Future active customer-integrated distribution networks

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Topic 7.1.1: Develop and validate *innovative control strategies and network architectures* for active networks with large-scale penetration of RES and DG

- ***Content/scope from FP7 call:***
- Research on new concepts for future active customer-integrated distribution networks and validation of most promising ones.
- These new concepts should enable the market based optimal exploitation of the multiple benefits of large numbers of renewables and distributed generation coupled with intelligent metering and real-time demand and response techniques, and at the same time fulfil customer expectations.
- In addition, research should also cover pre-regulatory issues related to the development of decentralised energy and ancillary services markets, the efficient allocation of network costs, new business models and flexible contract management.

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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 << cost of new hardware

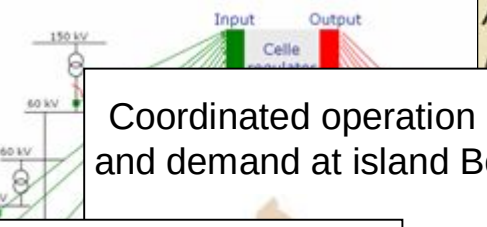
Research to be done

- Key enabling technologies to be developed
  - Standardised coherent *information architecture* for distribution system control
  - Customer access by *smart metering* with communication
  - Real-time *customer response*
- New concepts for market-based control strategies for active distribution network incl. integral network architectures
  - *Real-time price signal control* w/ future overall markets integration
  - *Nodal pricing* w/ coherent energy and network costs
  - *Virtual customer plants* w/ coordinated operation of customer installations
  - *Integrated markets* for energy and ancillary services
  - *Software agent*-based distributed control architecture (self-organizing and self-healing)
- Validation and perspectives
  - *Demonstration/test* of most promising concepts in different distribution systems with DG/RES
  - How to get there? Network and market transformations, grid codes etc.

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

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

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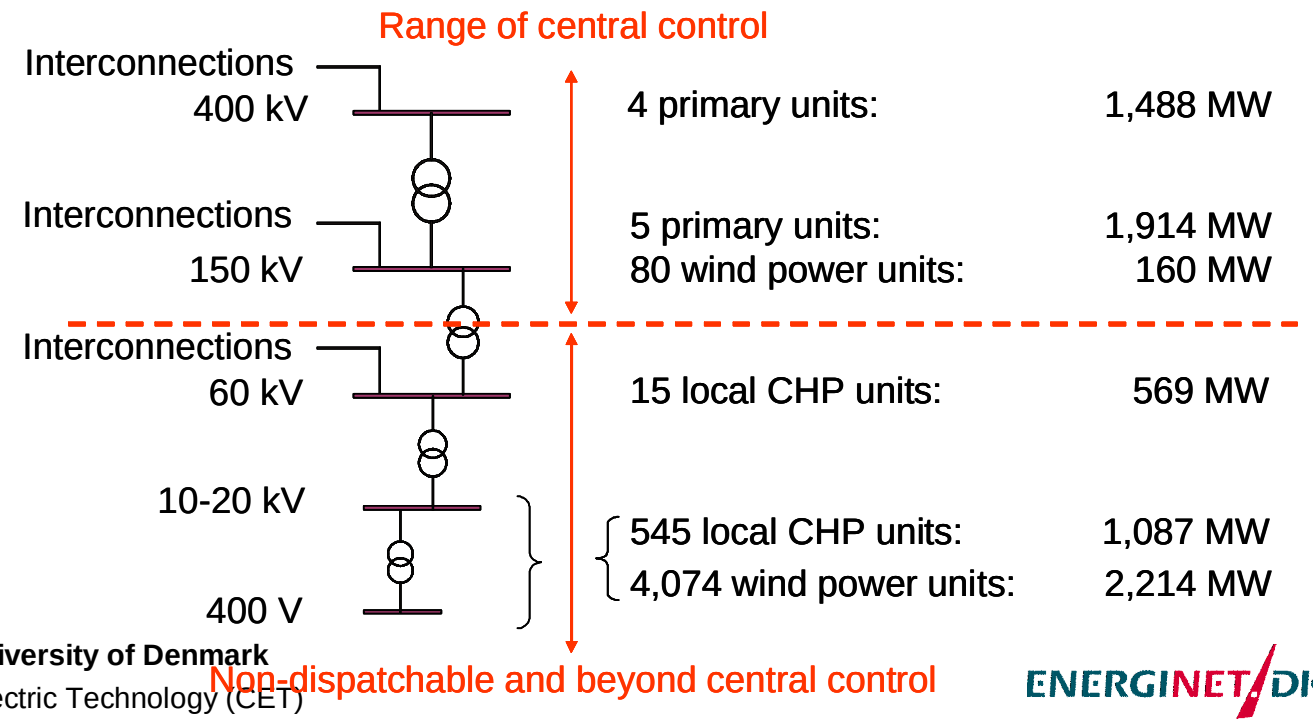
Why we look for new grid operation options

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.

