

European Conference on  
Impacts of Climate Change on Renewable Energy Sources  
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# Climate Change and the Future Nordic Energy System

with focus on the electricity system

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Nordic Project on Climate and Energy

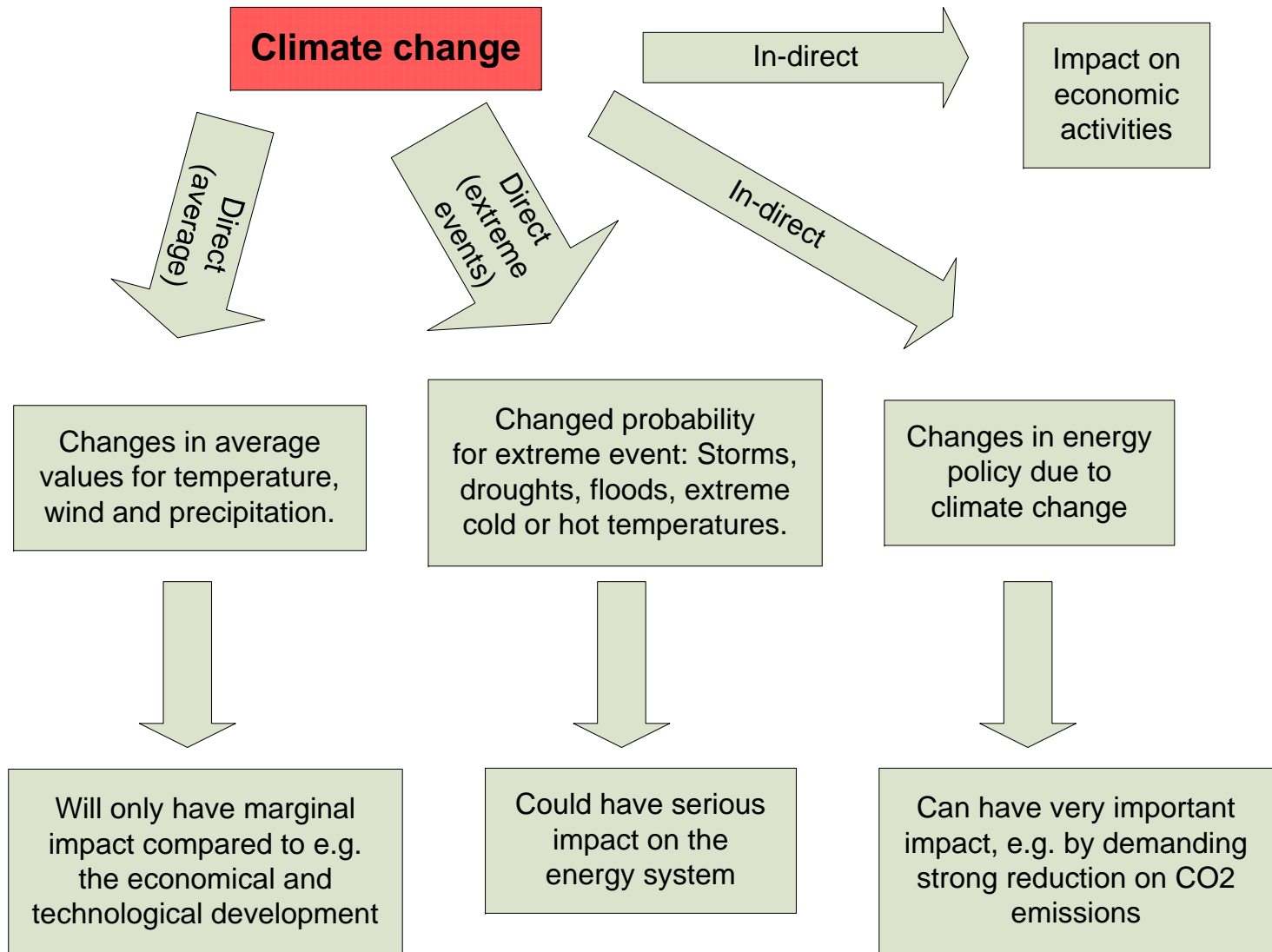
norden

Nordic Energy Research





# Direct and in-direct impact of climate change on the energy system

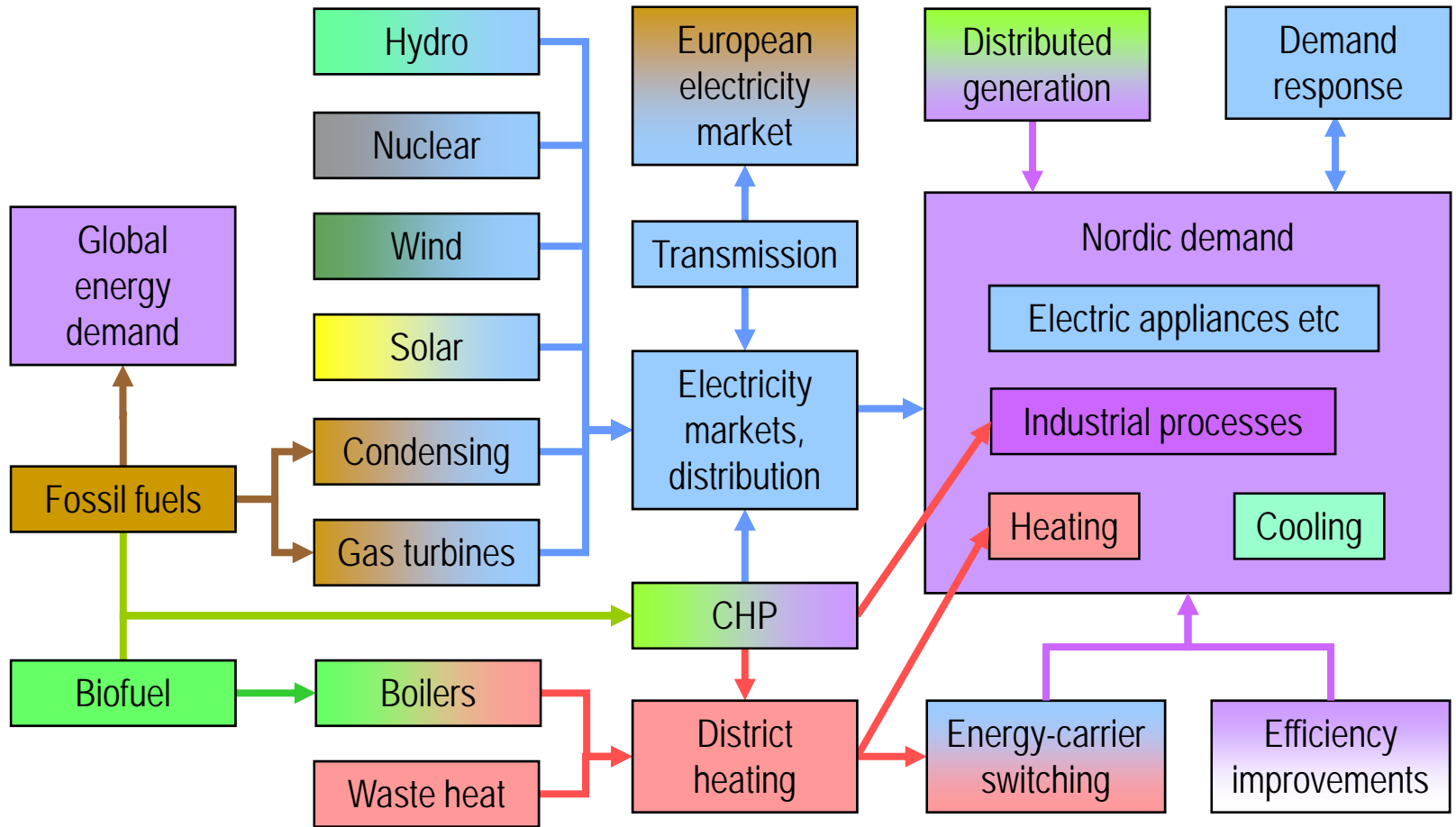


# Energy system development

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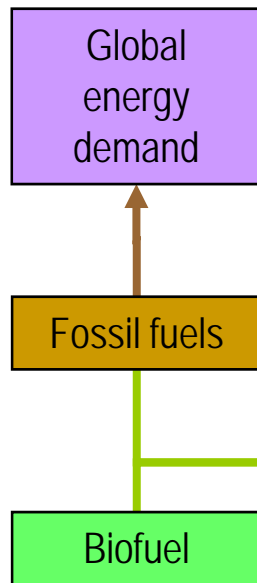
- Outline of possible long-term developments for the Nordic energy system due to economic, technical and political changes
- Stationary energy system focus on the electricity system
- 2050
- Three scenarios
- A medium-path scenario:  
a continuation of current trends  
modest economic growth  
balanced energy policy

