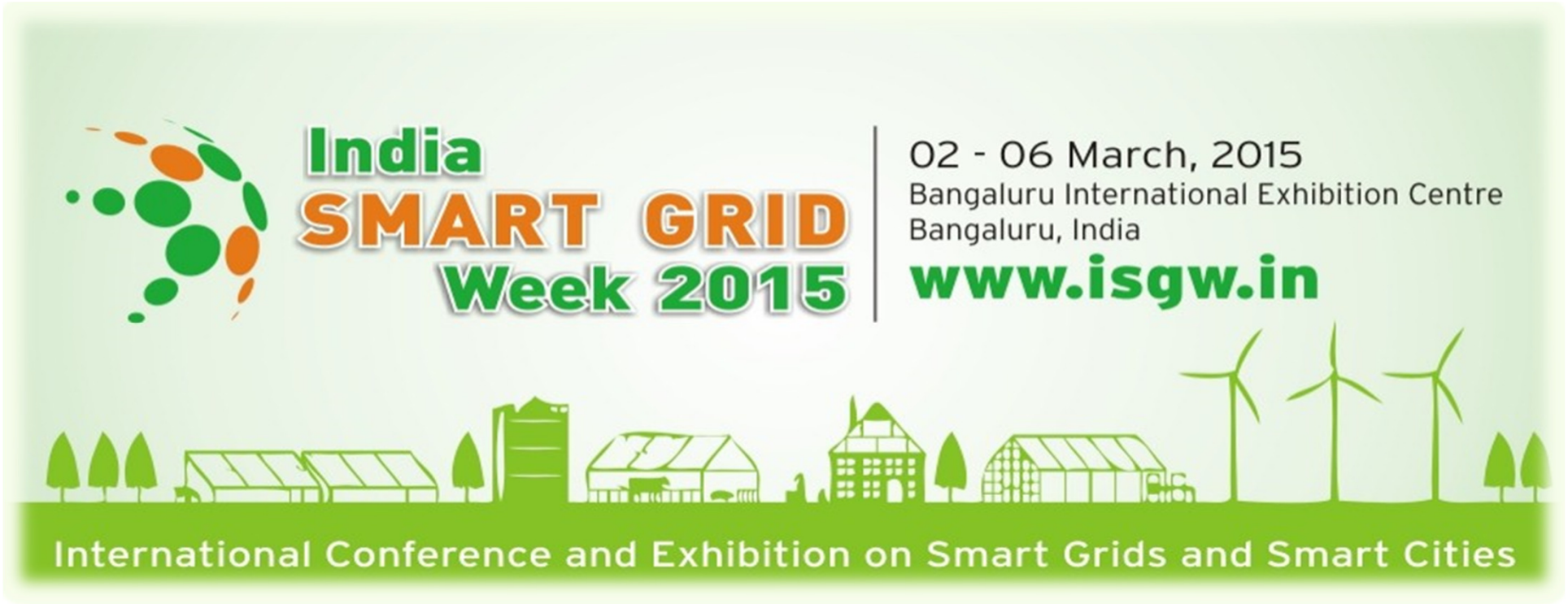

Practical experience from a Swedish Micro Grid project

Anders Lindskog, Researcher, Measurement Technology

SP, Technical Research Institute of Sweden

Practical experience from a Swedish Micro Grid Project

PV powered DC micro grid with battery storage

…on a farm

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Sötåsen Farming High School – Smart Grid demonstration

- Boarding school with 200 students
- Research farm
- Local 400V AC grid
- District heating system
- Production of biogas for heat and electricity production (CHP)
- PV production with electric energy storage and DC grid
- Measurement infrastructure with a large database