Free range production capacity in an open energy market economy

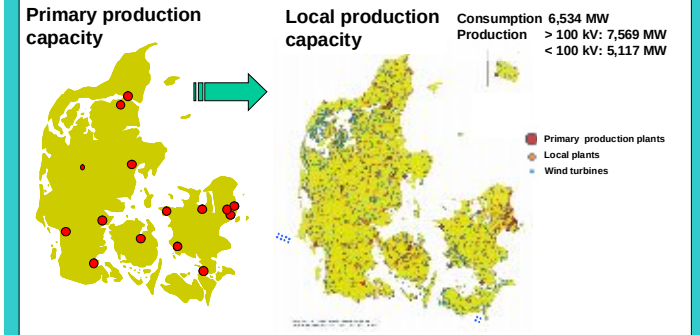
by Lise Nielson, R&D Programme Coordinator, Energinet.dk, lni@energinet.dk

Consider this

- What's the fun of a liberalized energy market if there are very few sellers in the market?
- Which technology is more attractive?
  - One that offers lots of capacity for one output?
  - One that offers several different outputs?
- Which technology is more attractive?
  - One that is high on investment but low on fuel consumption and maintenance?
  - One that is known and tried but with uncertain and increasing fuel prices?

The Danish market for power production is moving in the direction of embedded generation, and into renewable sources of energy.

Development from the 1980s to 2005



TSO challenges

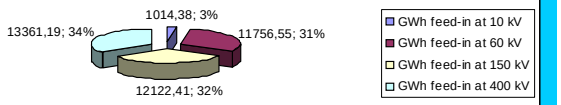
- Designing a fully functioning market
- Ensure the necessary RD&D for
  - System technology
  - Versatile generation capacity

The future grid is likely to be organized as microgrids connected to the main transmission levels. To learn more, technical solutions are pursued via R&D:

- Energinet.dk Cell project
- Ecogrid.dk project
- Joint projects with other TSO's, international collaboration such as NextGen, SmartGrids Technology Platform, and others.

Denmark is becoming a full scale test area for RE DE system technology

Feed in by voltage level, Denmark 2006 to date



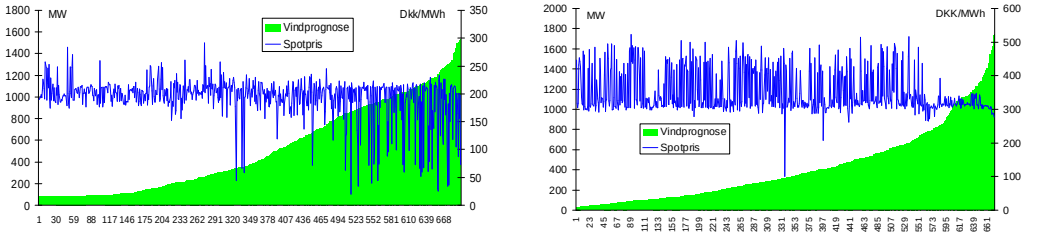
RE accounts for 23.3 % of the total production

(in the Western grid area, the RE percentage is 29.0)

