UiT

THE ARCTIC
UNIVERSITY
OF NORWAY

Smart grid solutions for integration of renewable energy in remote communities

Bjarte Hoff
Associate Professor
Department of Electrical Engineering

E.ON Stipendienfonds, Longyearbyen 2017
The Arctic & Energy – a Delicate Relationship

UNIVERSITY OF TROMSØ

Department of Electrical Engineering, UiT Narvik

Bachelor programs:

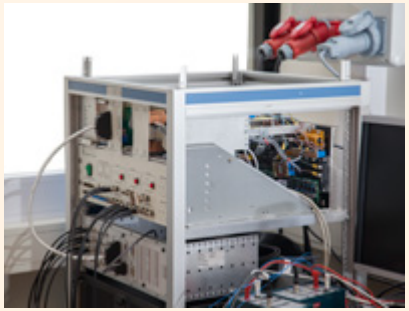
- Electrical Power Engineering
- Industrial Electronics
- Satellite Technology

Master programs:

- Electrical Engineering
- Satellite Technology

Research:

- Power electronic converters
- Distributed production
- Smart grid and microgrid
- Electric propulsion
- Motor drives



ARCTIC CENTRE FOR SUSTAINABLE ENERGY

- New initiative from UiT The Arctic University of Norway
- Projects and activities shared between several faculties and research areas

Goals:

- Be in at the cutting edge of research and education on sustainable energy in the Arctic
- Participate in international research projects (EnergyX, Horizon 2020)
- Establish centre for Environmen-friendly Energy Research (FME)

Arctic Energy project

«Low carbon self-sufficient arctic communities»

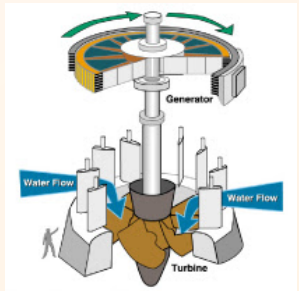
Goals:

- Increased self-sufficiency of energy in arctic communities
- Development of models and tools to support implementation of renewable energy
- Smart grid solutions
- Mapping of available renewable resources

Participants:

- Micropolis Oy
- Lapland UAS
- Centria UAS
- Norut Narvik
- UiT in Narvik and Tromsø

Integration of renewable energy



Power balance

On our way to collapse and chaos?

Many small can be combined into one virtual with centralized control

Regulations in Norway (Nordic power grid)

Prosumers: New regulations from January 1, 2017 (energilovforskriften):

- Prosumers do not pay grid tariff for consuming own production
- Prosumers can get El-certificates for the whole production (incl. own production)
- Prosumers have an agreement with power supplier to buy/sell surplus energy

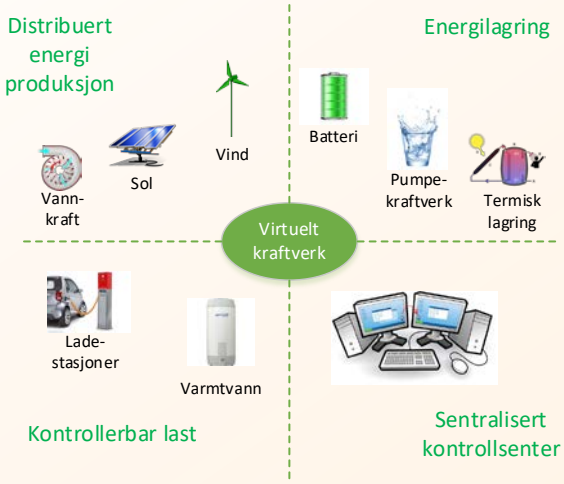
- Every installation (smart-meter) shall have one power supplier that buys or sell power going in/out of the installation

RfG (Requirements for Grid Connection of Generators)

- Small scale production (> 800 W) shall contribute to grid stability, type A
- Primary control: droop at over-frequency, or automatic disconnection and reconnection.

