Hydrogen Roadmap

Analytical approach of the supply side modelling

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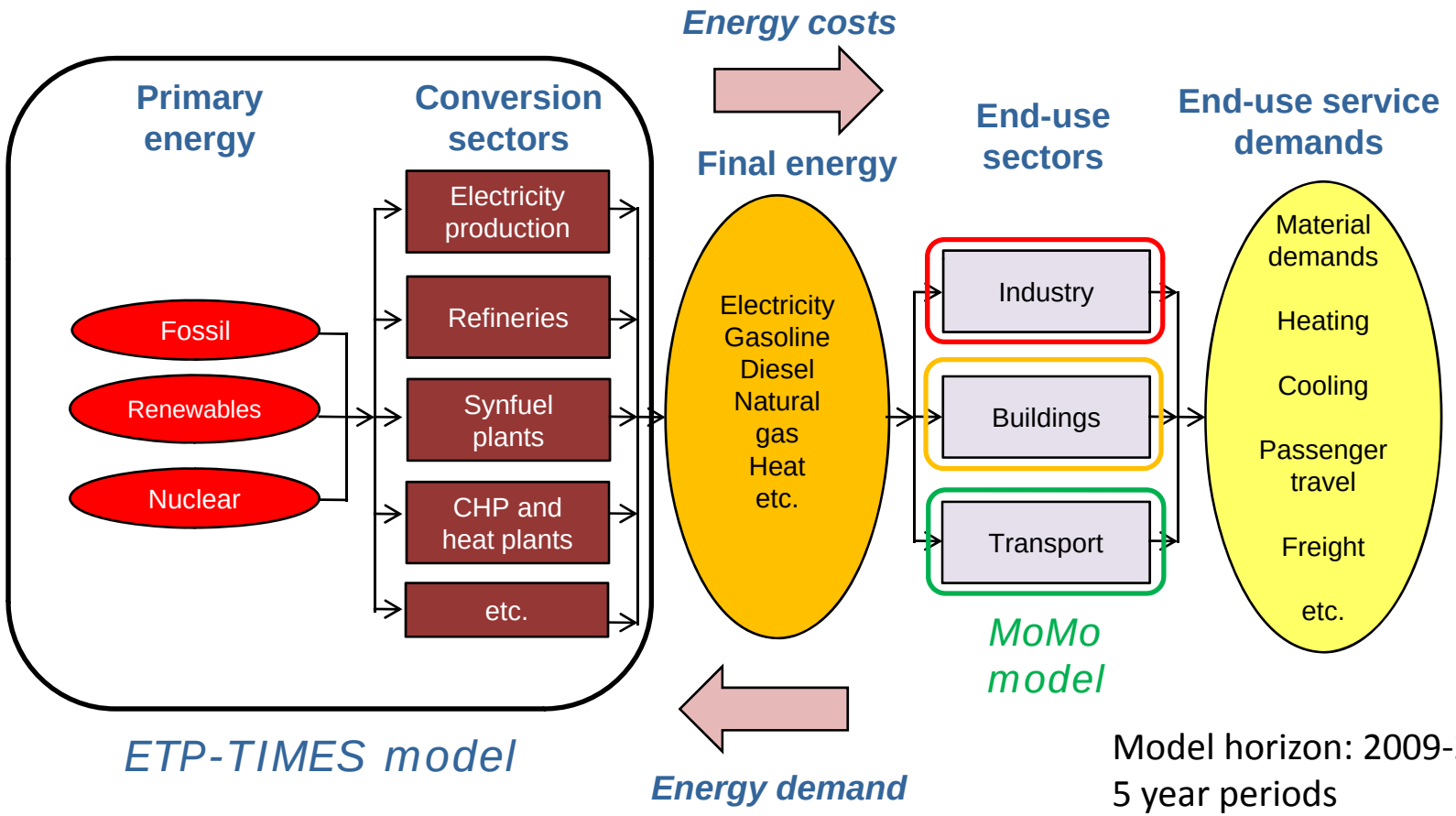
Low-carbon energy technology roadmaps