Sötåsen is a Smart Grid living lab and an open test bed

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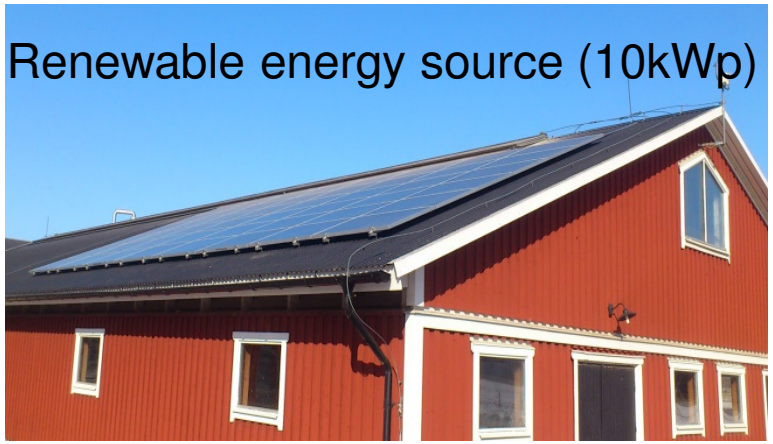
The DC Micro Grid research system



DC distribution grid (3 kW Load)

Energy storage (20 kWh) and measurement/control system

Why PV and electric energy storage?

- Energy storage combined with renewable energy sources are important in smart grid research
- There was a desire to add a flexible research platform to Sötåsen
- Gain practical experience from day-to-day operation of an electric energy storage
- Supply “real life” data for research purpose