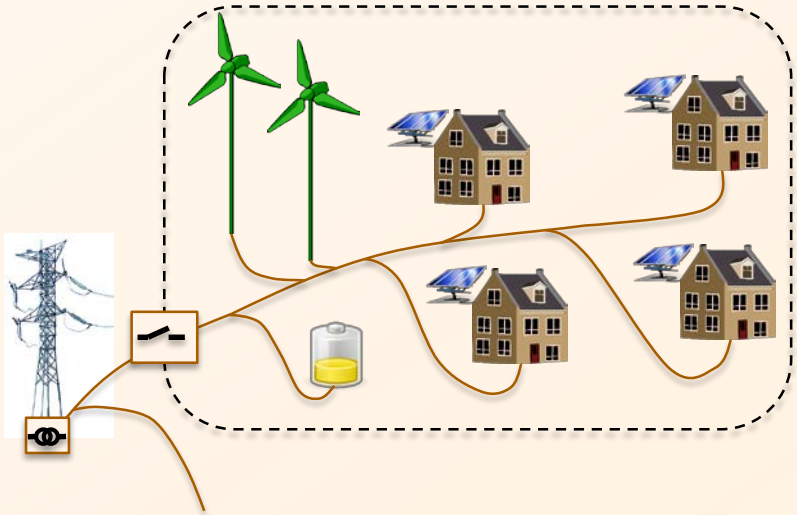
Two established concepts

Virtual power plants



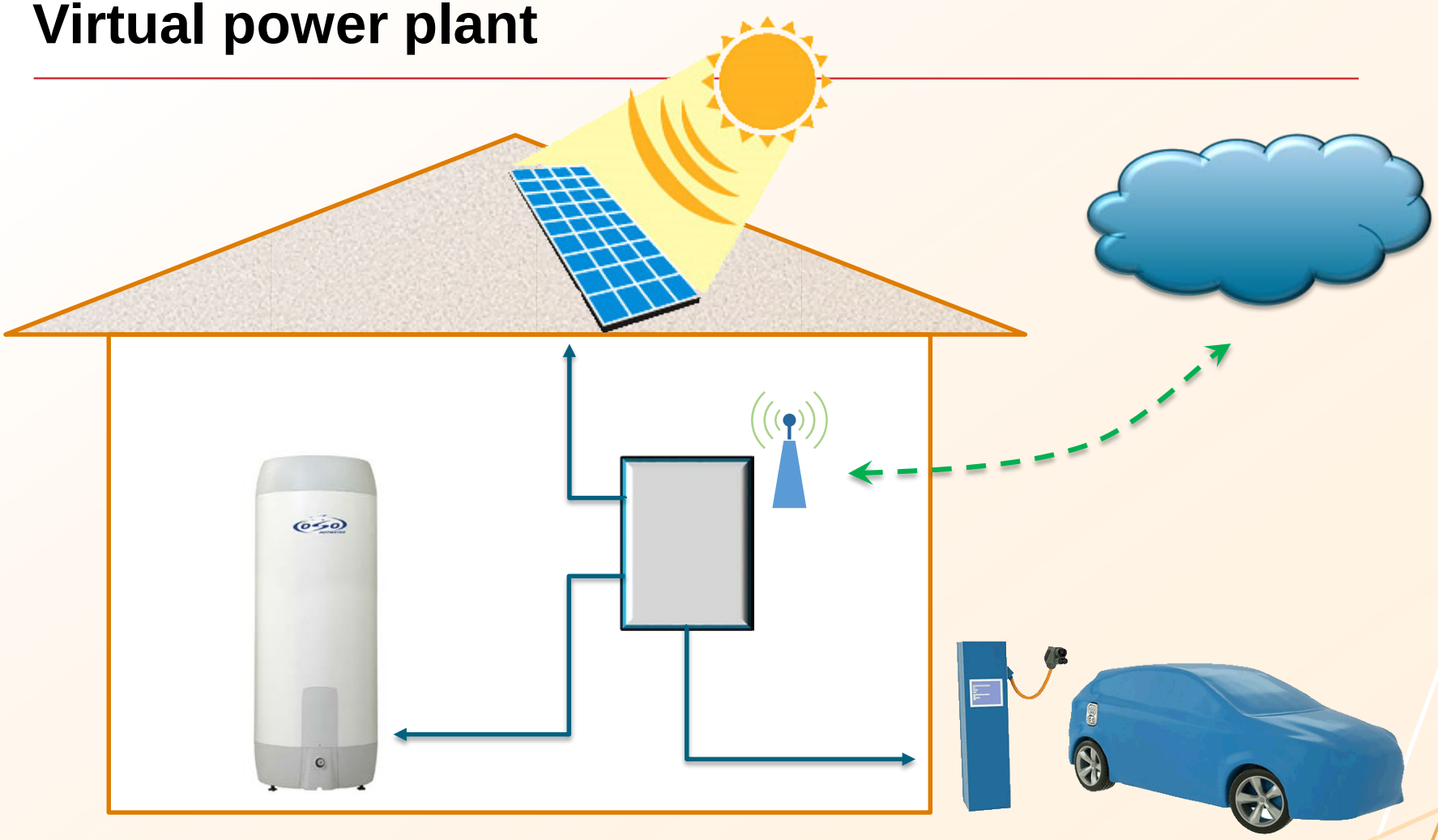
- Logical group
- Based on IT and communication
- Centralized controlled production/load
- Can include larger geographical areas

