

Energy Systems in Denmark



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Introduction to Denmark

- Population: 5,627,235(*)
- Area: 16,562 sq. mi
- GDP: \$211.321 billion



(*) 2014 estimation

Introduction to Denmark



Global Leader in Energy

- Uniquely united
- Wind
- Small-scale solar
- Crude oil until 2050
- Natural gas until 2020
- Imported Coal
- High energy efficiency
- Integrated CHP

Denmark energy goals

By 2030

- Coal will be phased out for power plants and boilers

By 2035

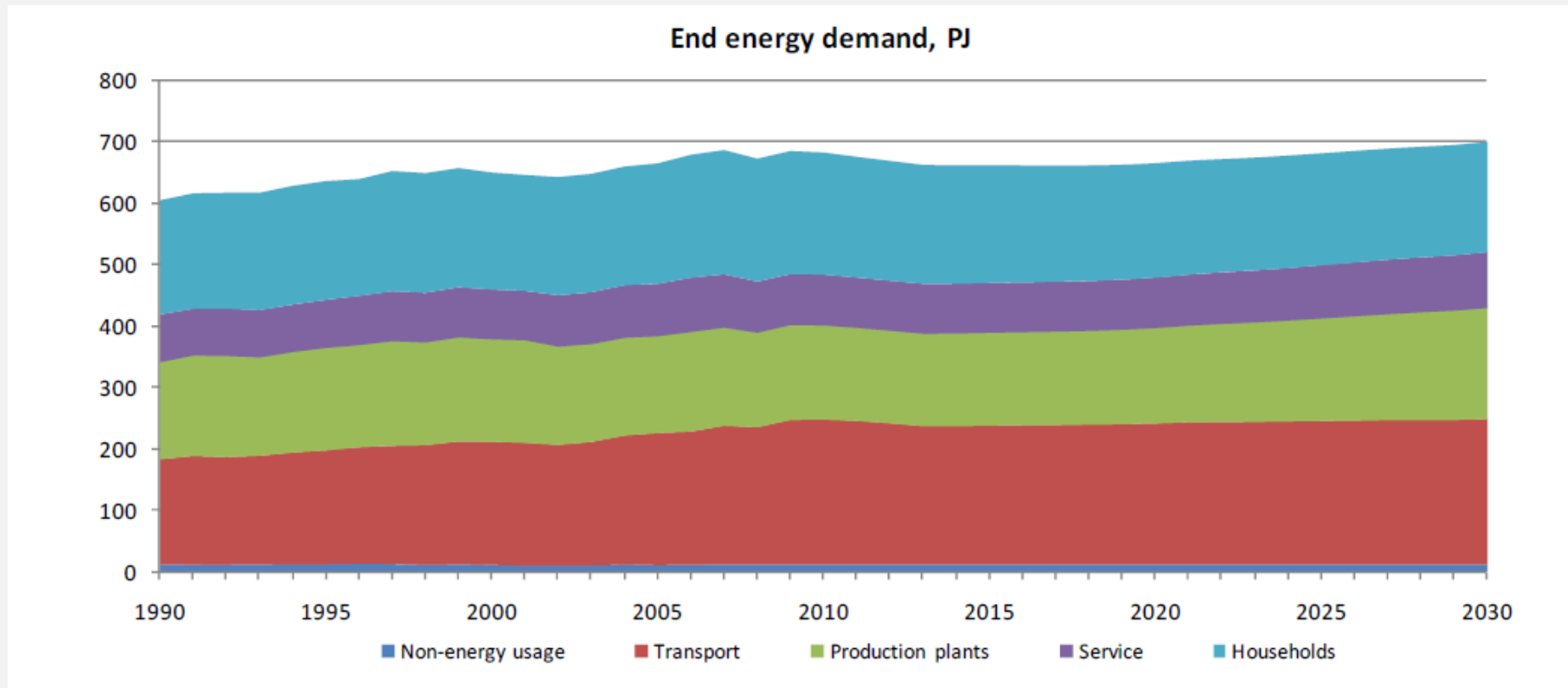
- Renewables will provide for all electricity and heat demand