# Interplay among components in the energy system

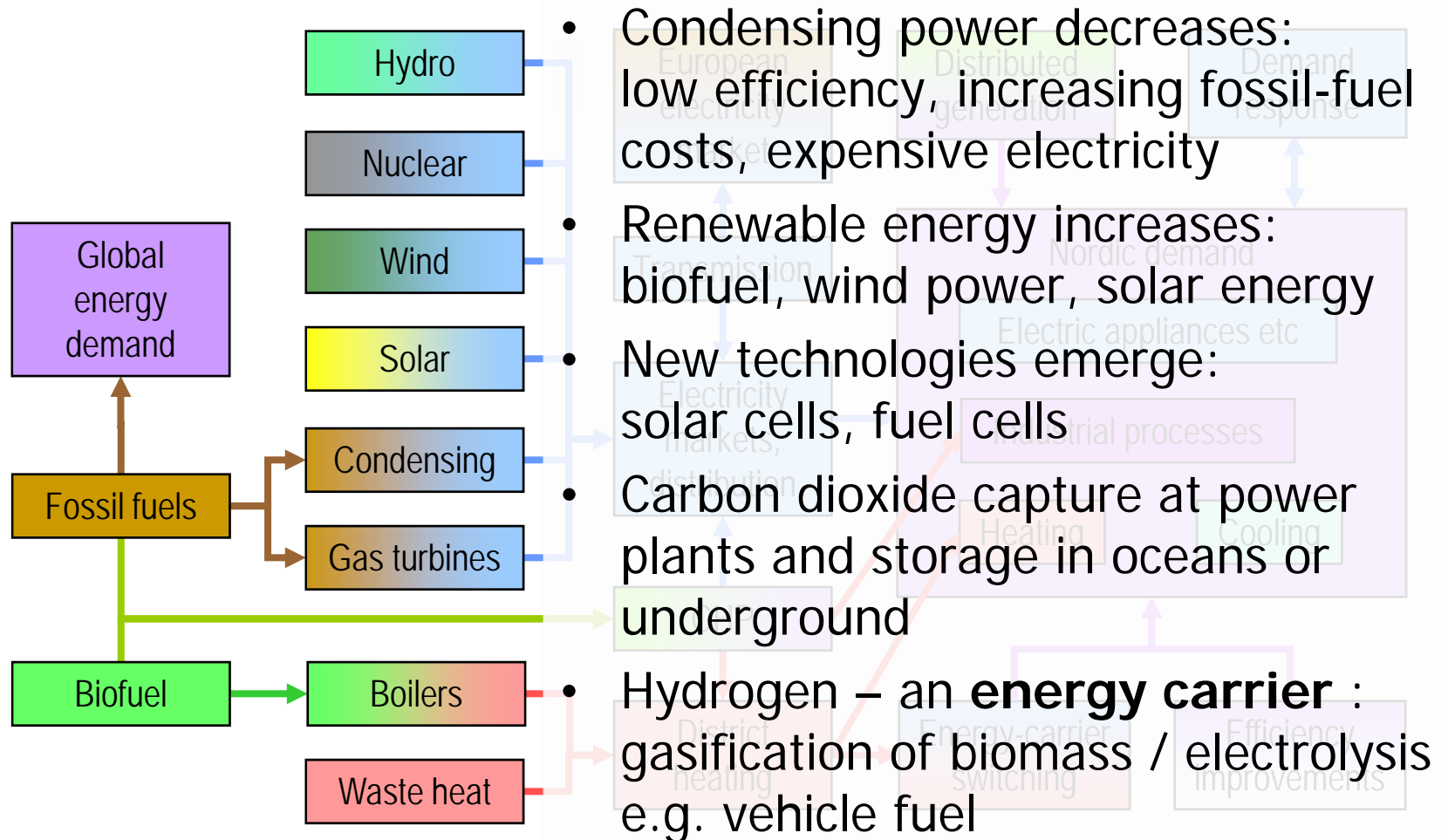


# Global energy demand and supply

- Global energy demand increases due to industrialization and enhanced standard of living in many countries.
- Increased energy demand and limited cheap energy supplies make energy carriers more expensive.
- Fossil-fuel use decreases.
- Better conditions for biomass production helps enhancing biofuel supply.



