



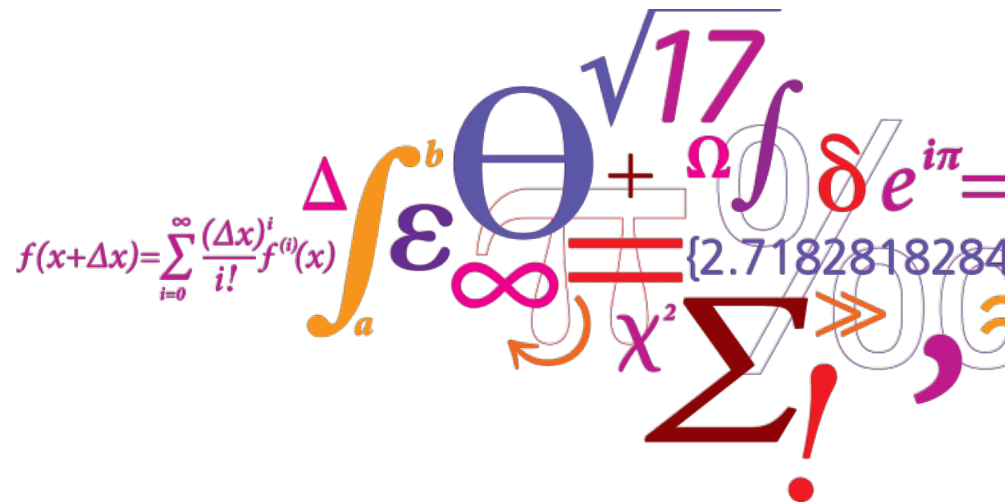
# Market environment for integrated energy system management

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# Outline

- Renewable sources of energy
- Flexibility and energy system integration
- Coupling electricity, gas and heat systems
- Future plans

## About me...

- Diploma in Electrical and Computer Engineering at the Aristotle University of Thessaloniki
- MSc in Sustainable Energy – Electric Energy Systems at DTU



Source: Google Maps

# Renewables in Denmark

- **Energinet.dk:** " In 2014, Danish wind turbines supplied what corresponds to 39.1% of Danes' electricity consumption. This is a new record."
- **Denmark's Energy Strategy 2050:**
  - Reduce the energy industry's use of fossil fuels by 33 percent in 2020, compared with 2009
  - Complete independence of fossil fuels by 2050



# European power mix

FIGURE 7: EU POWER MIX 2000 (MW)

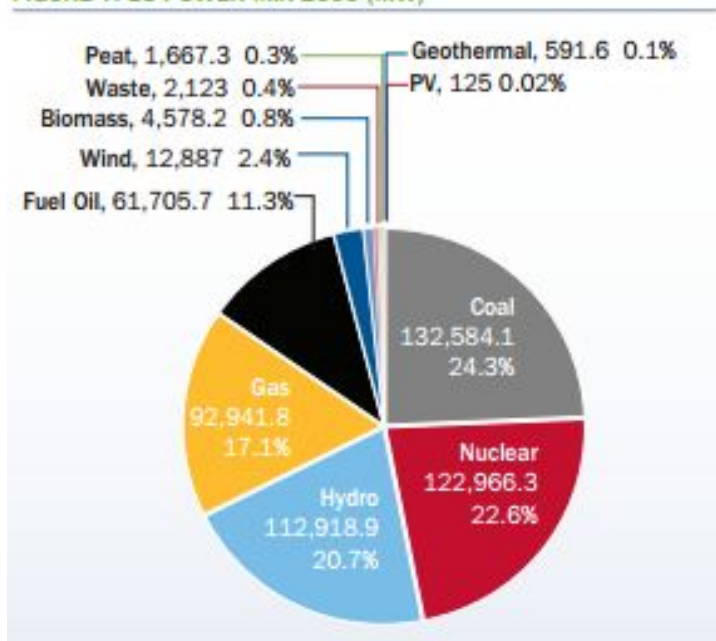
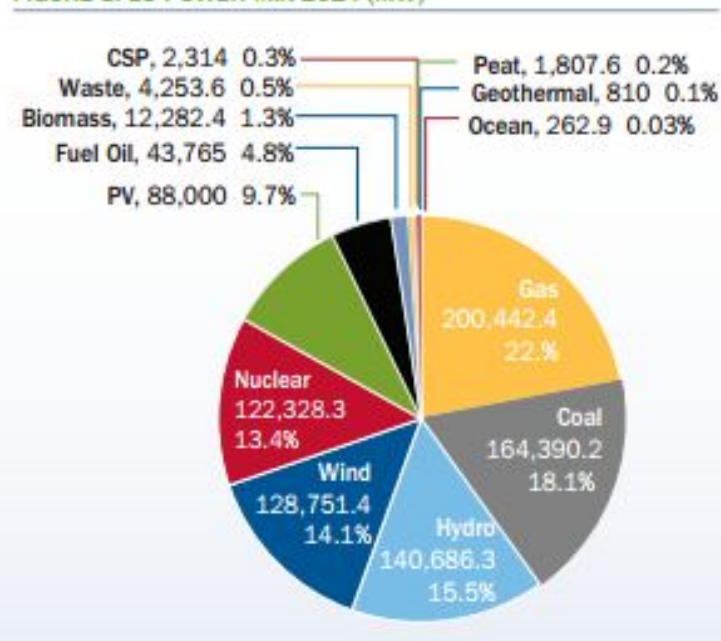