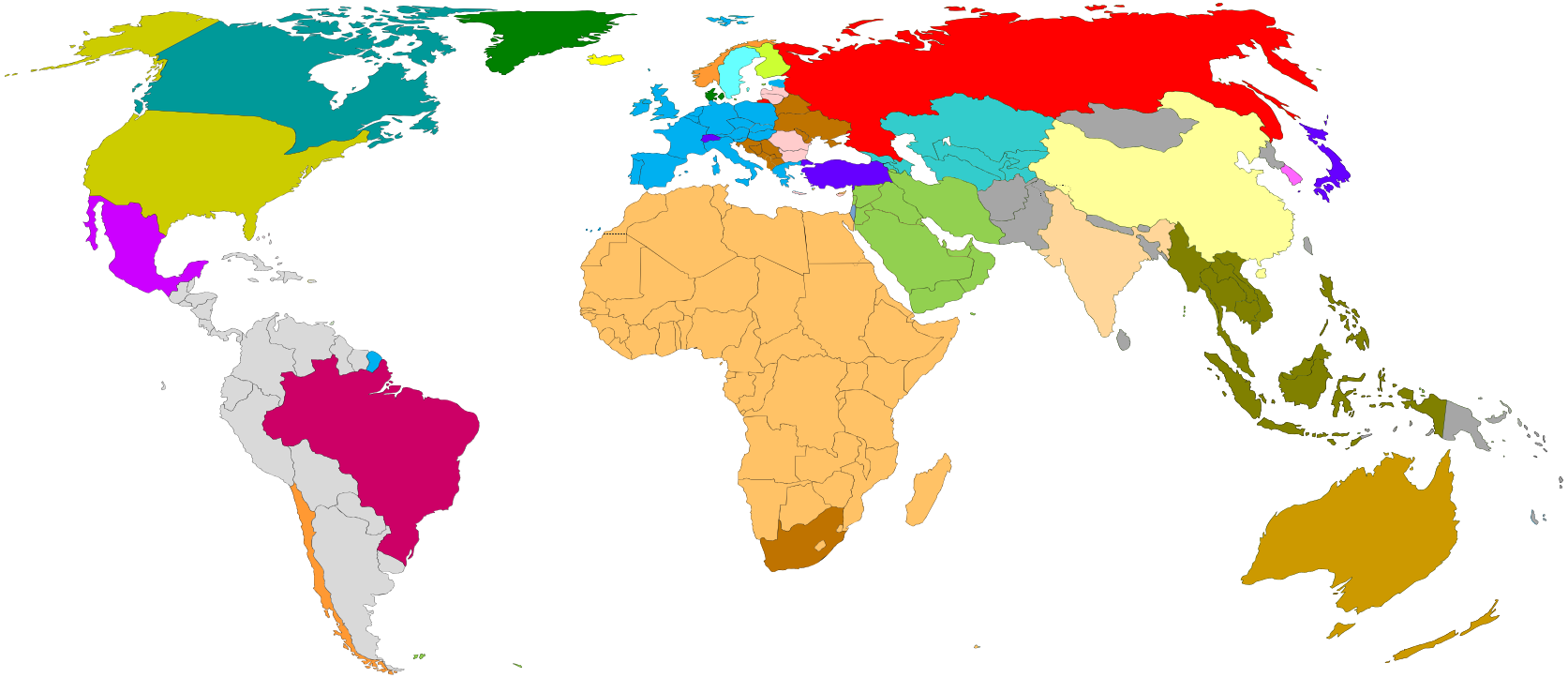
Supply-side modelling
ETP-TIMES

ETP modelling framework



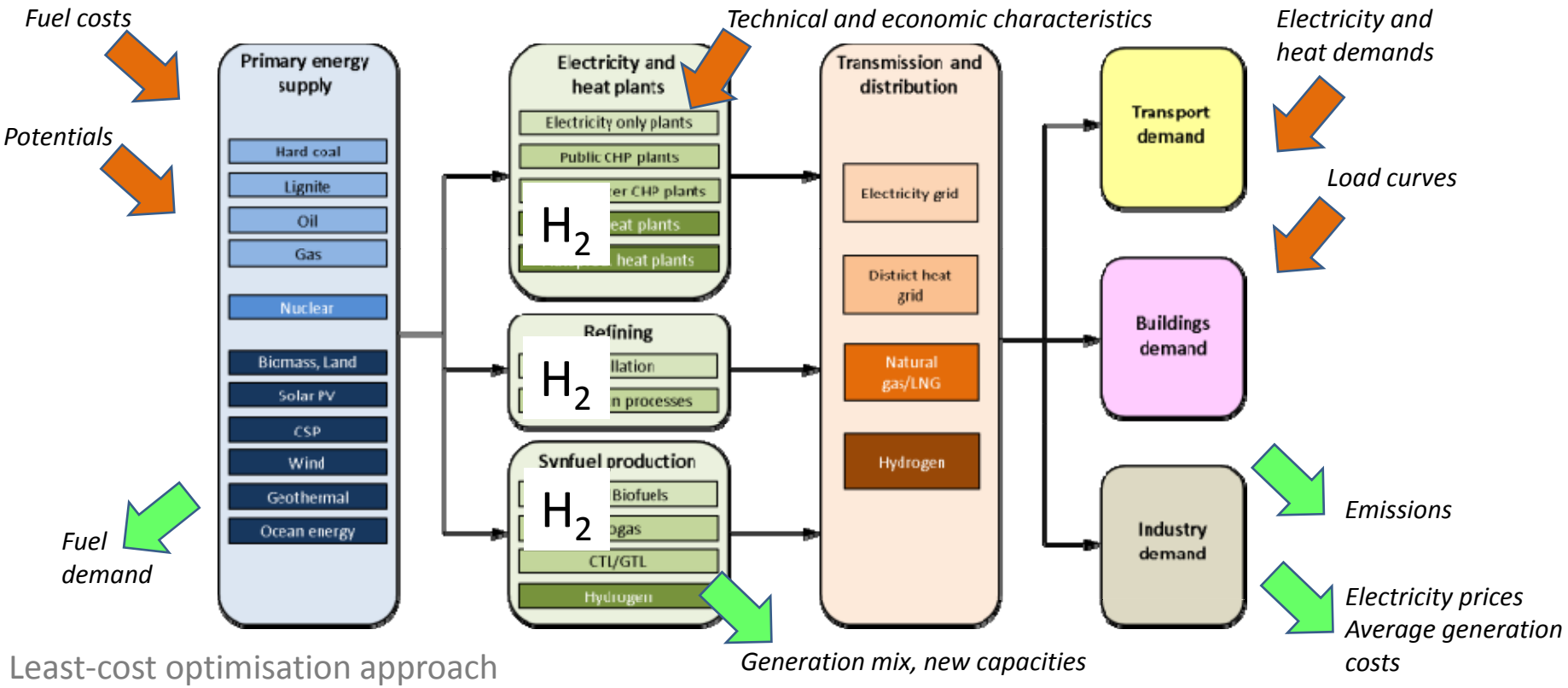
Model horizon: 2009-2050 (2075) in 5 year periods