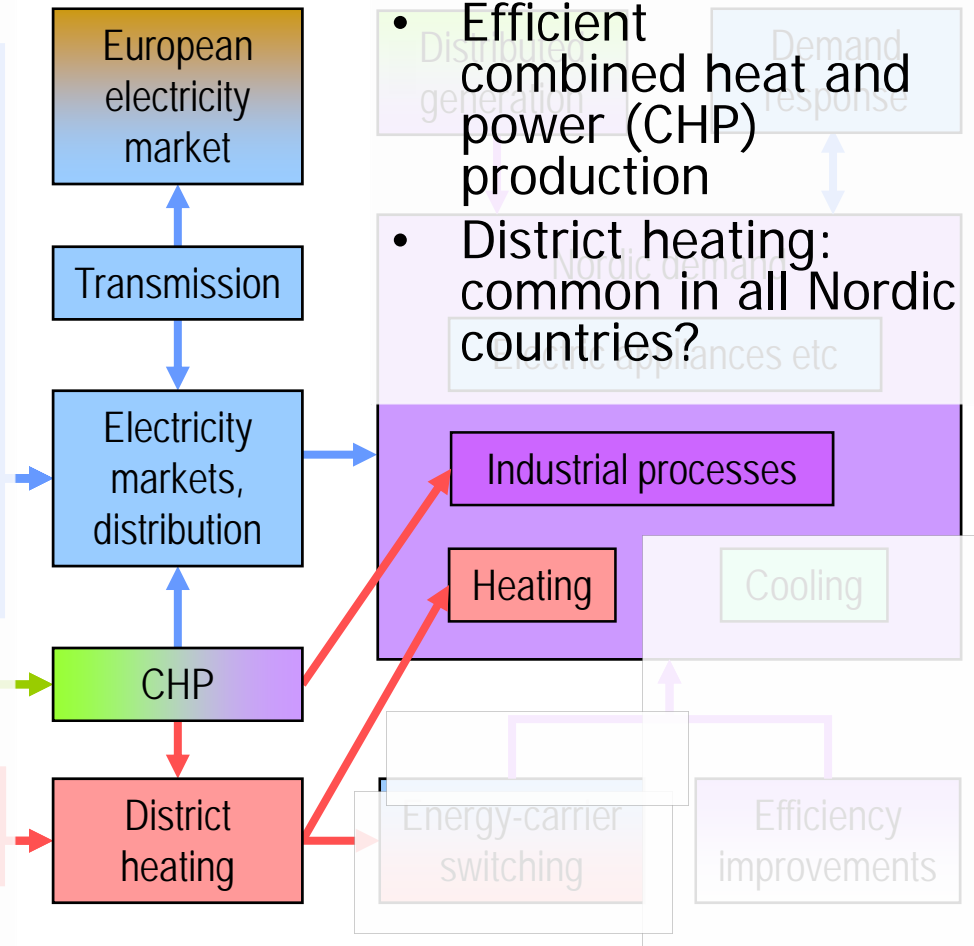
# Energy conversion



# Market, distribution

# CHP

- Nordic power grids more linked to continental Europe.
- A common European electricity market
- Long distance power transmission between countries increases.
- Power electronics, Flexible AC transmission systems (FACTS), superconducting cables
- Electricity flow controlled systematically: allows a high share of wind power.