FIGURE 8: EU POWER MIX 2014 (MW)



Source: European Wind Energy Association

**Wind** power's share of total installed power capacity has increased **five-fold** since 2000.

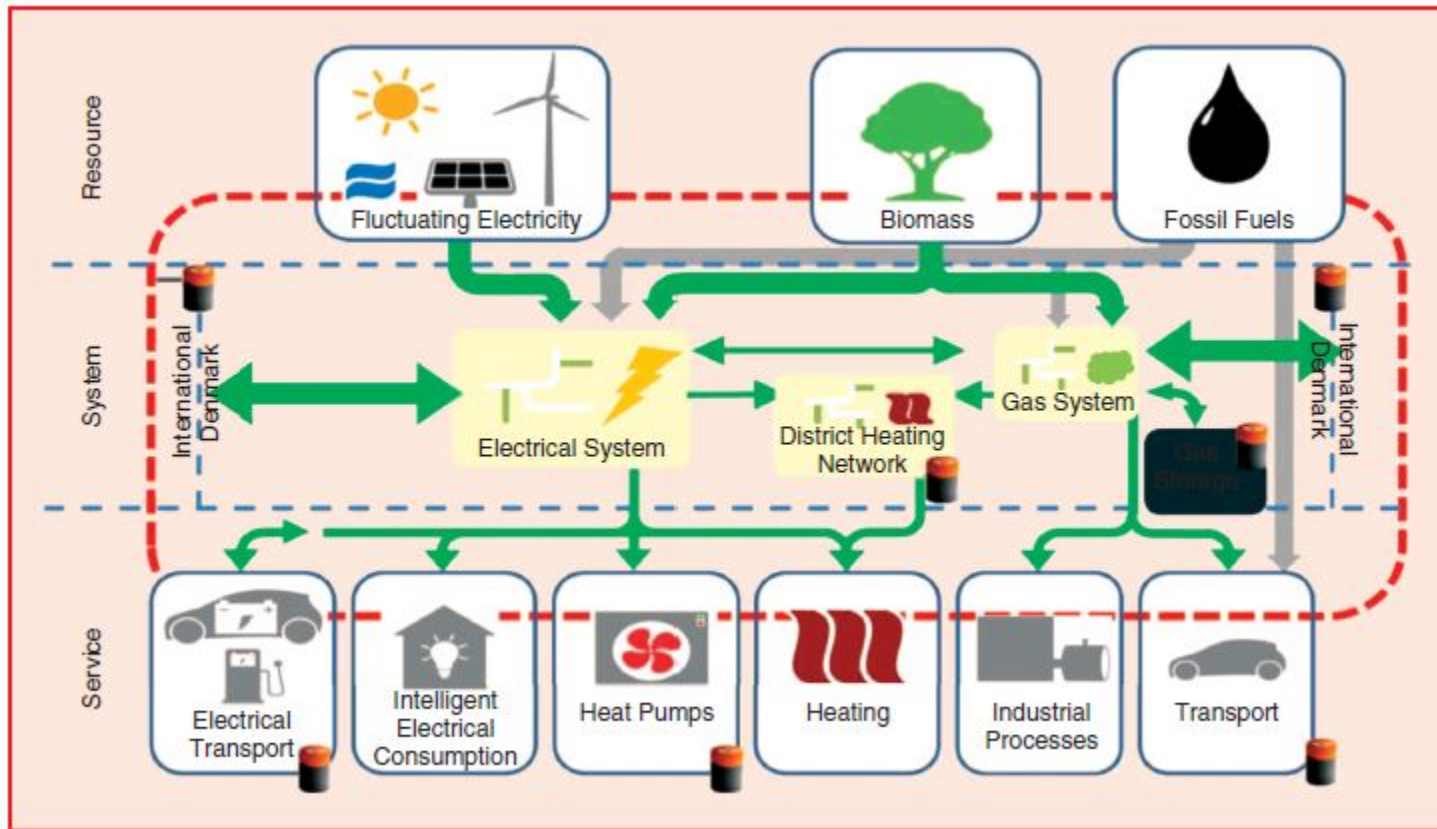
**Renewable capacity** increased from 24.4% of total power capacity in 2000 to 41.5% in 2014.

