Power system services provided by inverter connected distributed energy resources

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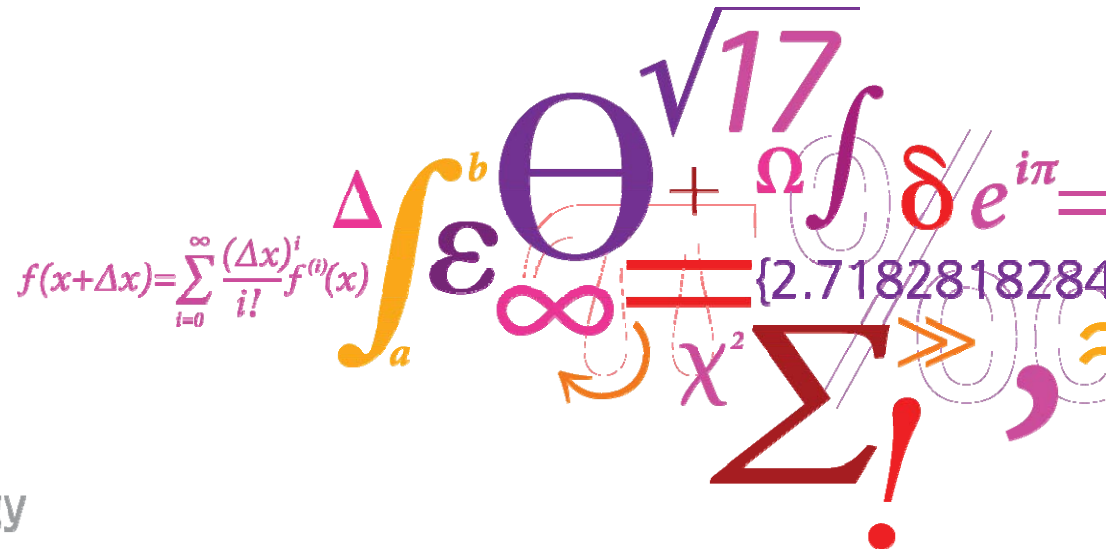
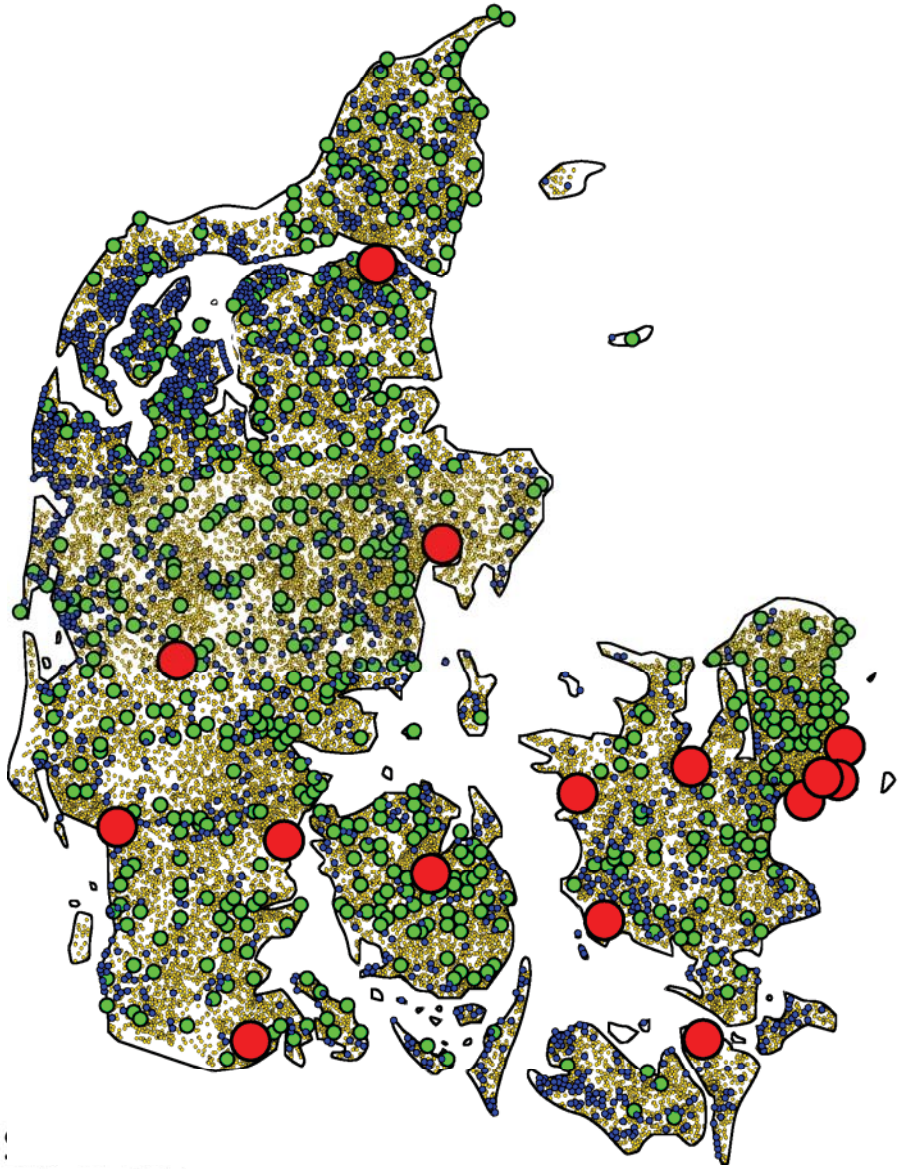