By 2050

- Fossil fuel independence
- Maintain high level of energy security
- Reduction of CO₂ emissions by 90% of 2000 levels



Energy Consumption



Energy Consumption

(Electricity generation, heating, transportation, and industrial consumption)

2050



■ Oil ■ Natural gas ■ Coal and coke ■ Waste, non-renewable ■ Renewable energy

Energy systems integration

Problem

- Fluctuations in renewable generation

Facts

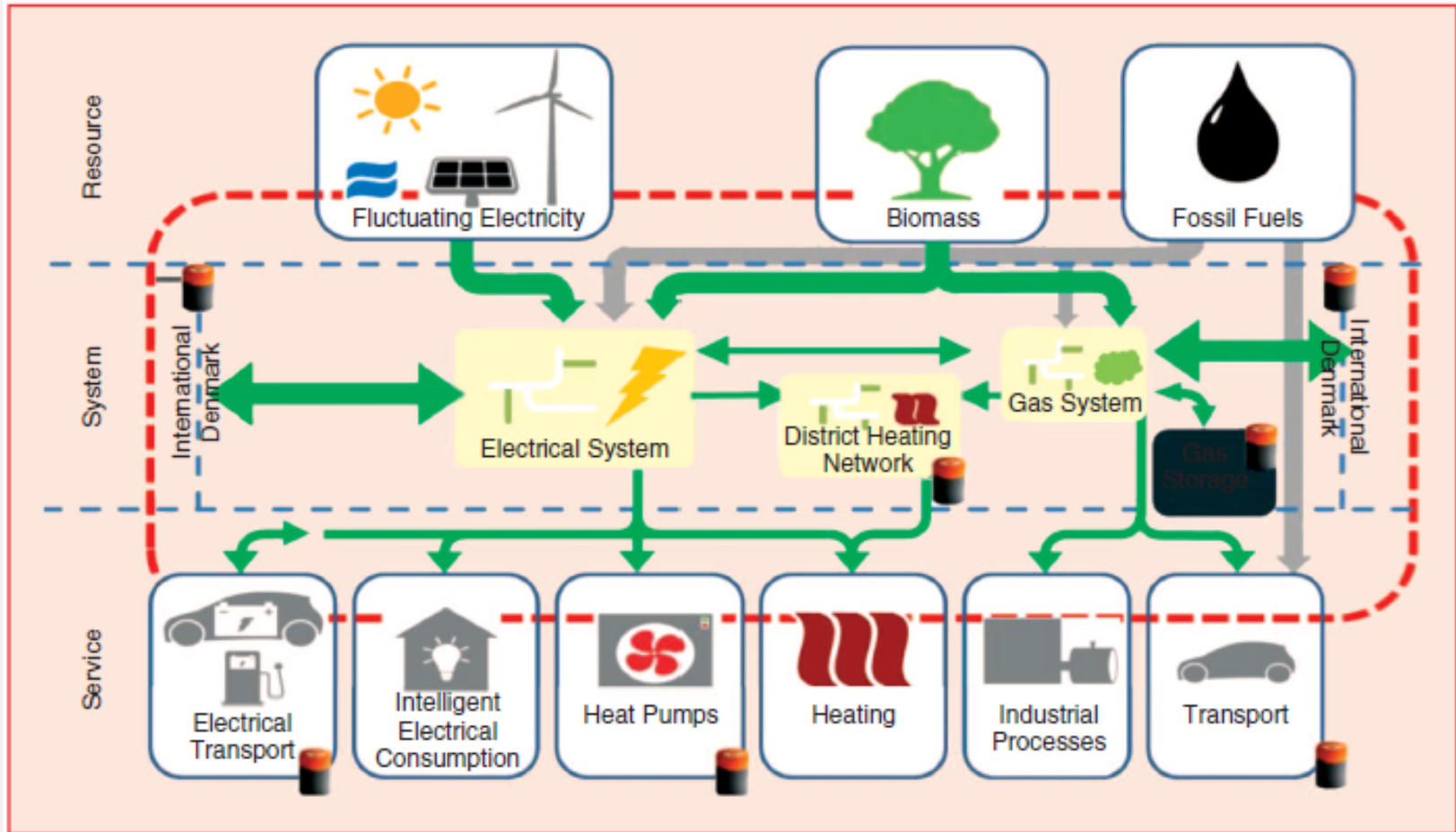
- Interconnections with other countries
- Existing gas facilities for storage
- Feasibility to use thermal systems for storage
- Coupling between heating and electric systems

Solution

- Integration of energy subsystems can handle the fluctuations



Energy systems integration



Renewable Energy Scenario

Ideal Targets:

- Technologies under developed are included in a large scale.
- Create market for new technologies.
- Fuel cells, Biomass and Co-electrolysis are executed in large scales.