Regional structure of ETP-TIMES



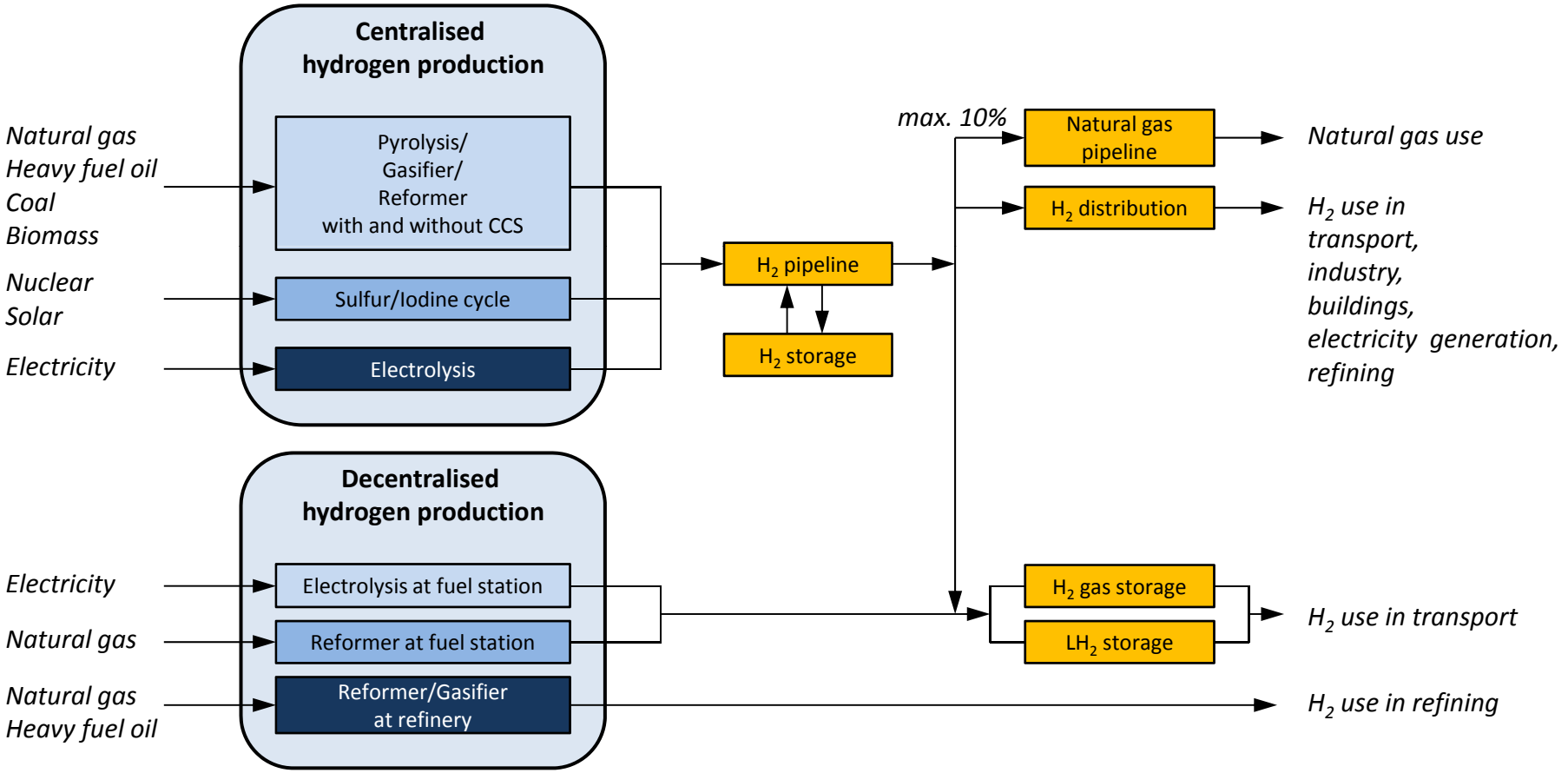
- 28 model regions representing individual countries or aggregations of countries
- Only one geographic point per model region; differentiation within a single region, e.g. through different resource categories

Structure of supply side model (ETP-TIMES)