Risø DTU
National Laboratory for Sustainable Energy

Introduction

- Electricity production from distributed renewable energy sources is increasing
- This distributed generation is becoming a larger and more significant resource in the power system
- More and more of these units are connected to the system using power inverters
- These inverters offer new opportunities in control and communications
- Inverter connected resources have the potential to enhance and increase power system stability

Distributed Small Energy Resources



Year 2025:

- 15 central power plants
- 500 local CHP plants
- 6.000 wind turbines (50% of energy)
- 1.000.000 small energy resources (households, vehicles, industrial consumers)

Small energy resources need to participate in the provision of ancillary services.

Danish grid codes

- Requirements for units smaller than 11 kW
  - External start and stop
  - Over and under voltage protection
  - Over and under frequency protection
  - Rate of change of frequency limits

Inverter capabilities

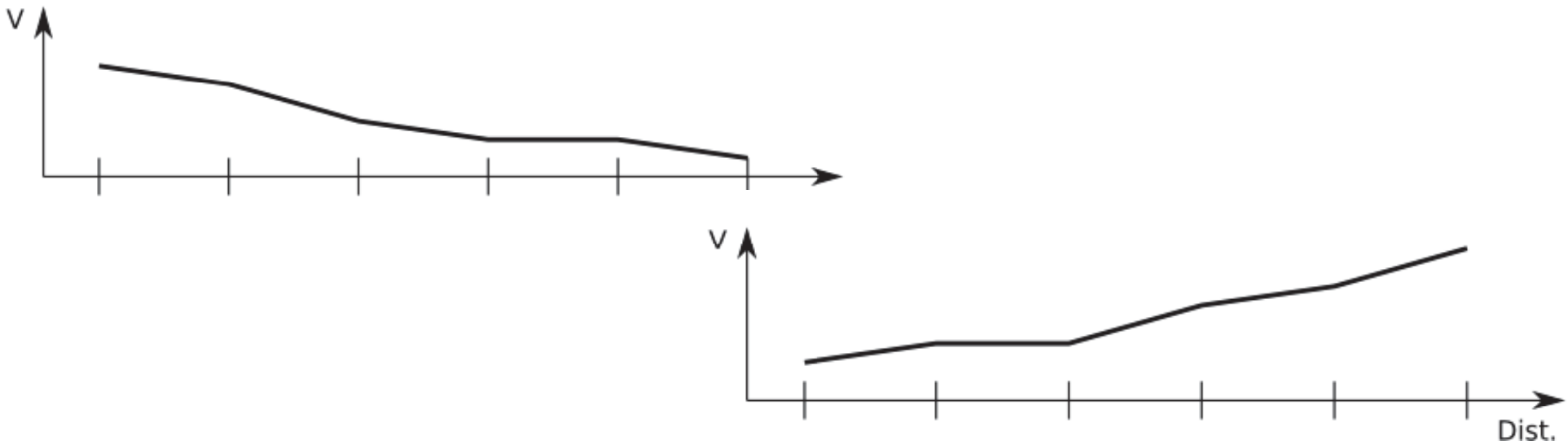
- The latest inverters have reactive power consumption and generation capabilities largely independent of active power generation
- The inverters are usually computer controlled, facilitating communications and fast control
- An aggregate of inverters can significantly contribute to power system control
- To enable aggregation, inverters need to have common functions and communication protocols

Inverter functions

- Connect/Disconnect from Grid
- Power Output Adjustment
- Reactive power Management
- Storage Management (Charging/Discharging)
- Event/History Logging
- Status Reporting/Reading
- Time Adjustment