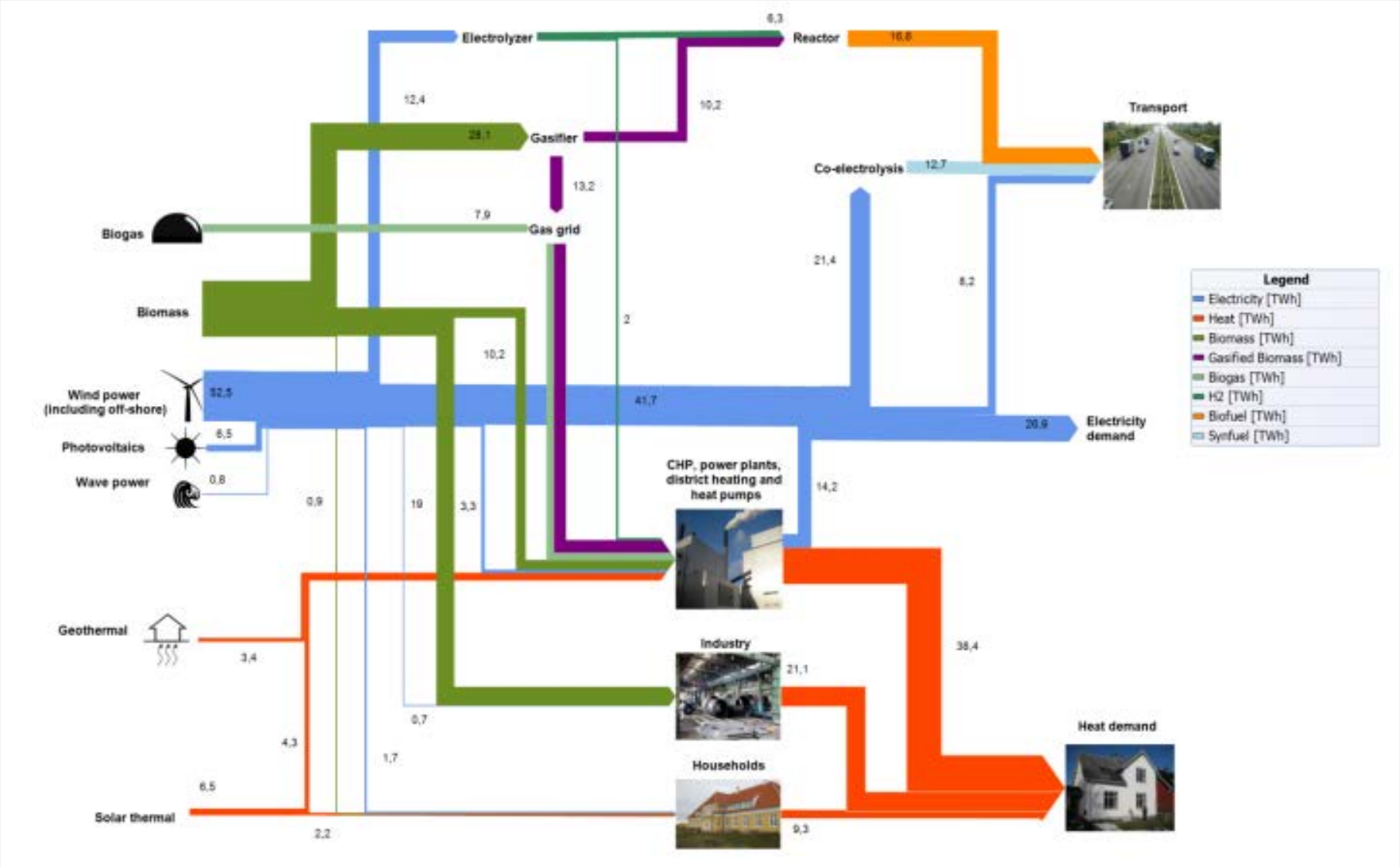
Realistic Targets

- Heat storages and district heating with CHP plants and large heat pumps.
- New electricity demands from large heat pumps and electric vehicles as storage options.
- The use of gas storage

