grid



SYSLAB / Hardware platform (III)

- Every unit is supervised locally by its own controller “node”. Nodes contain a computer, measuring and network equipment, data storage, backup power and field buses “in a box”.
- Each node can communicate with all other nodes.
- The design does not enforce a central controller. The whole system can be run from anywhere.
- 21 SYSLAB nodes +20 helper machines, total ~1000 source files

SYSLAB/ Software platform

- Coded in Java and C
- Interaction between nodes based on Java RMI, over Ethernet links
- SYSLAB RMI interfaces are presenting available methods

Unit representation

Type-based:

- All similar type of devices are represented similarly
- High level interface is reused, drivers are specific

Service-based:

- Devices with same services are represented similarly
  - Producer, consumer, infrastructure
  - Power system services: frequency control, peak shaving, dealing with congestion
- Type of the unit is no longer important

Controlling units

Reaction to external signals

- Direct control
- Indirect control

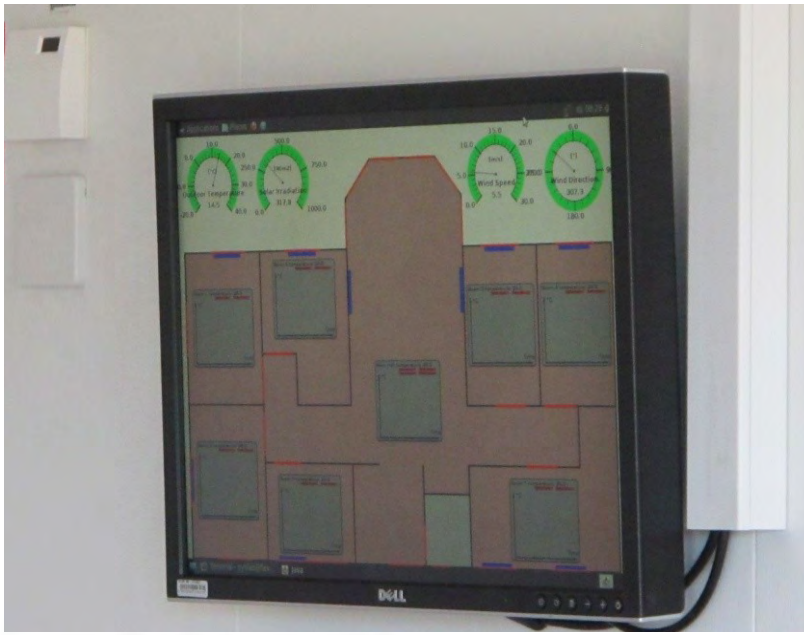
To control units information is needed:

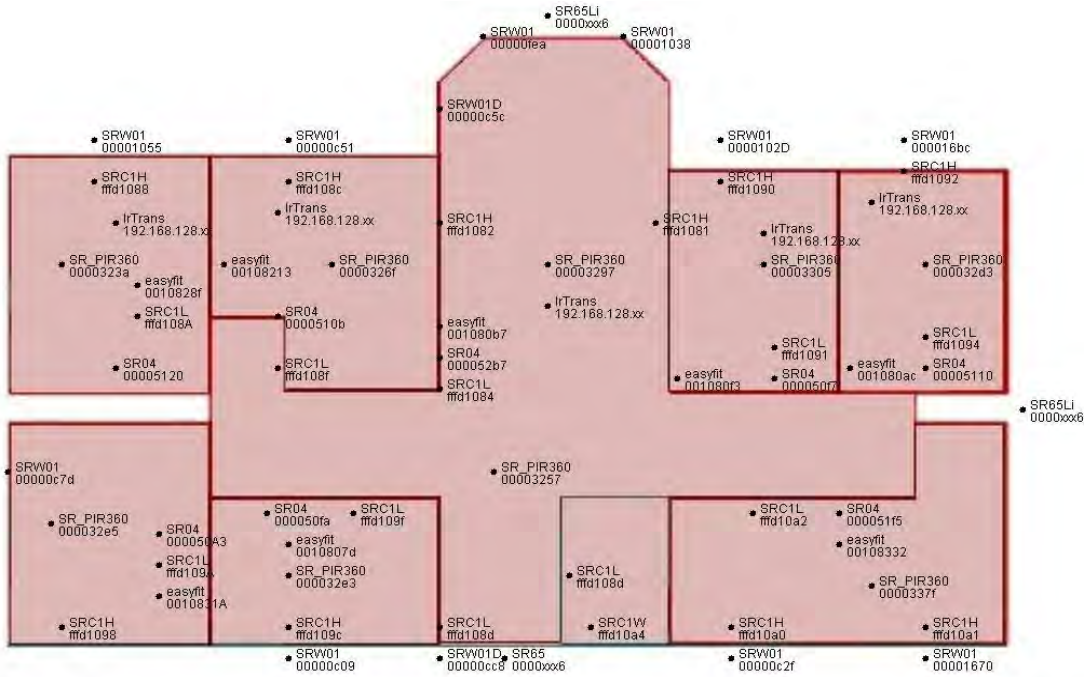
- SYSLAB RMI interface presents available methods
- With service-oriented approach, services can be described in more machine readable way (perhaps with help of ontologies and represented with OWL-S)
- In iPower Flexibility Interface is developed – information model for representing units flexibility in delivering power system services

Power FlexHouse

Power FlexHouse

- Software and hardware platform for implementation of controllers for flexible consumption
- About 50 sensors in eight rooms: temperature, motion, ...
- Actuators for heating, cooling, lighting, fridge, hot water boiler
- Study control strategies for flexible loads, sensor requirements, modelling