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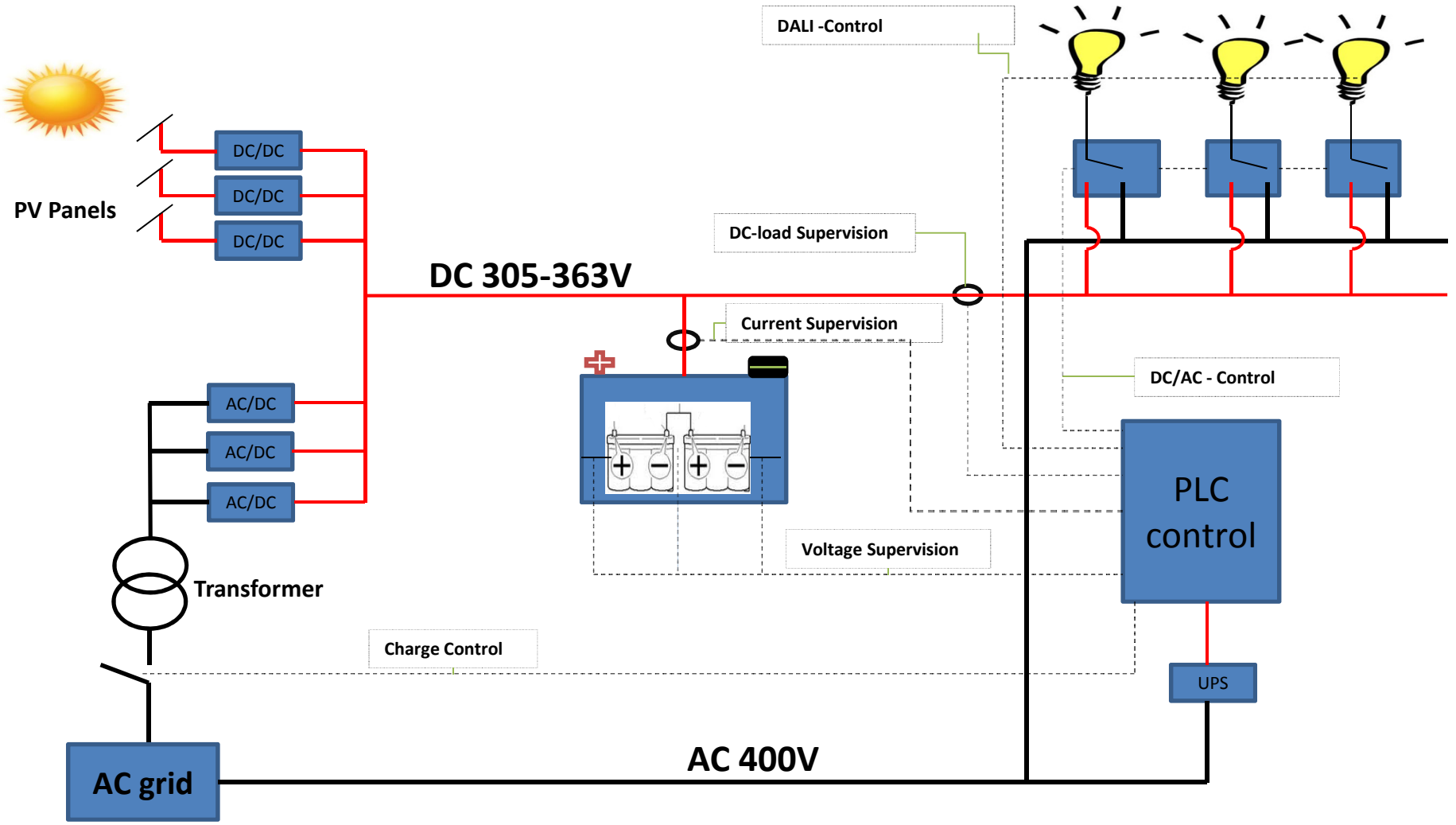