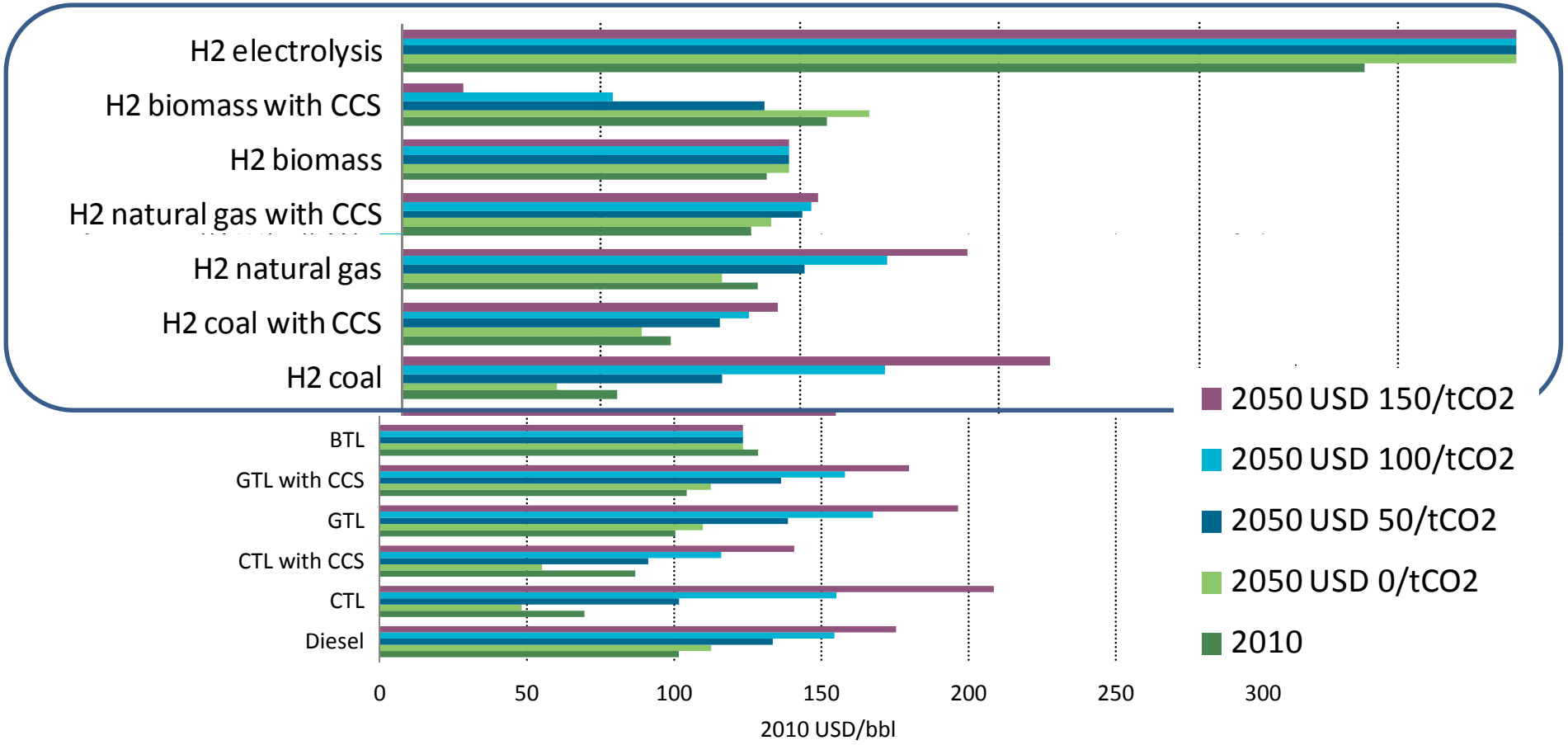


- Least-cost optimisation approach
- Methodology developed by ETSAP (Energy Technology Systems Analysis Programme) implementing agreement of the IEA