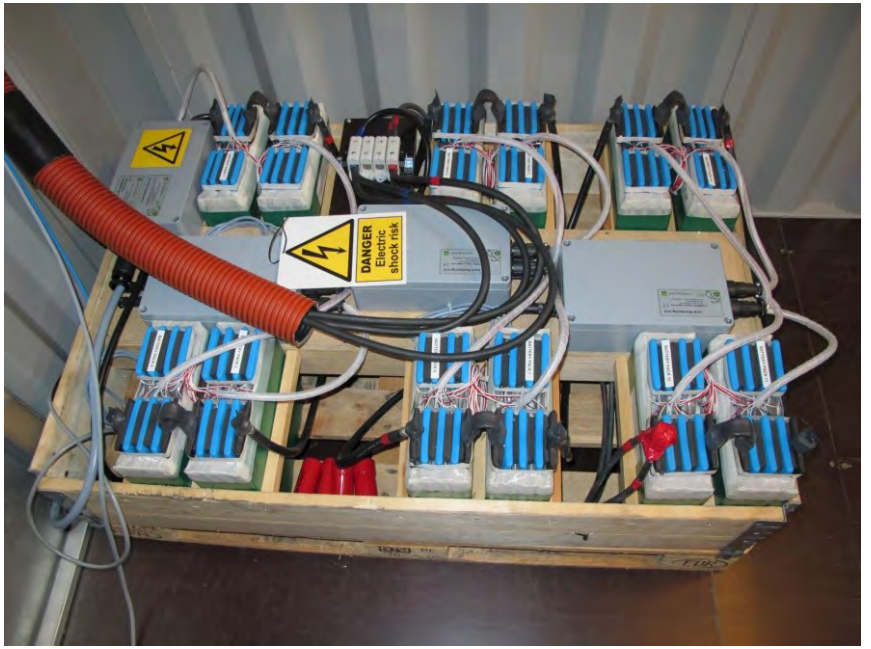
- System services provided by Demand Side Loads
  - Aggregation and Proof-of-concept implementation in SYSLAB
- Communication interface between load and system:
  - Which information to exchange,
  - How to communicate strategies,
  - Links to existing communication protocols

Demand side management projects in Power FlexHouse:

- Yi (MPC+power price)
- Daniel (policy based control)
- Jan (distributed demand response)
- Anna (Flexible load with in-house negotiation)
- Anders (PowerHub)
- Venkat (INCAP)
- Giuseppe (On-line scheduling for peak shaving)

Electric Vehicles

- End to end testing of EV infrastructure incl. communication
  - Coordination control of charging/discharging to support grid



- Testing of battery packs
- Battery modeling for performance and ageing
- Testing of charging stations incl. Grid impact

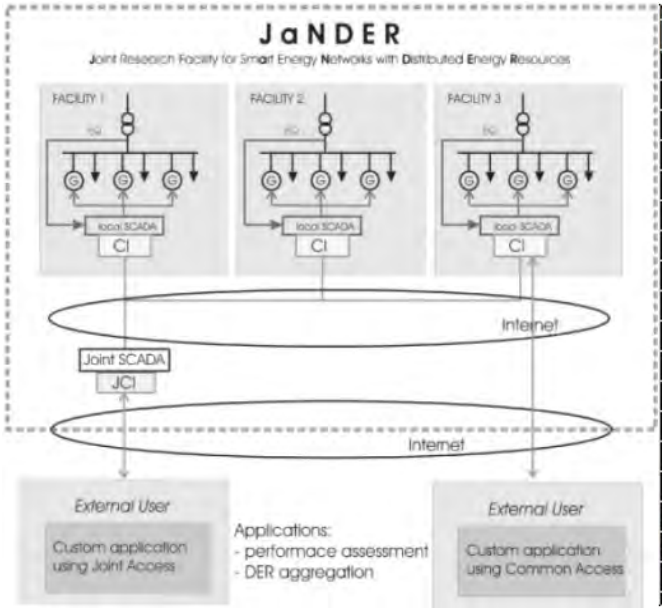
The DERRI project

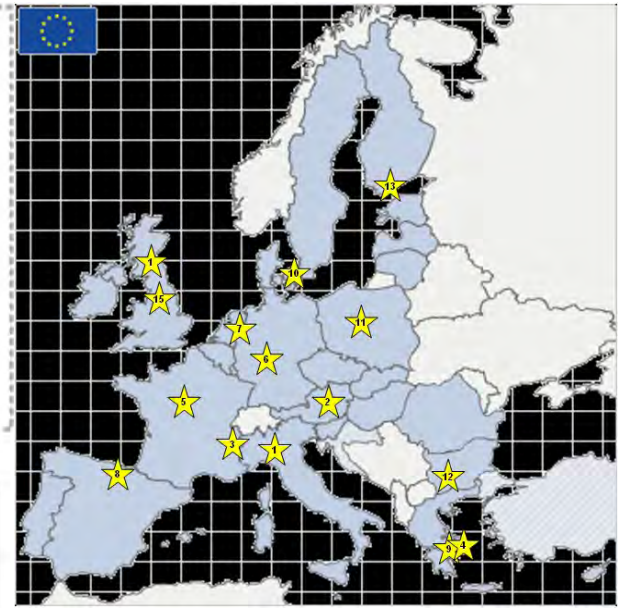
The project

- Project period: 2009 – 2013
- 15 partners from 12 countries
- 17 RI facilities
  - @ 13 of the partners
- Joint research activities
  - JaNDER – joint virtual DERlab
  - DER testing methods
    - Storage units
    - Large scale inverters
  - Real time simulation
    - Hardware-in-the-loop

Transnational access

- External access to partners RI facilities
  - Through applications
  - EU research teams
  - Including assistance
  - Free og charge





Thank you