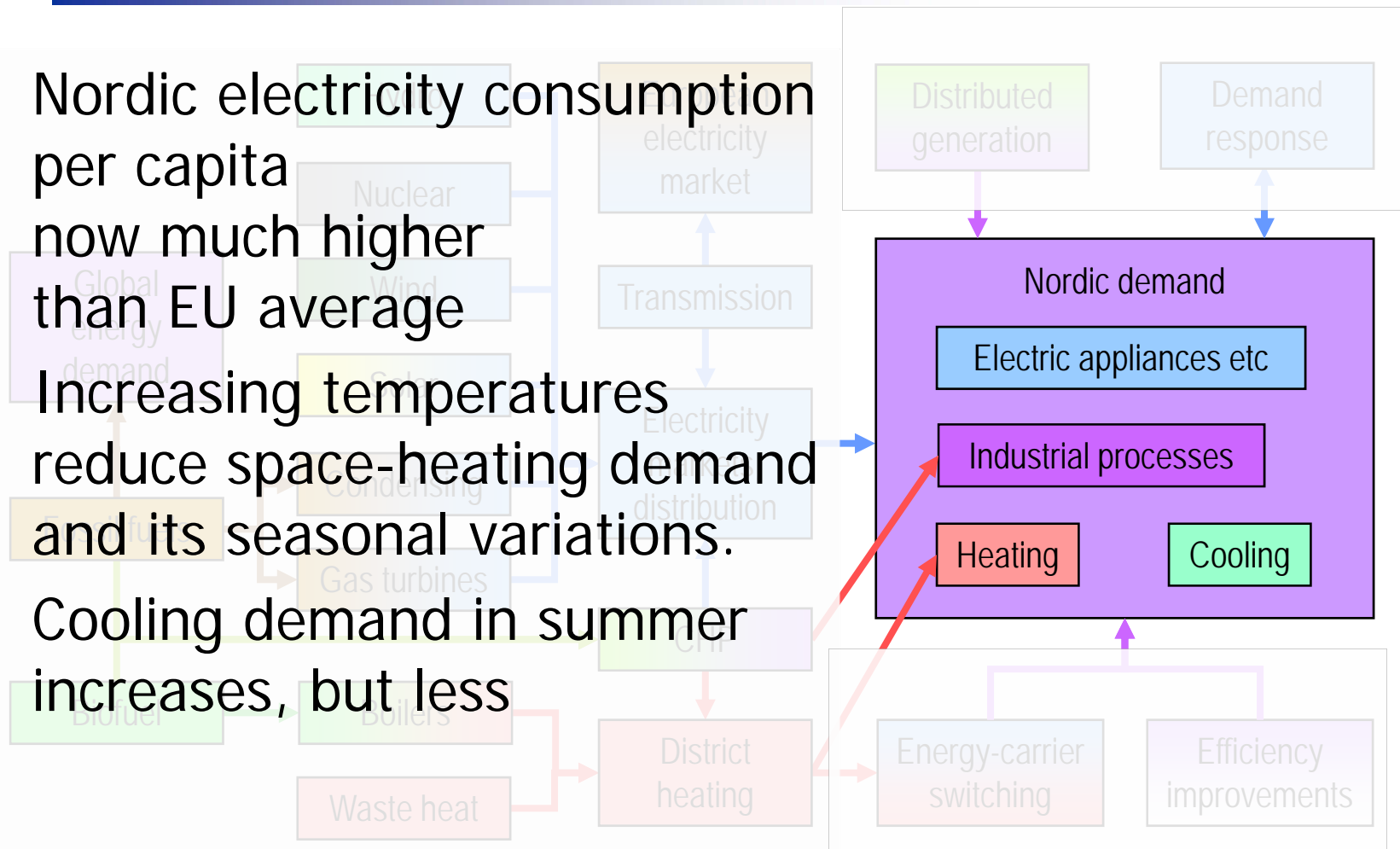


- Efficient combined heat and power (CHP) production

- District heating: common in all Nordic countries?

# Energy demand

- Nordic electricity consumption per capita now much higher than EU average
- Increasing temperatures reduce space-heating demand and its seasonal variations.
- Cooling demand in summer increases, but less