Steps Involved in achieving the Target:

- Planning, regulations and evaluations
- Tariff and tax systems
- Research, development and demonstration
- Transport sector
- Smart energy systems
- Special schemes for mitigation of CO₂

100% Renewable Energy Scenario



Innovations required

- Dynamic price signals
- Regulatory framework for virtual power plants
- Optimal distribution of solar and wind power across the country
- Technical breakthrough to deal with the fluctuation of electricity production from renewable energy.



Tools techniques required

- Accurate wind and solar forecasting
- Integrated models with holistic view
- Advanced power system modeling and control
- Appropriate financial incentives and adjustments to existing energy tax rules
- Intelligent Demand Response



The side B

- Nimbyism (2014, 2030, 2050?)
- Valuation of demand responsiveness to price signals
- Costs involved in the transition
- Use of interconnections with other countries
- Greenhouse gases leakage among countries



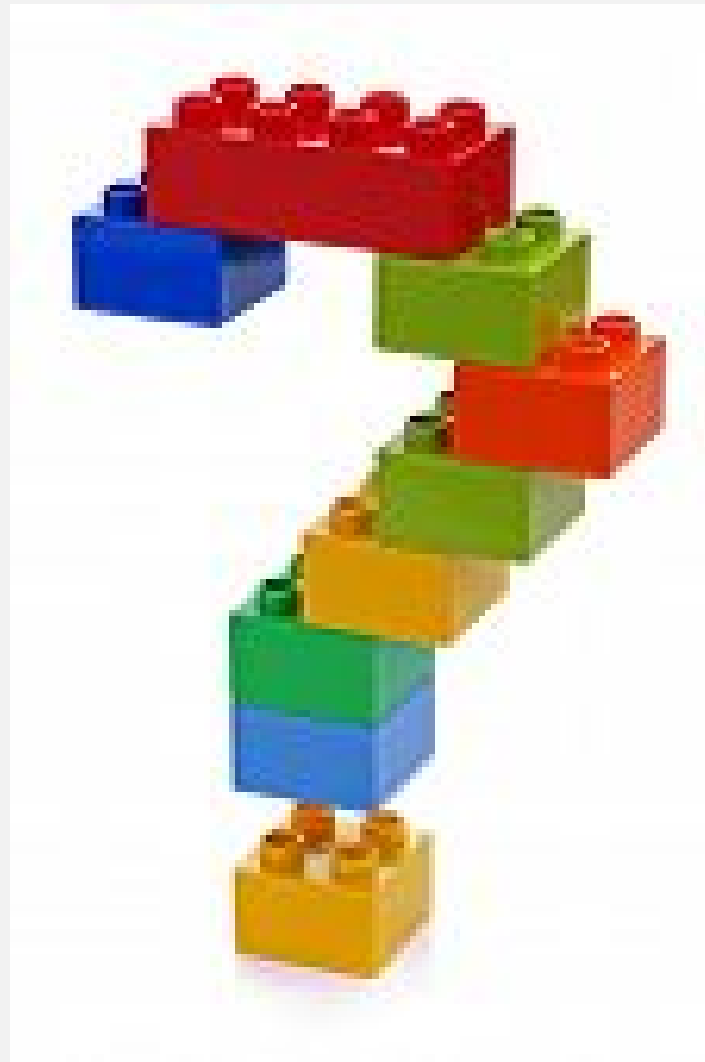
Conclusions

- Denmark is a global leader in energy sustainability and it is posed to remain so in the future
- They have set very ambitious goals for 2050 and the years leading up to it
- In order to achieve their goals, high levels of research and integration will be required

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Questions?



Electricity Generation