Microgrids

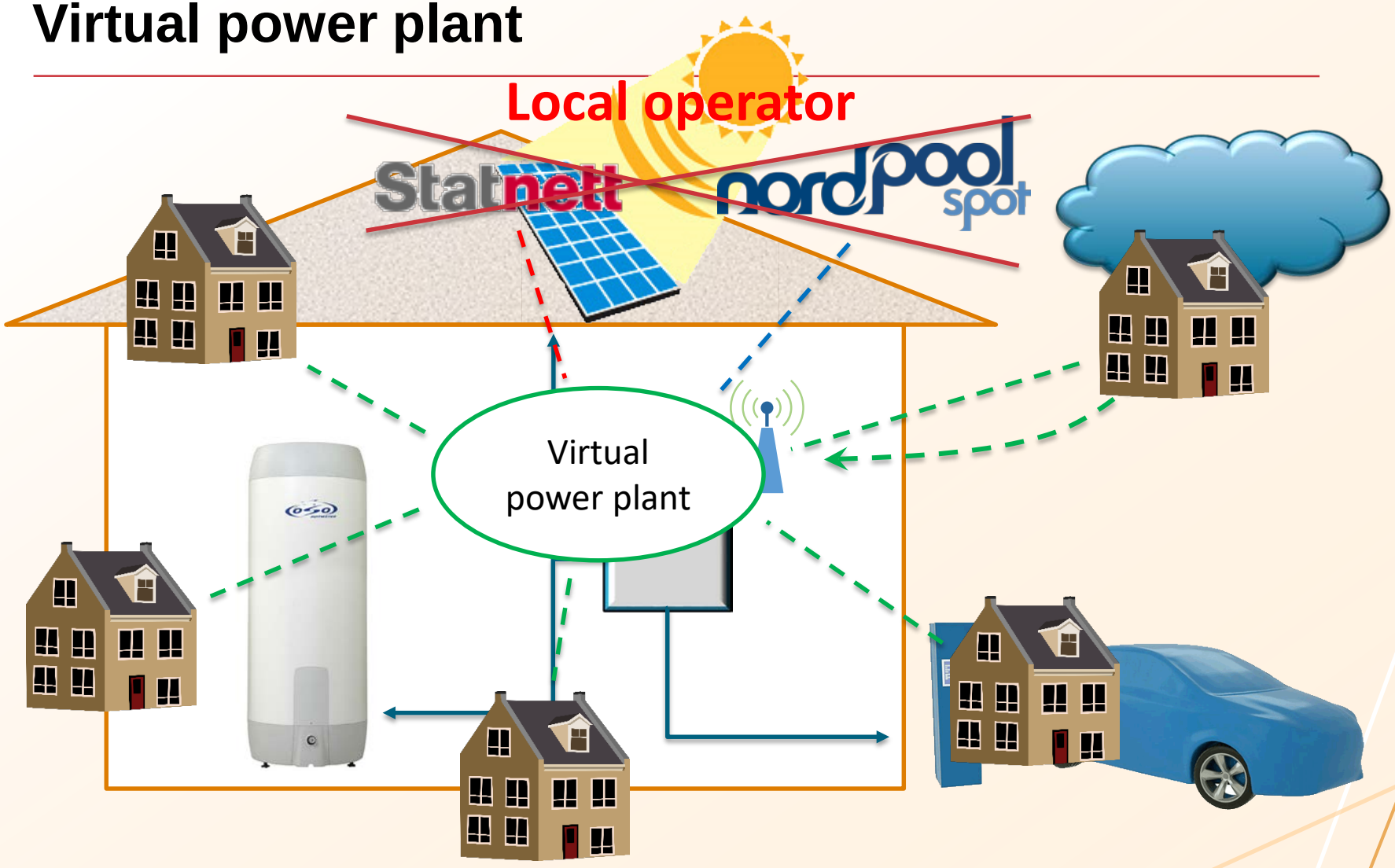


- Physical group
- Can operate independent (island mode)
- Locally controlled production/load
- Central coordination is possible