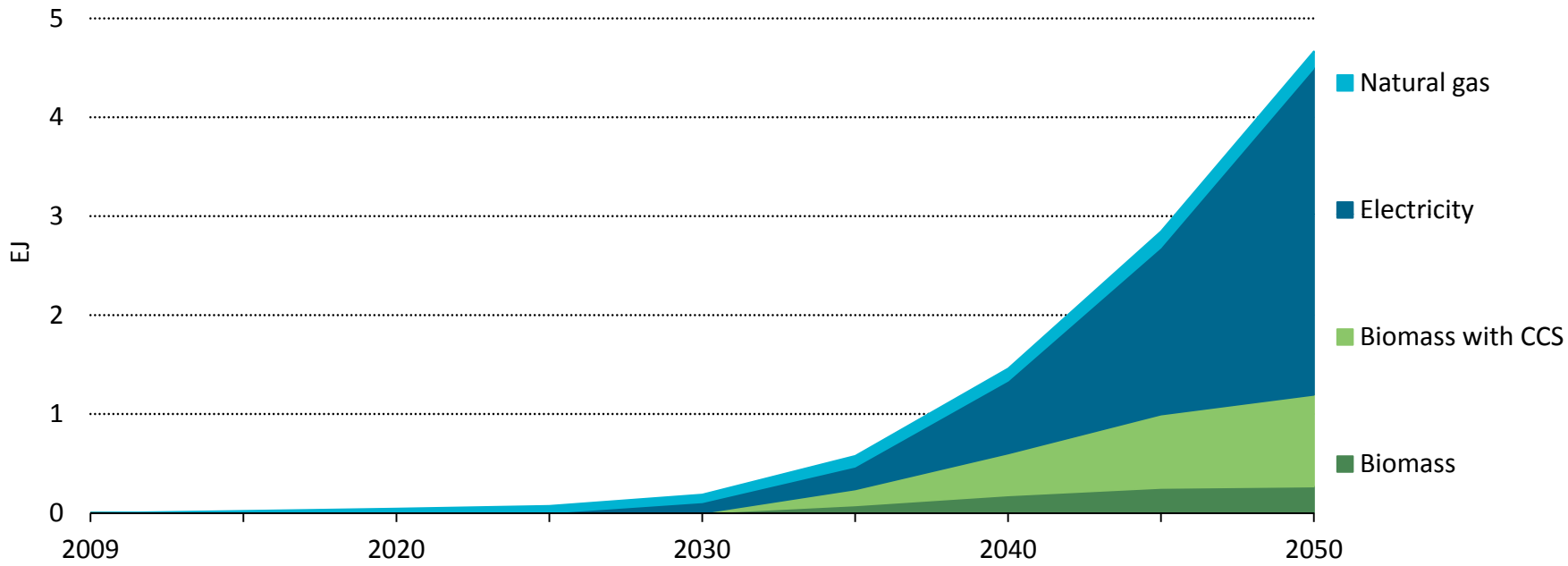
Hydrogen supply options



Hydrogen supply costs in comparison to other fuels

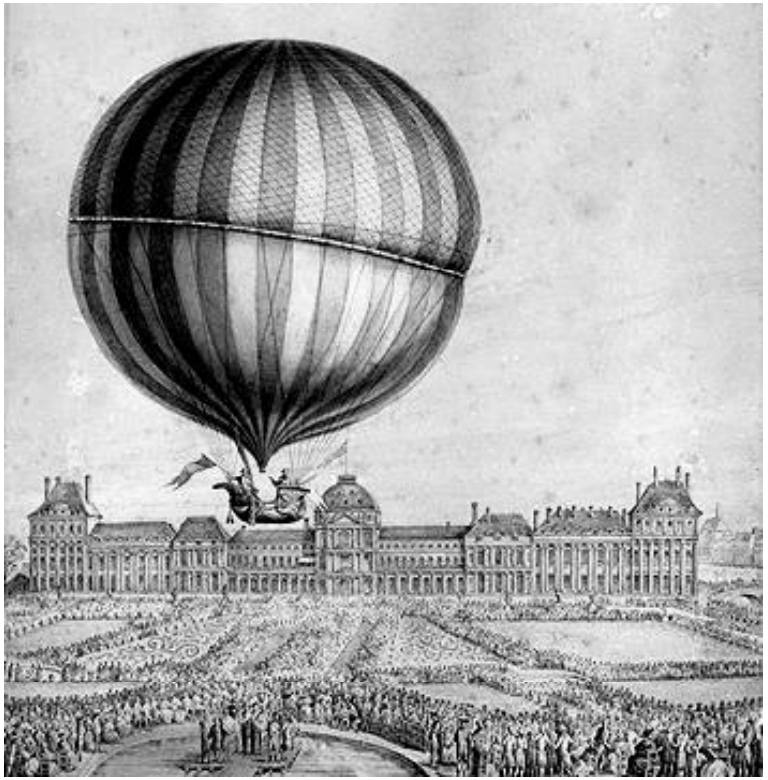


Global hydrogen supply in the 2DS



Note: Captive generation at refineries and chemical plants not included.

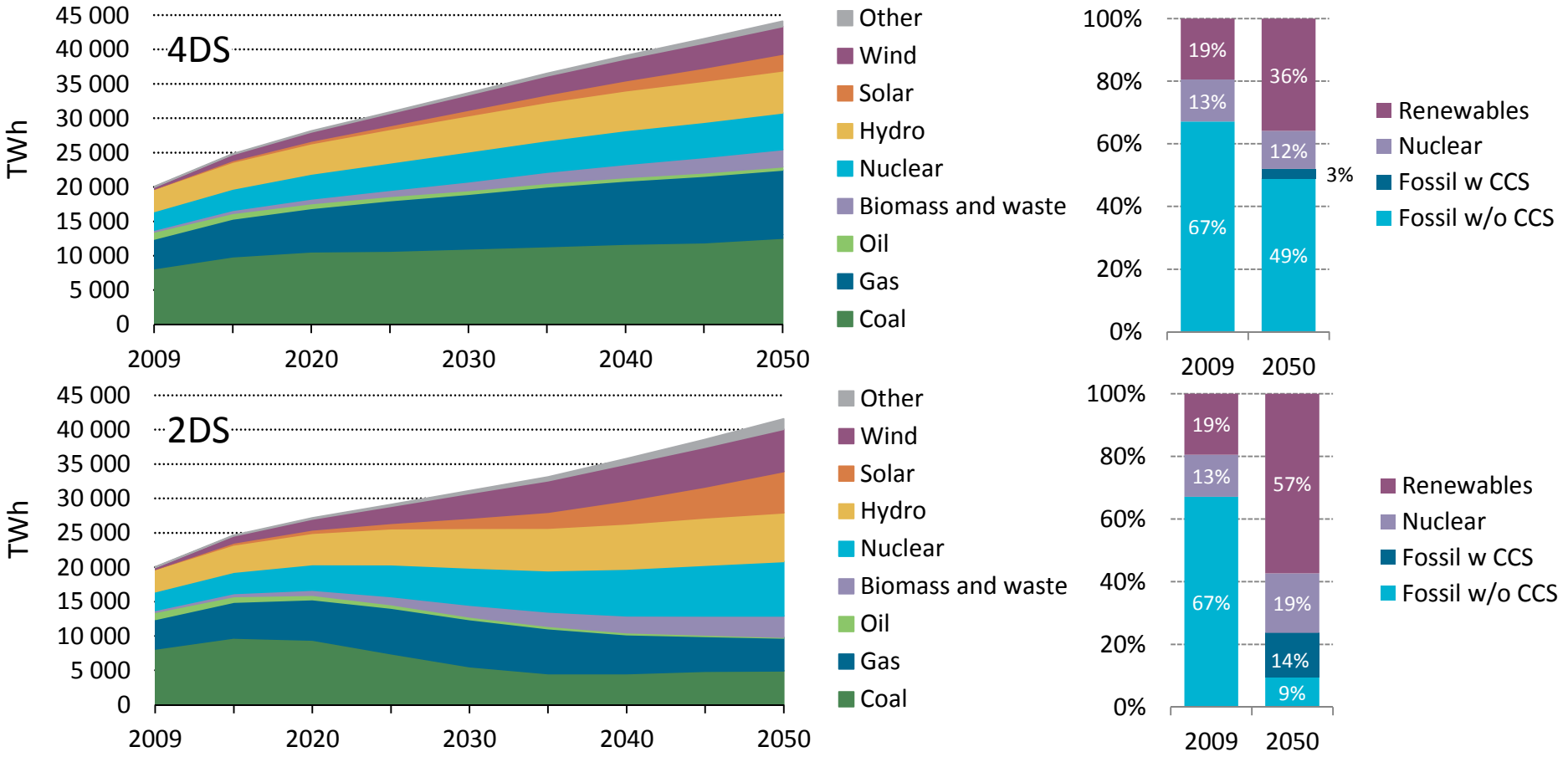
Hydrogen may become an attractive storage option for surplus electricity from variable renewables by 2050



