Full Use of Local Flexibility: An Intelligent Grid for 100% Renewables in Denmark

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Danish Renewable Energy

Renewable Energy Supply (PJ)

- Solar PV
- Solar heat
- Wave Power
- Wind offshore
- Wind, land
- Geothermal
- Biogas
- Bio-fuel, liquid
- Energy Forest
- Solid biomass
Danish Power Supply

- Fossils
- Waste
- Solar PV
- Wave & Hydro
- Biomass

PJ


0 20 40 60 80 100 120 140 160 180 200
Power system for flexibility

- Efficient power use, reduce demand 30%
- 10% flexible electricity use from current use
- Heat pumps in district heating + 3 day storage (water)
- Heat pumps in households, 25% of dwelling+day storage (water)
- Electric cars, flexible (smart) charge
- Hydrogen production for transport with H₂ storage
- Combined Heat and Power(CHP) in district heating
Power demand and supply

2030 Export
Hydrogen f. transport
Electric transport
Heat pump, domestic
Heat pump, central
Flexible electr. use
Unflexible electr. use

2030 Import
PV
Wavepower
Windpower
Power plant
CHP – bio
Incineration CHP

Peak power (GW*10)
Energy (el.TWh)
District Heating = 70% of Heat

District Heat Supply, Denmark (PJ)

- Heat pumps
- Solar heating
- Geotermi
- Bio-CHP
- Bio-heat
- Waste
- Gas-CHP
- Gas-heat
- Coal+oil-CHP
- Coal+oil-heat
System in balance in 2030 – hour by hour

- Wave + solar power
- Windpower
- CHP
- Import
- Heat pumps
- Solar thermal
- CHP
Some results

- System can be in balance
- 1% unused windpower
- only need for existing import/export lines
- need for smart grid and fast reacting CHP
- not base load in traditional sense, but need for regulation power
Thank you

See
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