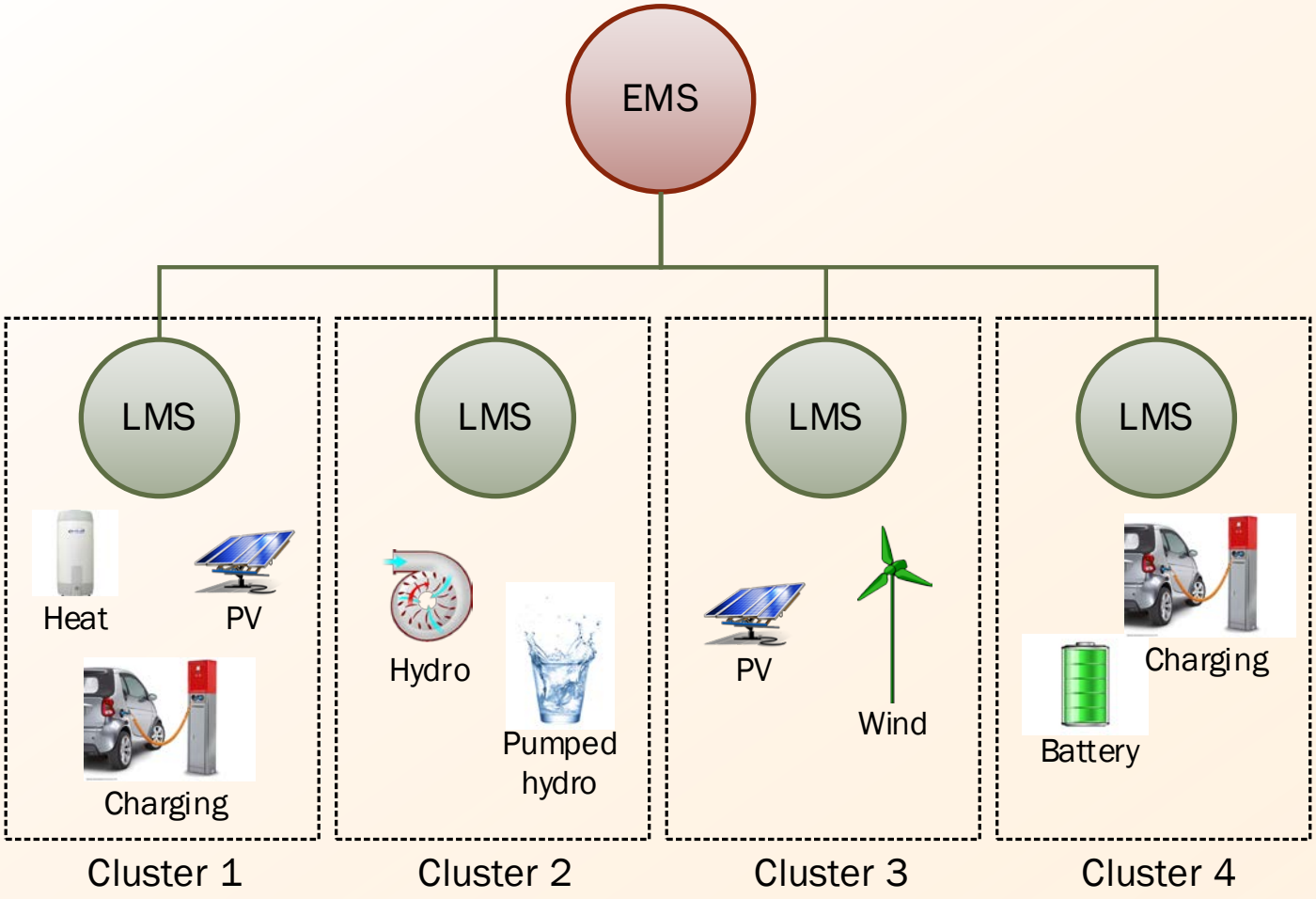
Virtual power plant



Virtual power plant



Virtual Power Plant topology



Communication in virtual power plants

- Open industrial standard to control virtual power plants based on TCP/IP

- Requirements to be VHPready compatible:
  - Technical plant-related requirements
  - Control and communication protocols (IEC 60870-5-104 or 61850-7-420)
  - Exchange information
  - IT security

Virtual power plants in operation

Next Kraftwerke (Tyskland)

- Volume: 10,2 TWh
- Units: 4 076
- Capacity: 2 726 MW
- Secondary-reserve: 657 MW
- Tertiary-reserve: 756 MW