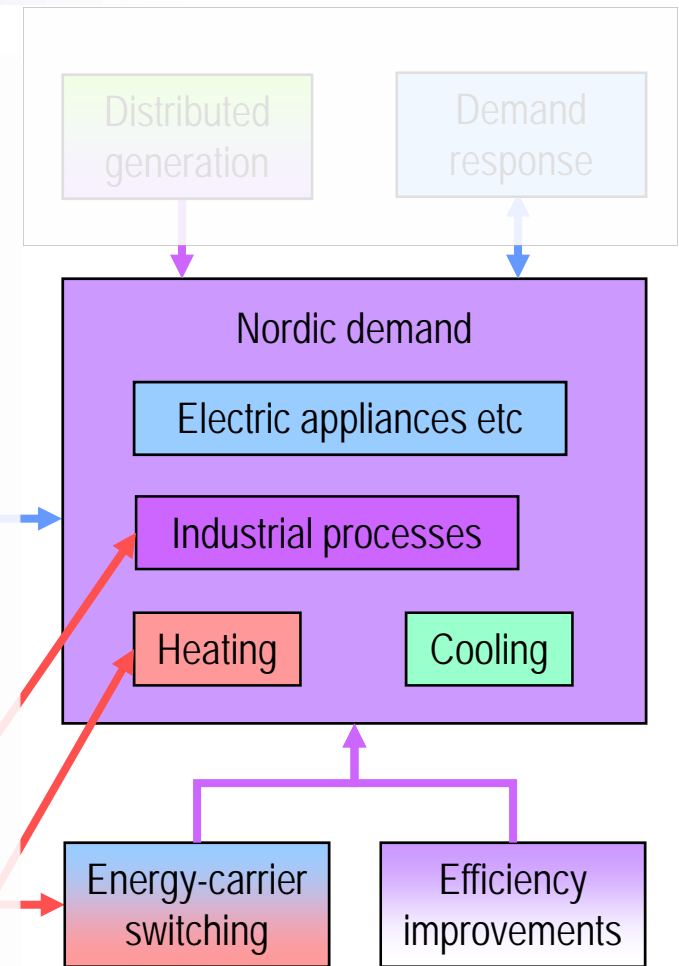




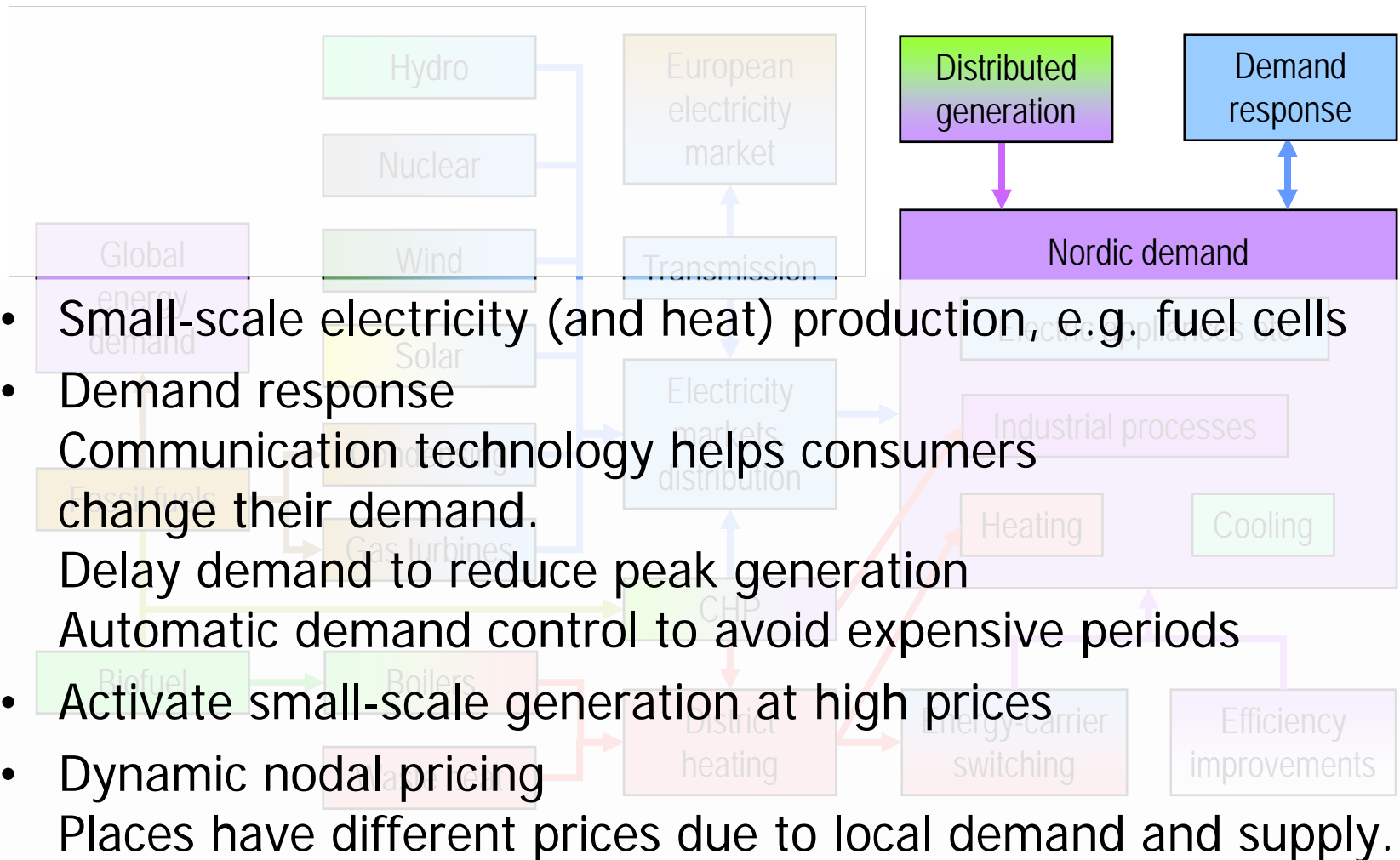
# Energy conservation

## Energy-carrier switching

- Energy is used more efficiently.
- Heat can be recovered for repeated use in industry and for heating.
- Electricity used for heat production can be replaced by fuels, district heating or solar energy.
- Heat-driven cooling
- Industrial electricity consumption decreases to continental level.