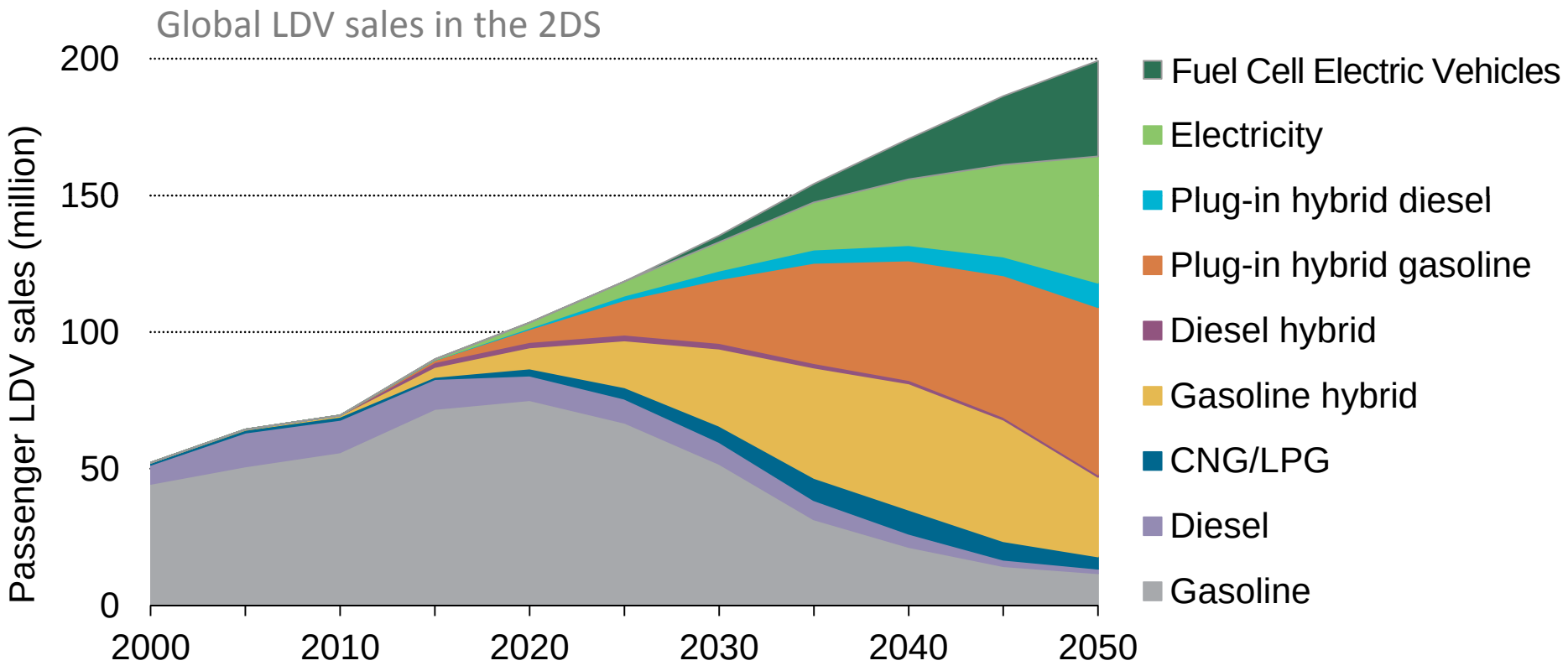
First hydrogen balloon flight by Jacques Charles
and Nicolas Robert in Paris on 1 December, !783.

