

# Experience of DER integration in Denmark,

Role of DER in the EU and current status in the Baltic States. Vilnius, March 6<sup>th</sup>, 2007.

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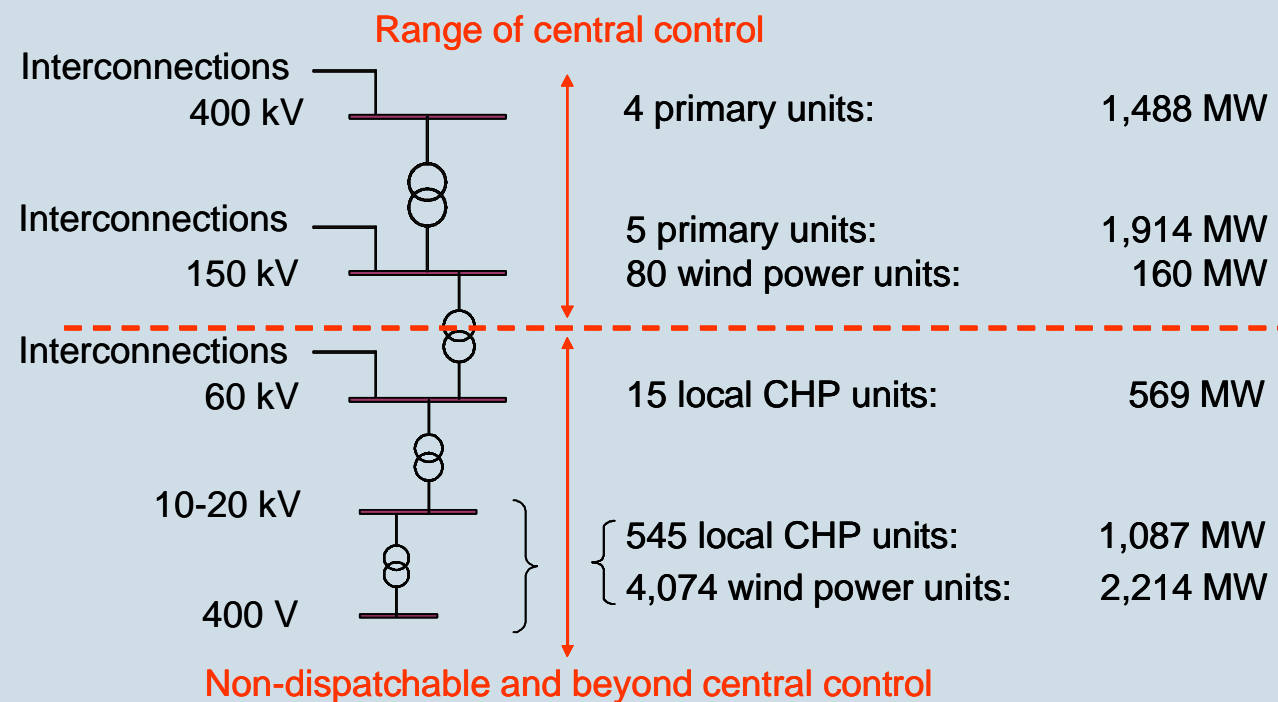
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# Why we look for new grid operation options

The impacts on power markets, system operation and security of supply are causing concern. Energinet.dk, the TSO of Denmark, is developing new solutions for optimal management of the large DG base at hand.

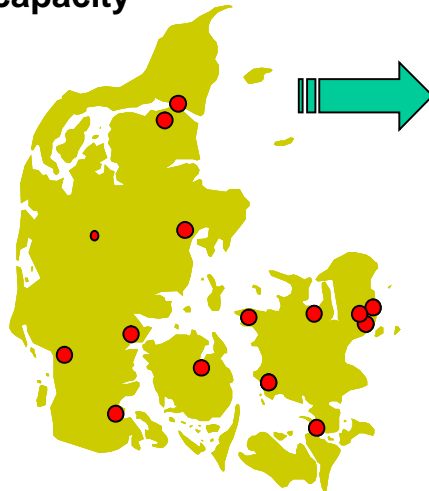


Production capacity per voltage level in western Denmark, 2005.

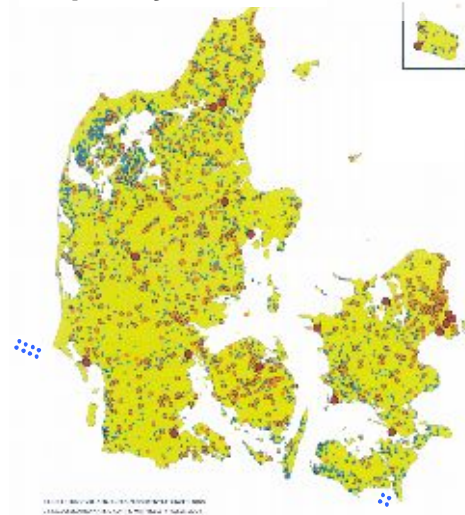
# How did we get there?