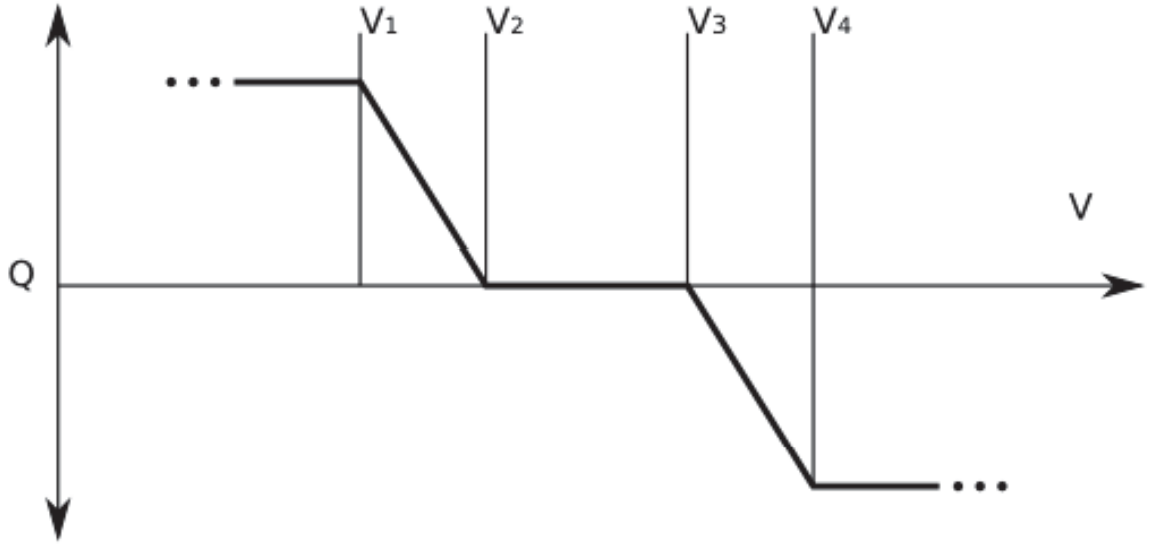
Voltage control in the distribution grid

- Distribution grids face increased loads and production
- Voltage control on the 400 volt level is not automatic and set for predetermined situations
- Cases such as low load and high production in a feeder can cause local voltage problems



Control methods

- Control has to be achieved without frequent communication
- It should be possible to send out control signals without addressing individual units
- It should be possible to achieve a coordinated response from multiple inverters



Feedback to system operators

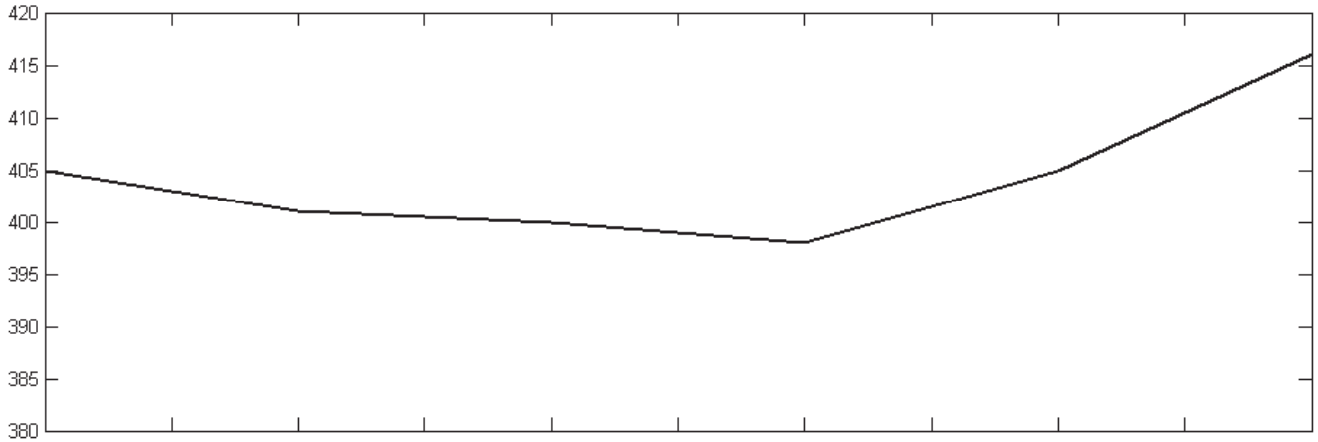
- How can the system operator know how much of the resource is available?
- How can the system operator know which units will respond and have responded?
- Should this information come from bi-directional communication between the inverter or an aggregator and the system operator or are other methods needed?

Results from the DERlab workshop

- A 10 kW PV inverter was tested for voltage support capabilities in different grid setups with 20 kW load distributed along the feeder

- The tests showed that the inverter was able to improve voltage profile along the feeder

- The tests also showed that a relatively small amount of reactive power injection can induce a considerable voltage increase in a loaded feeder



Summary

- Inverters could be a cheap and simple way to provide ancillary services
- Control and feedback require an increased level of communication in the distribution system
- If services from inverter connected units is to be utilized a more advanced grid code is needed
- Methods for estimating and evaluating the response from multiple units are needed