## Flexibility is the key

- Transition into a system based on fluctuating energy sources presumes energy movement in both **time and space and between systems**.
- Constantly meet the demand.
- Market designs for integrated systems and coordination are **inexpensive** compared to solutions, such as investing in power system reinforcement or interconnections among countries.
- Penetration of **renewable energy** will mainly increase through the electricity sector.

# Energy comes together in Denmark

- Danish electricity consumption makes up approximately 20% of total national energy consumption; this figure is expected to increase in the coming decades to between 40% and 70%.



Source: Meibom et al., 2013



# Multi-carrier energy systems



Electricity

Gas

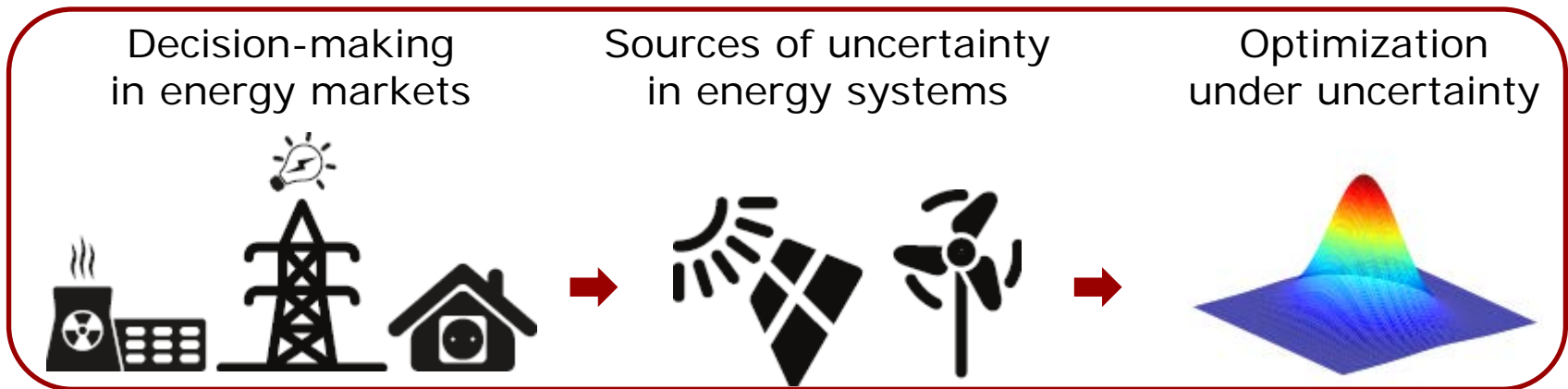
Heat

Integrated Market Design: Coordination of different energy systems. Emergence and exploitation of synergies, i.e. bridging uncertainty in supply and demand.



# Objective

- Define **existing synergies** among energy systems.
- **Efficiently align** the existing synergies towards **optimal operation** of the energy system.
- New **market** structures that will provide incentives to market participants.
- Manage high **uncertainty** on both supply and demand sides.
- **Forecasting** renewable energy and study correlations with prices and demand in different power systems.



# First test case to be examined

- Simple power system network
- Natural gas storage tank that Gas-fired power plants are connected
- Study operational cost and market dynamics of electricity and gas systems
- Extension 1: Include stochastic generation (e.g., wind power)
- Extension 2: Cover heat demand if we include CHP plants
- Extension 3: Model gas network with pipelines
- Extension 4: Use Energinet.dk data to model the Danish system

## Future plans

- Examine interactions among energy systems and markets.
- Efficiently align the operation of the systems.
- Propose market products and models for a common market clearing of the whole system.
- Perform the studies under uncertainty on both supply and demand side.

# Thank you for your attention !