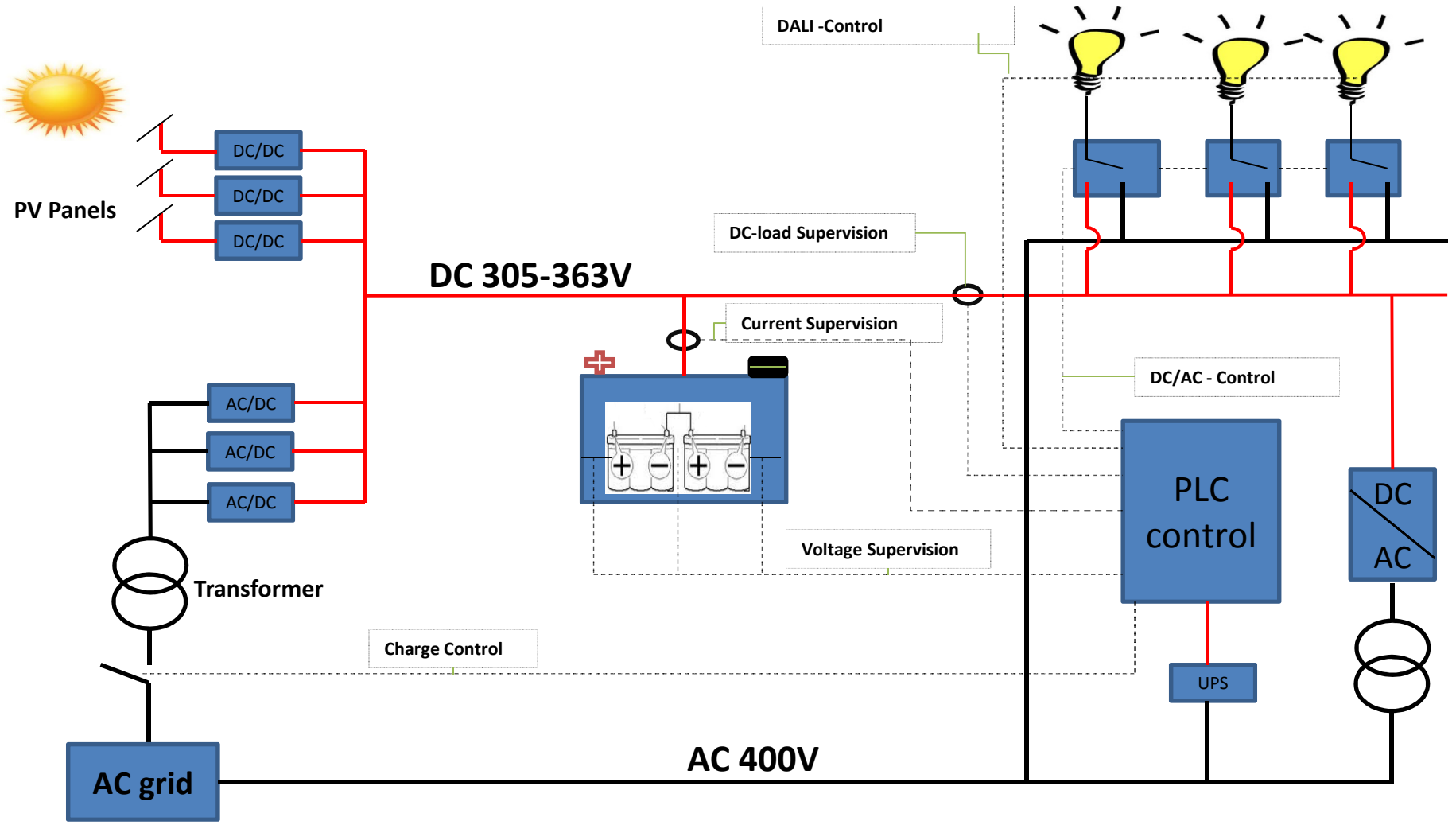
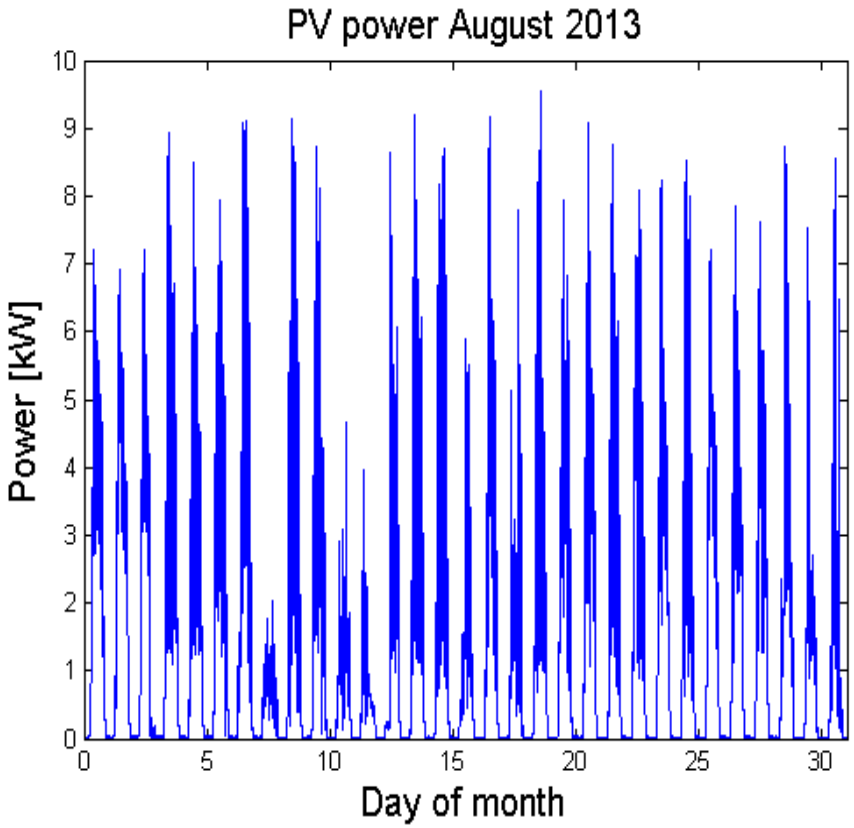
Why a DC micro grid?