## Development from the 1980s to 2005

Primary production capacity



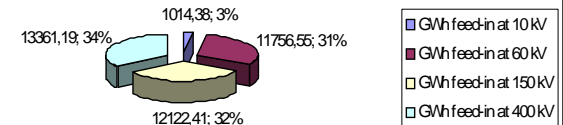
Local production capacity



Consumption 6,534 MW  
 Production > 100 kV: 7,569 MW  
 < 100 kV: 5,117 MW

- Primary production plants
- Local plants
- Wind turbines

Feed in by voltage level, Denmark 2006 to date



RE accounts for 23.3 % of the total production  
 (in the Western grid area, the RE percentage is 29.0)

If the rest of Europe was to follow this path, there would be more than 2 million distributed generators, not counting roof-top PV.

## Denmark is a "real-life laboratory"

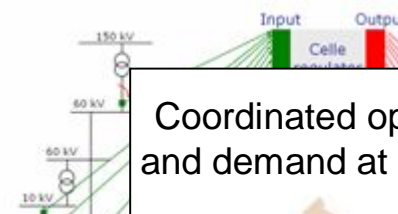
- High DG penetration in Western DK power system

- Installed DG: 3,857 MW
- Average load: 2,469 MW
- Wind power covers 20% of the load

- Several research activities regarding network and control architectures in progress incl. real-life demonstration

Technical University of Denmark  
Centre for Electric Technology (CET)

### Cell controller pilot project



Coordinated operation of wind and demand at island Bornholm

### NextGen – future coherent electricity and information system with integrated DG



- Participation of local CHP in markets
- Ancillary services from DG/RES
- Development of IEC61850-standards



## The Cell Project

Objective: Operate a 150/60 kV substation and all generation and loads below it as a controllable power plant capable of import/export control, baseload operation, and island operation.

- In October 2005 Energinet.dk launched phase 1 of a full scale cell operated micro grid test area. The test area has several embedded power generators of varying specifications. The first phase comprises installation of measuring and surveillance equipment in the test area which is to be operated as a pilot cell. During 2006 the pilot cell was modeled in detail and simulations were run on the cell regulator in laboratory scale tests.
- Full scale cell operation of the grid area is being launched in the coming months, the functionality of the cell regulator will allow the cell to disattach from the grid and go into controlled islanding in situations where a critical operation implies that a break down of the primary grid is about to happen. The project partners are
  - ♠ Spirae Inc, Fort Collins, Colorado, USA
  - ♣ Energynautics GmbH, Langen, Germany
  - ♥ Sydvest Energi Net A/S, Esbjerg, Denmark
  - ♦ Energinet.dk, Skærbæk, Denmark

## The Cell Project... continued

### Status:

- Background study of related research and applications completed in 2005.
- Deployed high speed monitoring system in pilot test area, deployed prototype controller, and validated controls in simulation lab tests.

### Next steps 2007-2008:

- Expanding the monitoring system and deploying field pilot in ~3 MW load area.
- - to be expanded to ~50 MW load area.
- Expert authentication of more detailed results in 2007.
- Stay tuned!