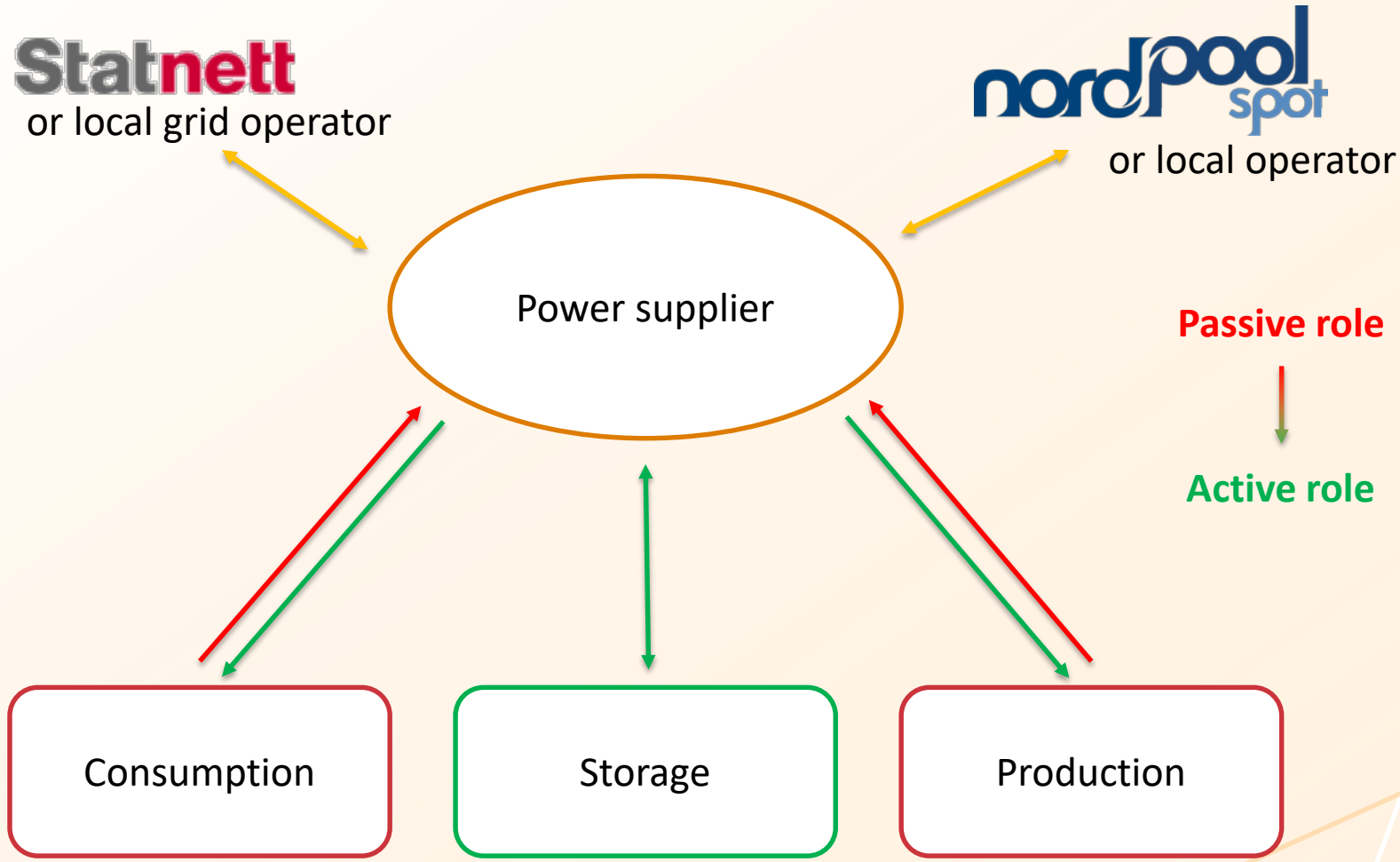
Link: https://www.next-kraftwerke.com/

A new research project «Det virtuella kraftverket» (Sweden)