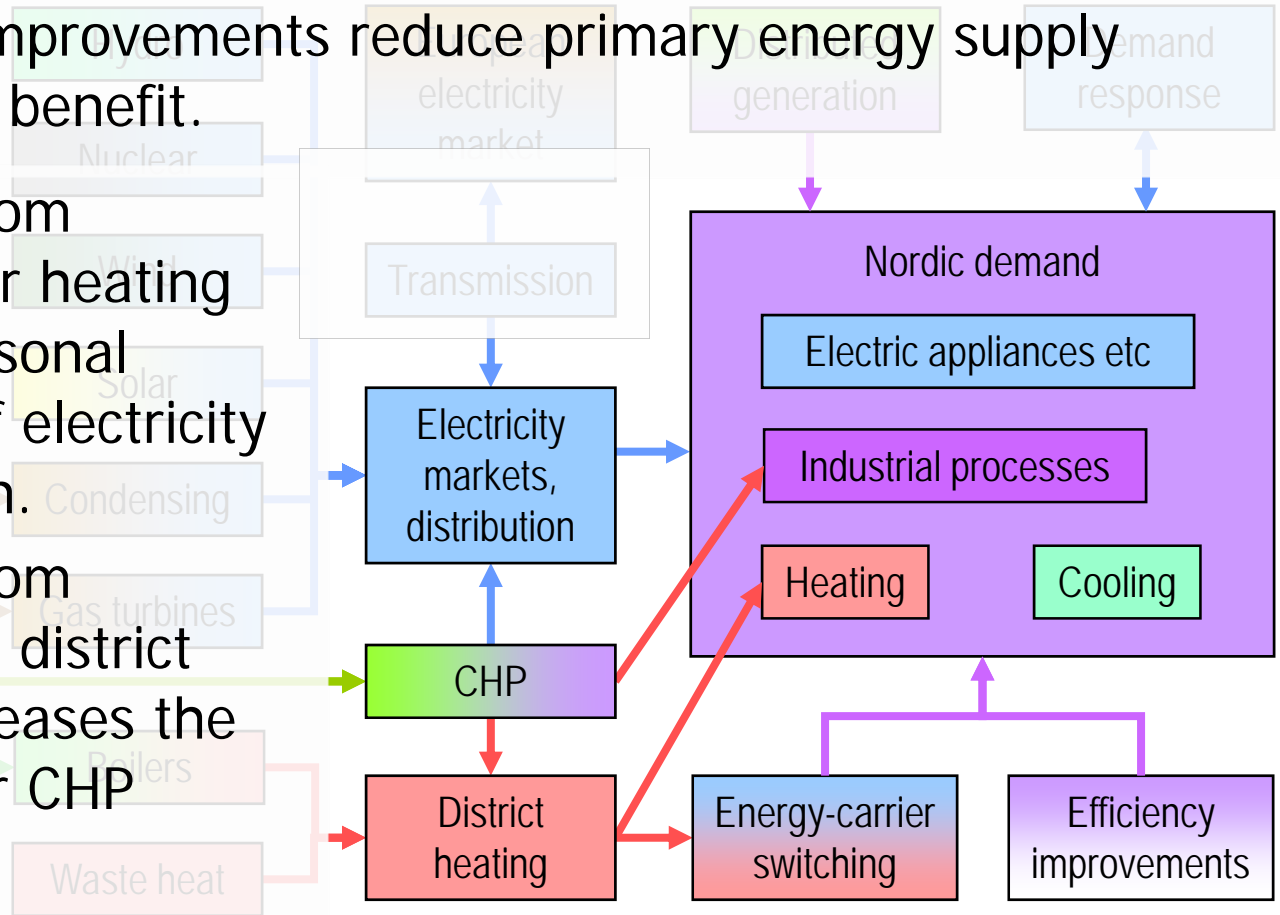
# Distributed generation, demand response