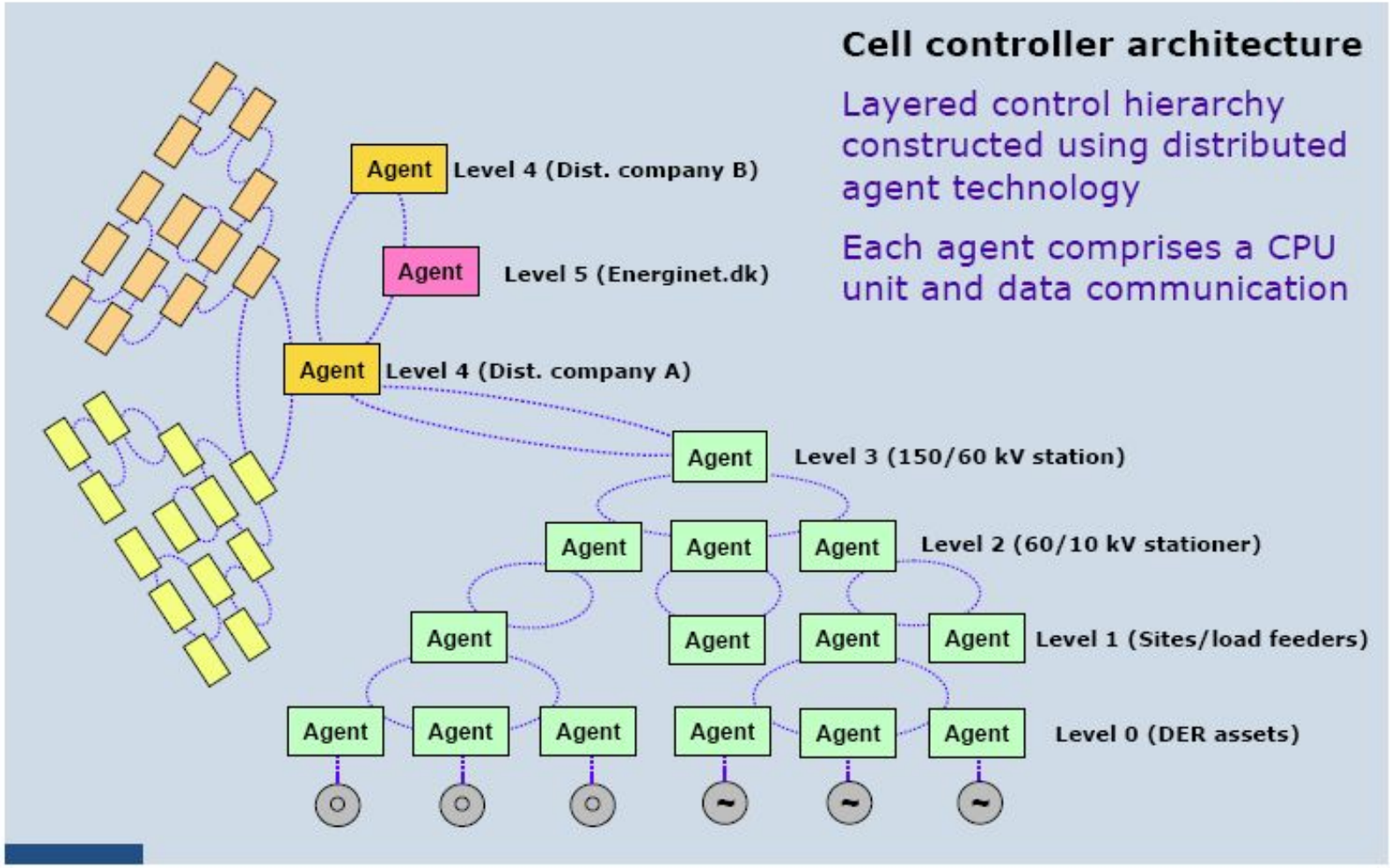
It seems that the level of RE and DE has reached a point where further liberalization of the energy market may be realized only if the level of RE is increased, and vice versa.

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


Cell controller architecture
Layered control hierarchy constructed using distributed agent technology
Each agent comprises a CPU unit and data communication
Agent
Level 4 (Dist. company B)
Agent
Level 5 (Energinet.dk)
Agent
Level 4 (Dist. company A)
Agent
Level 3 (150/60 kV station)
Agent
Agent
Agent
Level 2 (60/10 kV stationer)
Agent
Agent
Agent
Agent
Level 1 (Sites/load feeders)
Agent
Agent
Agent
Agent
Agent
Agent
Level 0 (DER assets)