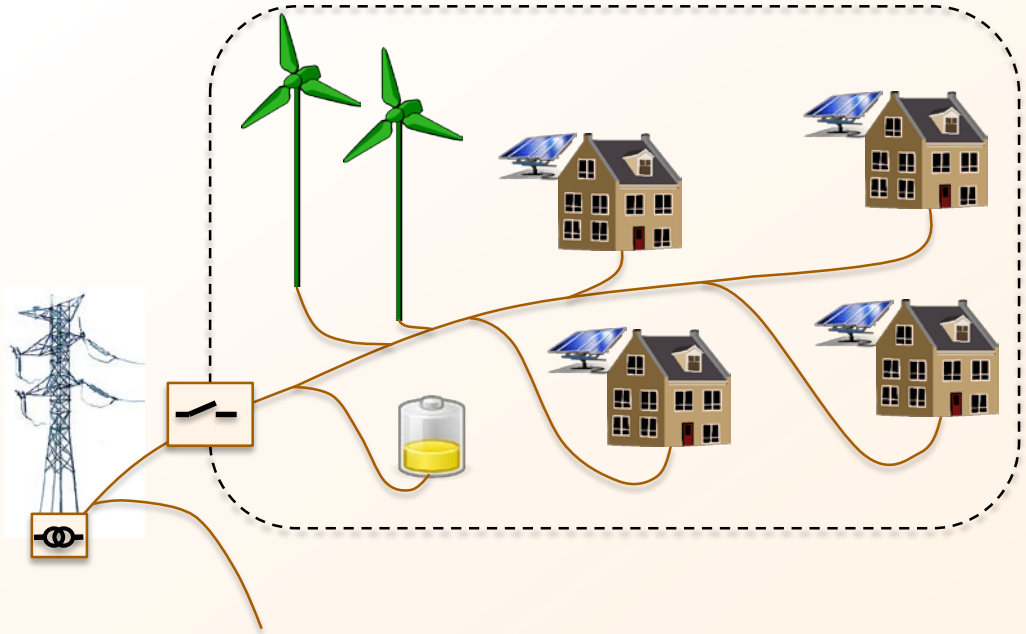
- 100 households are participating
- Hot water tanks are automatically controlled by an algorithm