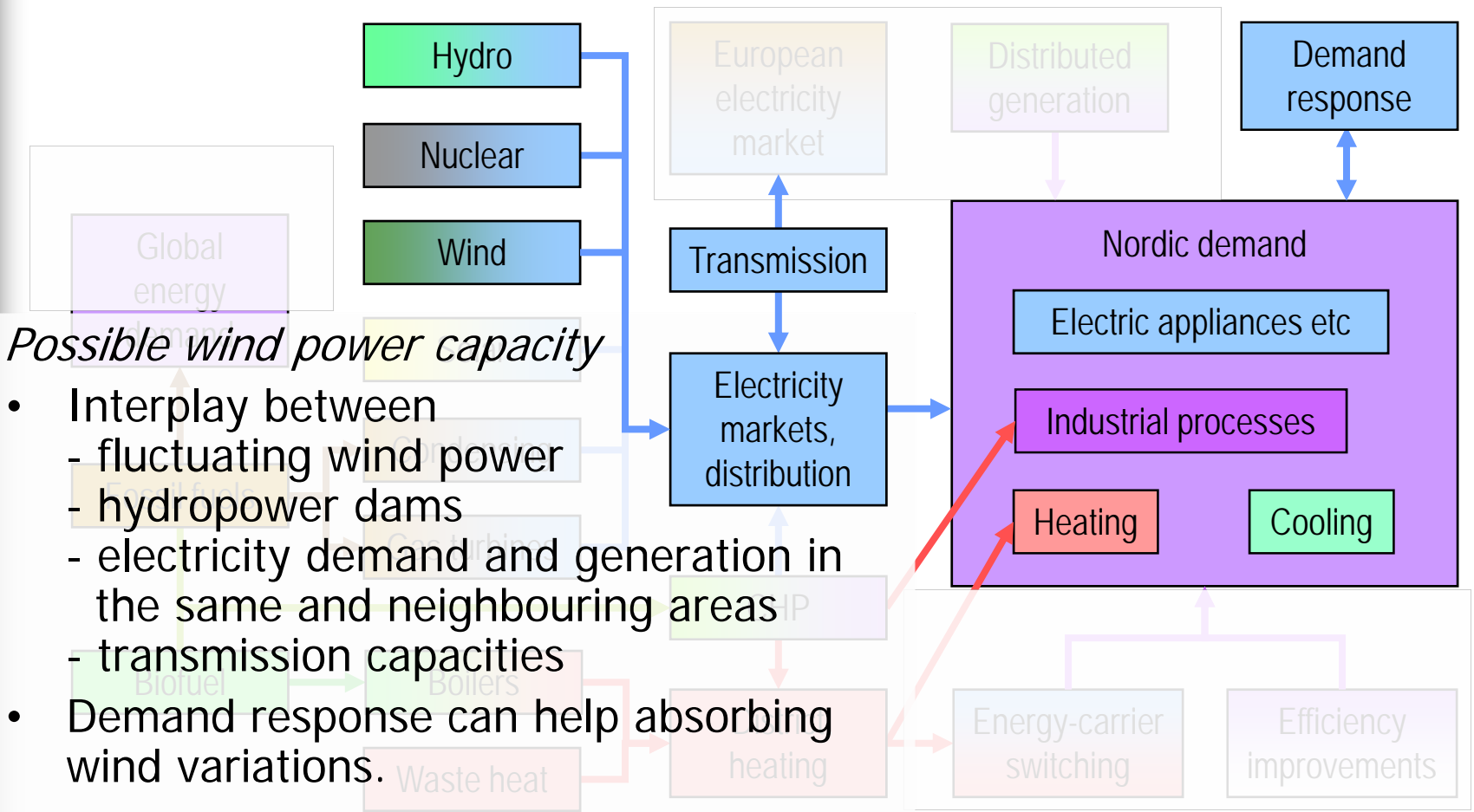


# Impact of demand-side measures

- Efficiency improvements reduce primary energy supply but not the benefit.
- Switching from electricity for heating reduces seasonal variations of electricity consumption.
- Switching from electricity to district heating increases the heat sink for CHP production.



# Balancing wind power



## Possible wind power capacity

- Interplay between
  - fluctuating wind power
  - hydropower dams
  - electricity demand and generation in the same and neighbouring areas
  - transmission capacities
- Demand response can help absorbing wind variations.



# Alternative scenarios

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- *An extreme free market scenario*
- High economic growth
- Little environmental regulation
- High energy demand
- Large power plants:
  - fossil fuel
  - condensing power
  - new large hydroelectric
  - and nuclear plants
- *An environmental scenario*
- Low energy demand:
  - high energy efficiency
  - less heavy industry
- Firm policy instruments:
  - renewable energy
  - reduced CO<sub>2</sub> emissions.
- Distributed generation
- Low-energy buildings
- internal DC micro grids
- Domestic energy resources
- security of supply
- *Robustness*
  - *share of hydropower*
- free market: low
- environmental: high

# Conclusion

- The direct impacts of climate change have less influence on the energy system than other transitions.
- Events occur that we cannot even imagine.