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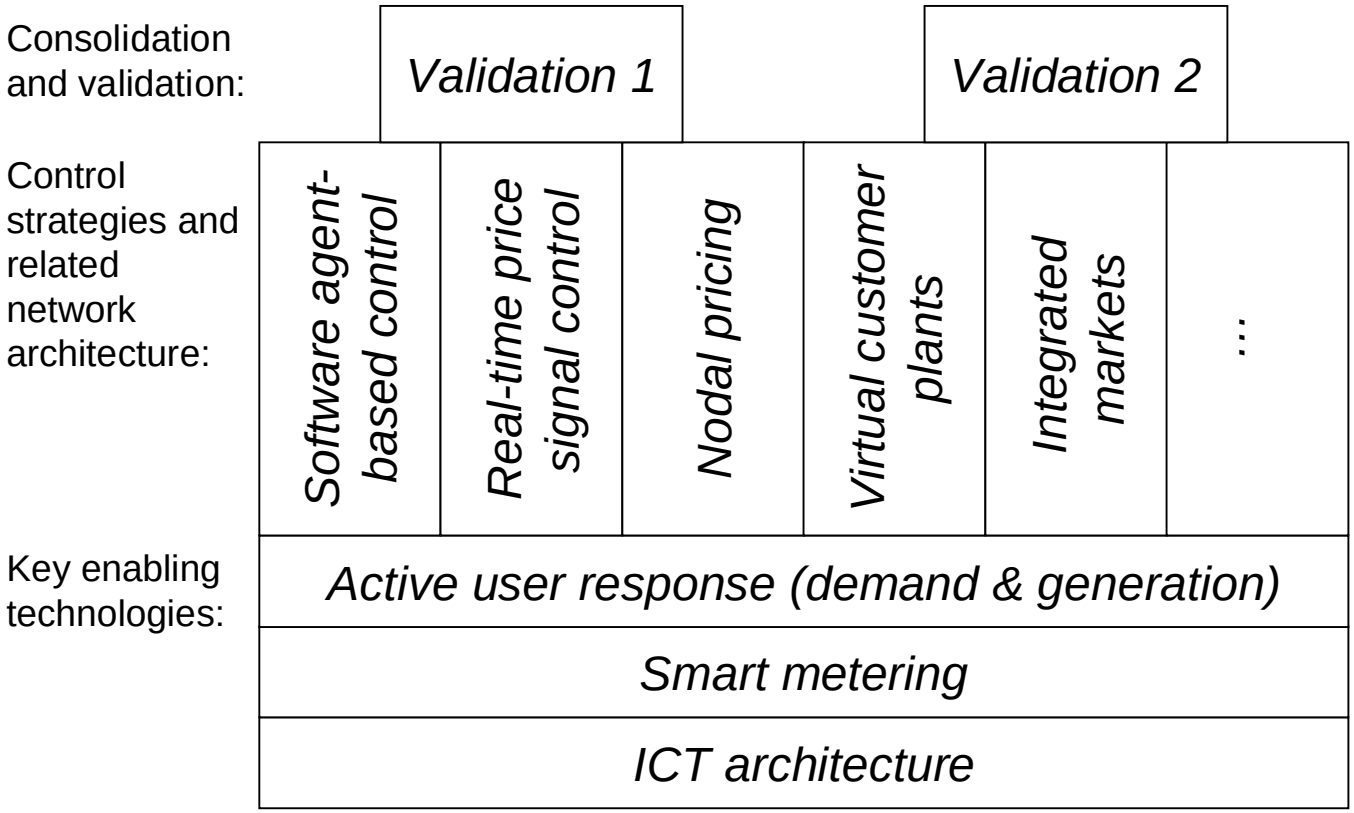
The Cell Controller Pilot Project aims to

- Gather information from the international community about the feasibility and approaches to utility-scale microgrids (Cells)
- Develop requirements specifications and preliminary solutions for a pilot implementation of the Cell concept
- Implement measurement and monitoring system to gather and analyze data from the targeted pilot area
- Perform detailed design, development, implementation and testing of a selected full scale Pilot Cell

A new ambitious Danish energy policy

- The Danish government has proposed a new energy policy
- 30% RES in the overall energy system in 2025
- Wind power covers 50% of electricity demand in 2025
- Energinet.dk (Danish TSO) has responded with a research and development programme *EcoGrid.dk* with the goal to develop the new technologies and new market solutions

Project structure proposal (WP's)



- Concept development
- Development of needed theoretical fundament
- Modeling and simulation of the coherent control strategies and network architectures
- Feasibility and impact assessment

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Details on control strategies WP's

- Development, analysis and assessments
  - Concept development
  - Development of needed theoretical fundament
  - Modeling and simulation of the combined control strategies and network architectures
  - Feasibility and impact assessment
- Important aspects shall be include as integrated elements
  - Network architecture development
  - Security, reliability and stability
  - Costs, business models, future regulatory issues

Conclusion

- 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

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Thank you for your attention!

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