Energy storage

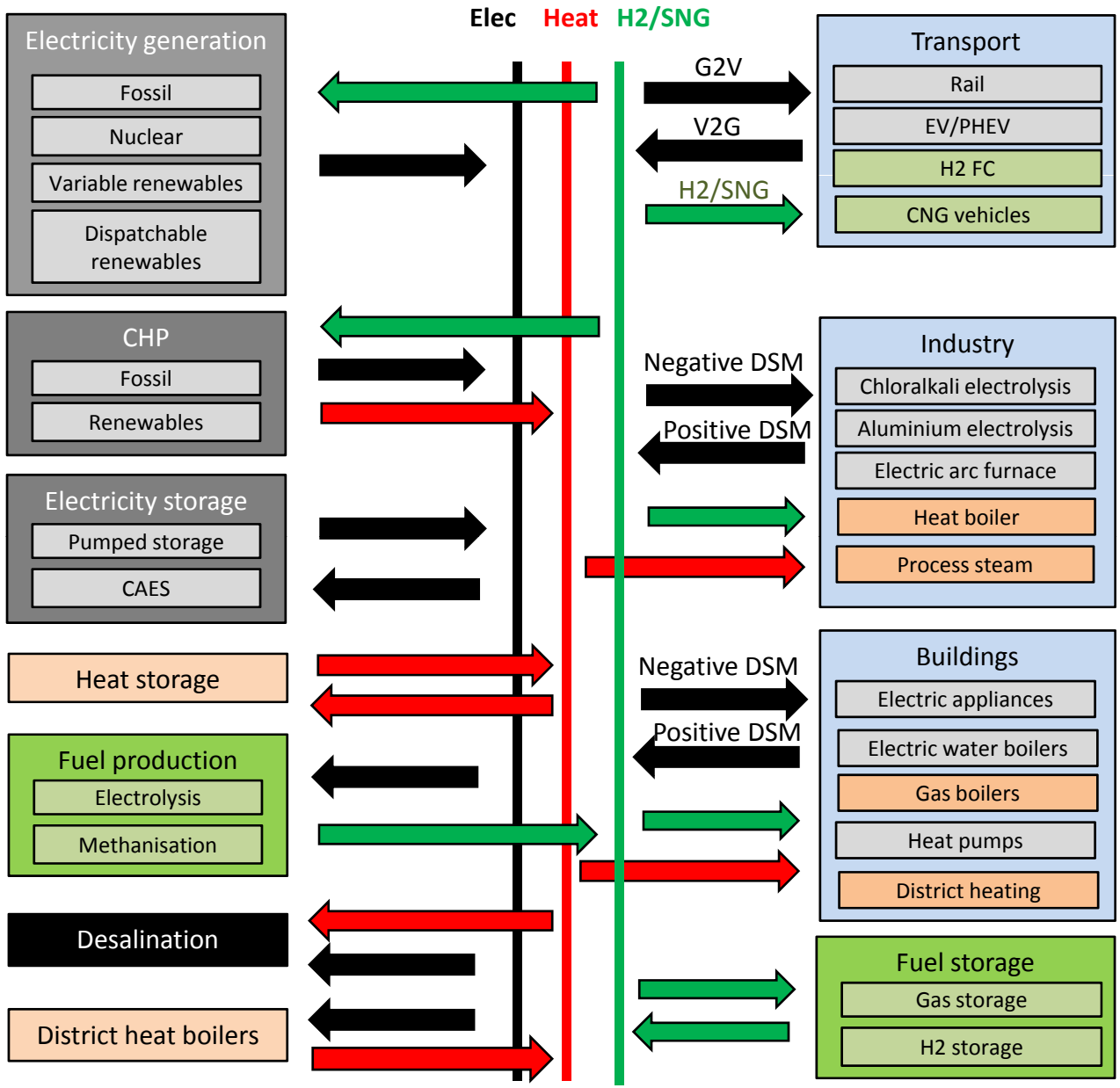
The way electricity is produced changes in a 2DS



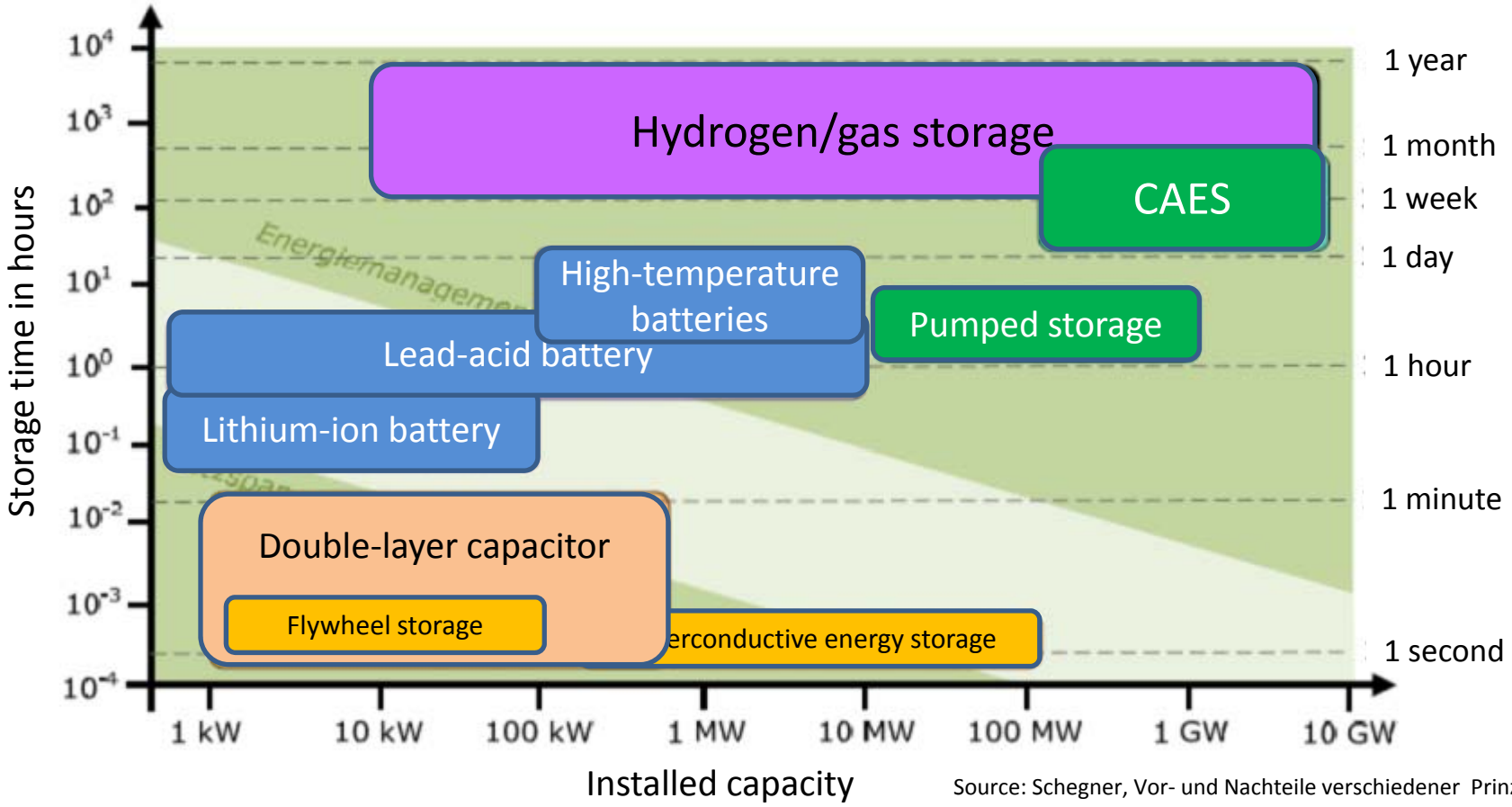
…but also electricity consumption changes