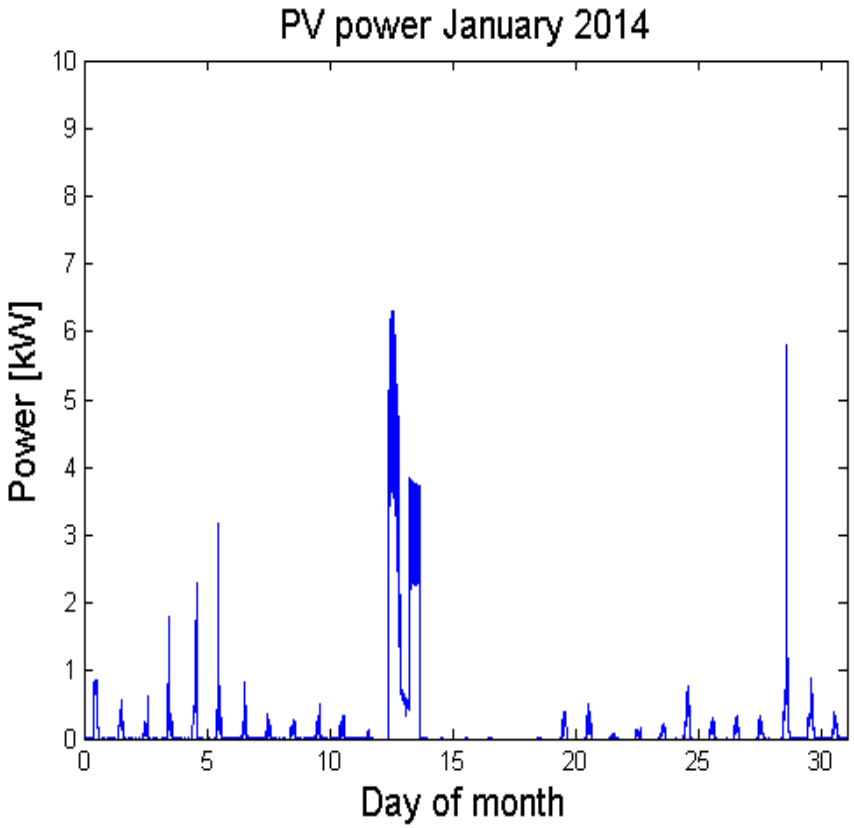
- In the planning and design process it became evident that a DC grid would be much more efficient.
- It is easier to connect different loads and production sources to a electric energy storage when using DC.
- Even if the need for DC micro grids in Sweden is low it is still a valid research topic and the technology is interesting for many parts of the world.
- DC has been widely used over 100 years and has many positive features that almost has been forgotten. It is time to renew and add to the DC system knowledge…