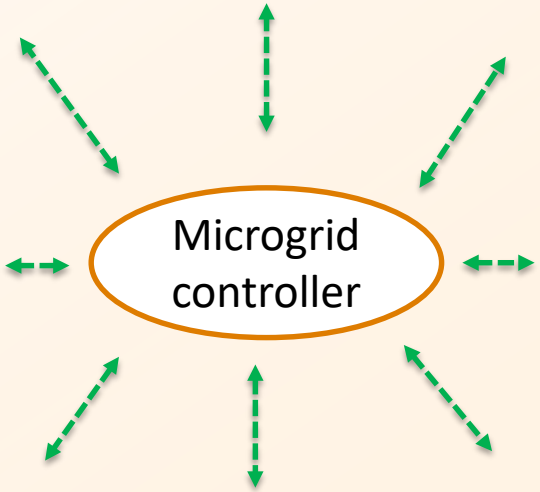
Link: http://www.nyteknik.se/energi/frivillig-styrning-ska-gora-elsystemet-flexibelt-6820497

The role of a power supplier?



Microgrid and control





Has its advantages in:

- Geographical limited areas with weak/unstable supply
- Installations with high power quality requirements

New standard for microgrid-controller

International standards arriving soon:

- IEEE P2030.7 – Specification of Microgrid Controllers
- IEEE P2030.8 – Testing of Microgrid Controllers – based on P2030.7
- Planned to be approved and published this year

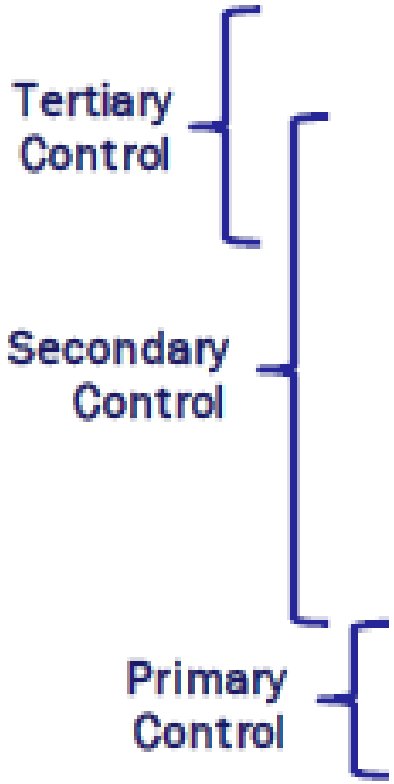
Main functions in P2030.7 the standard:

- Transition between gird-connected and isolated mode without interruption
- Control of distributed production and controllable load
- Other minimum functions common for all microgrids

From the P2030.8 standard:

- Defining a generic microgrid the controller can be tested against
- Could give some guidelines on how microgrids should be built (Compatibility with microgrid controllers)

Functions in a microgrid



Function Assignments to Blocks

Block 4

Grid Interactive Control Functions

Area EPS Control, Markets, DMS, Distribution SCADA

Block 3

Supervisory Control Functions

Forecasting, Data management and Visualization, Optimization (e.g. Volt/VAR, Economic dispatch), Dispatch, State Estimation, Emergency Handling, Generation Smoothing, Spinning Reserve, Topology Change Management, Black Start, Protection Coordination

Block 2

Local Area Control Functions

Sequence Logic/Status control, Load Management, Building Energy Management, Plant Controller, AGC, Fast Load Shedding, Resynchronization, Disturbance Recording

Block 1

Device Level Control Functions

Voltage/Frequency Control, Reactive power Control, Electric Vehicle Control, Energy Storage Control, Load Control, Generation Control, Islanding Detection, Fault Protection

Source: IEEE p2030.7 WG

Summary

Virtual power plants and microgrids can allow renewable energy production and electrification of transport

Technology behind virtual power plants and microgrids are suitable for remote communities

Technical solutions from many years of research, are about to become commercial available

Thank you for your attention