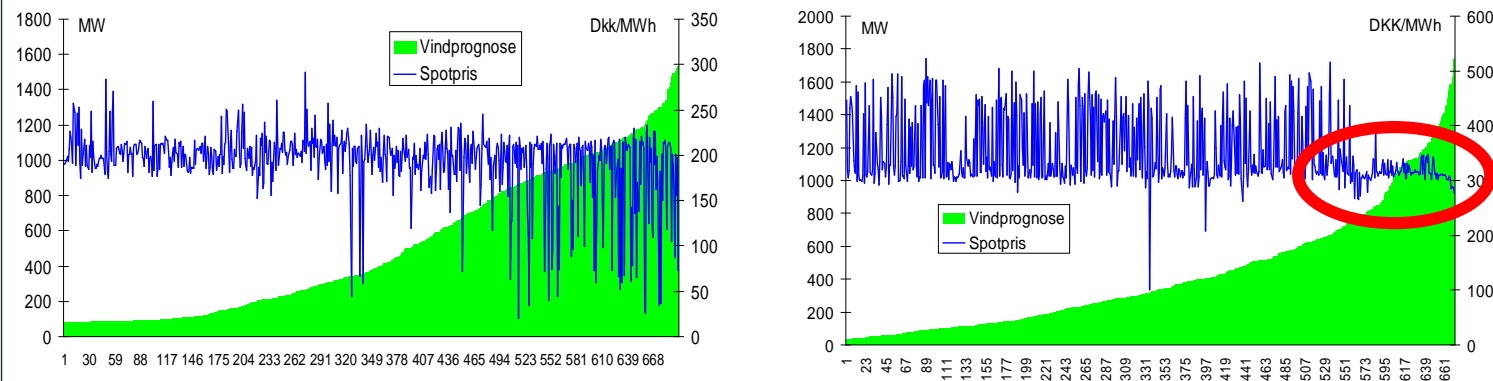
## The Cell Project, references

- "Developing And Demonstrating An Advanced Cell Architecture For Managing Electric Power Systems With High Penetration of Distributed Energy Resources". Eltra Cell Controller Project, Phase A. Interim Project Report, Workshop II, Billund, Denmark, February 7-8, 2005. Deals with protection issues and the practical definitions of a cell.
- "A Cell Controller for Autonomous Operation of a 60 kV Distribution Area". 10th Kasseler Symposium Energy Systems Technology 2005.
- Grid code: "Technical specification for thermal power generators larger than 11 kW and smaller than 1.5 MW", TF 3.2.4, version 2 2006-11-29 (Danish only). Touches upon all distributed or embedded generators that operate without a converter unit. Doesn't specify codes for islanding mode.

It seems that the level of RE and DE has reached a point where further liberalization of the energy market may be realized only if the level of RE is increased, and vice versa

- Energy storage, heat pumps, solar thermal, co-generation of biofuels and power etc. all increase the degree of freedom for the plants to operate at a maximized economic output. This also benefits the market, as the number of actors offering balancing power increases.

Wind prognoses and spot prices; Feb 2004 and Feb 2006



**The difference? DG combined heat and power plants larger than 10 MW joined the Nordpool markets**

## Energy Forecast

Objective: Customer ethnology

- Project started this year, to work with customers on their level of technical insight.
- Energinet.dk will fund and oversee the project, and also provide model simulations and market price signals.
- A local TV network will broadcast daily energy forecasts, right after the weather guy.
- The challenge is to work out the language and the technically honest terms that will supply the electricity consumer maximum instant knowledge and the ability to act on market price signals.
- Monitoring of the customers in the area (250,000 households) to survey and meter their uptake of the new regime.

## New concepts for active customer-integrated distribution networks *are needed*

- Resources in the distribution networks are not truly integrated and not fully utilized in the power system
  - Wind power, PV, local CHP, micro CHP (incl. fuel cells, micro turbines ...)
  - Demand
  - Heating and transportation (e.g. electric car, plug-in hybrid cars)
- Current network architecture is not designed for DG and intermittent sources
  - Flow pattern, protection, reactive power management, losses ...
- Active distribution networks are needed
  - Optimal utilization of the distributed resources
  - Active market participation
  - Appropriate emergency response
  - Intelligent customer integration
  - Cost of bits  $\ll$  cost of new hardware

## EcoGrid challenge

- Need for development of new market-based control concepts and the related network architectures
  - Totally new solutions for power systems with high penetration of DG/RES is needed
- The Danish situation
  - A “real-life laboratory” is available
  - Data and operational experiences exist
- Denmark can contribute to European research on active distribution networks
- Security of supply is expected to stay high, but what levels are achievable?
- The results will show whether 100 % RE beyond 2025 is an option, with subtargets at 30, 50 and 90 % RE in the power mix.

## Areas for cooperation

- Communications
  - What to relay to the TSO
  - What to relay to the DSO
  - What not to relay but just monitor
- How much demand response?
  - Only relevant in emergency mode and only the lower priority demands?
  - Or everyday, integral to the operation of the entire grid?
- What's the interface between demand response and market price signals?
  - Customer profile, equipment, time to react..
- Case studies
  - Animations, models, simulation data and examples, benchmarks.
  - We need to share generic cases with transparent data sets, to speak the same language. This will provide a short cut to good solutions to the other issues.

## EcoGrid – A new project in the making

Objective: To take the cell project to the next level

- The aim is to develop farsighted new technologies and market solutions, for a better future grid.
- Energinet.dk is leading a consortia to apply for EU funds under FP7.
- The project will coordinate and interact with ongoing core activities such as More Microgrids, Reliance, EU-Deep, the Cell Project, model tools and market design.
- Phase 0 - December 2006 to May 1st 2007. Consortia start up and terms of agreement developed. Application writing.
- 2007-2012. Project in progress.
- Beyond 2012 the project results are expected to be implemented in Denmark in full scale.

# Thank you for your attention

- More information:

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