DALI -Control
PV Panels
DC/DC
DC/DC
DC/DC
DC-load Supervision
DC 305-363V
Current Supervision
DC/AC - Control
AC/DC
AC/DC
AC/DC
PLC control
Transformer
Voltage Supervision
Charge Control
UPS
AC grid
AC 400V



PV power fluctuations short and long term





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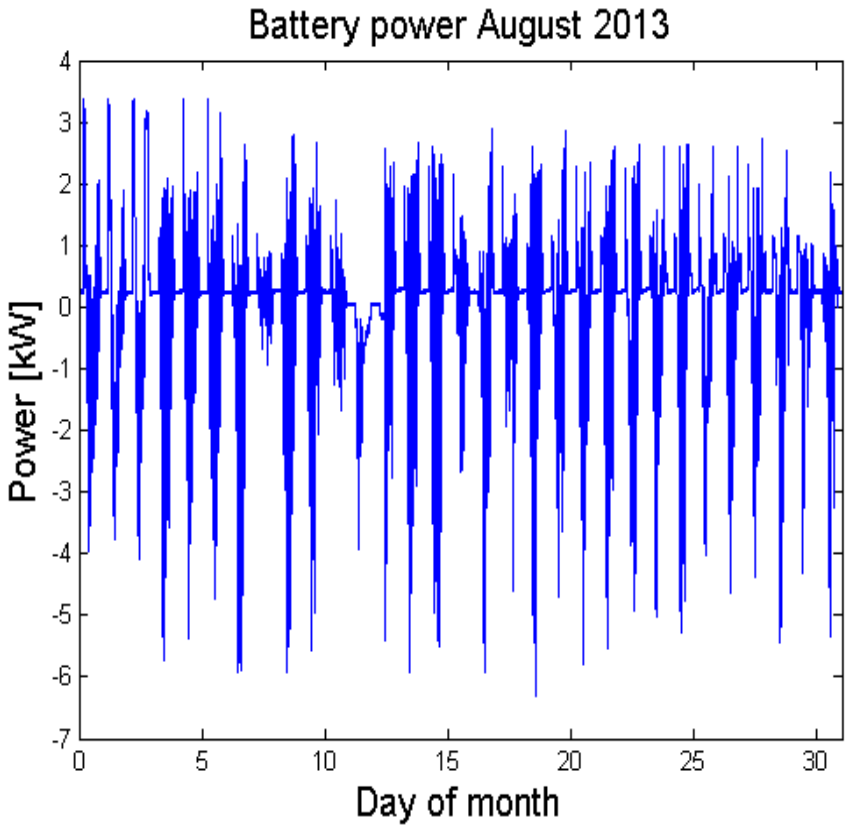
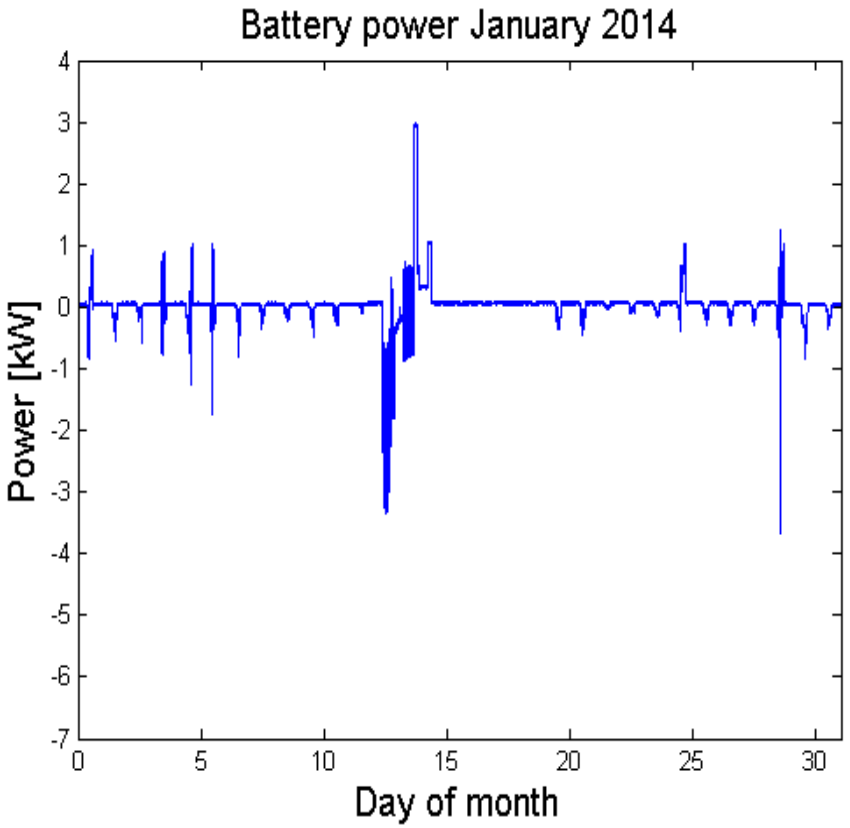
Battery usage





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Practical experience from Sötåsen

- The system at Sötåsen has been running with no failures and minimal service for over two years in a challenging environment.
- It is more cost and energy efficient to use DC instead of AC when building a micro grid with PV production and electric energy storage.
- The system was build from commercial off the shelf products.
- There are a massive amount of products that can run on DC, but very few of them are certified to do so. This creates a warranty issue…and limited selection possibilities.
- Using a system voltage in the level of 300-400V will decrease the system cost, increase the efficiency and increase the possibility to find suitable components.
- The battery and management system is the most critical and complicated part of the system.
- Detailed knowledge of the power and energy demand is vital for the system planning stage.
- Multiple types of energy sources will increase the performance of the system.

Some other reflections

- If we would rebuild our electric grids from the beginning again, with todays knowledge, I bet it would be DC rather than AC grids.
- Today it is difficult to find solid business cases for electric energy storage in a region with a well developed electric grid (and massive amounts of hydro power...)
- DC micro grids with energy storage is probably a good choice in developing economies where the electric grid infrastructure is not developed.
- The DC micro grid system voltage should probably be higher than 200V

THANK YOU!

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