Systems thinking is needed



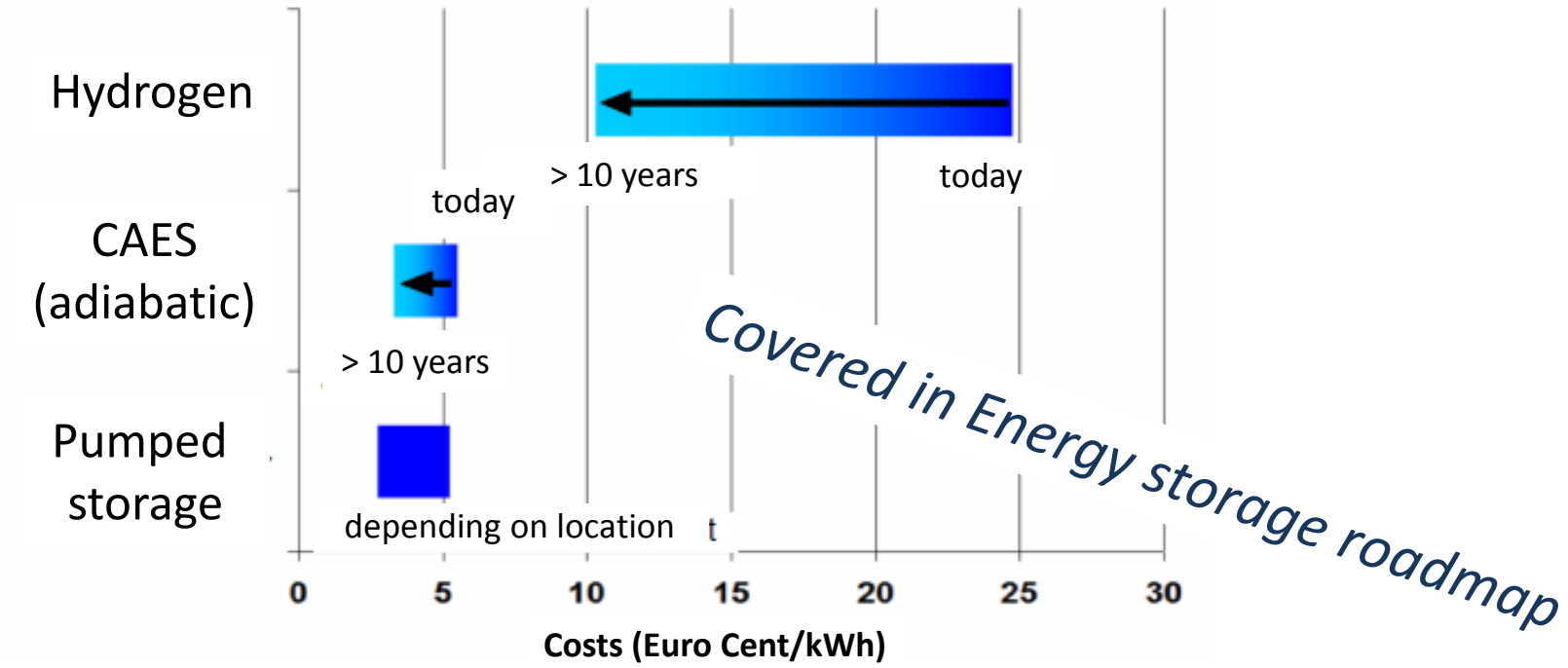
Storage technologies are different



Source: Schegner, Vor- und Nachteile verschiedener Prinzipien der Speicherung elektrischer Energie, 2012

Comparison of storage cycle costs: Daily operation

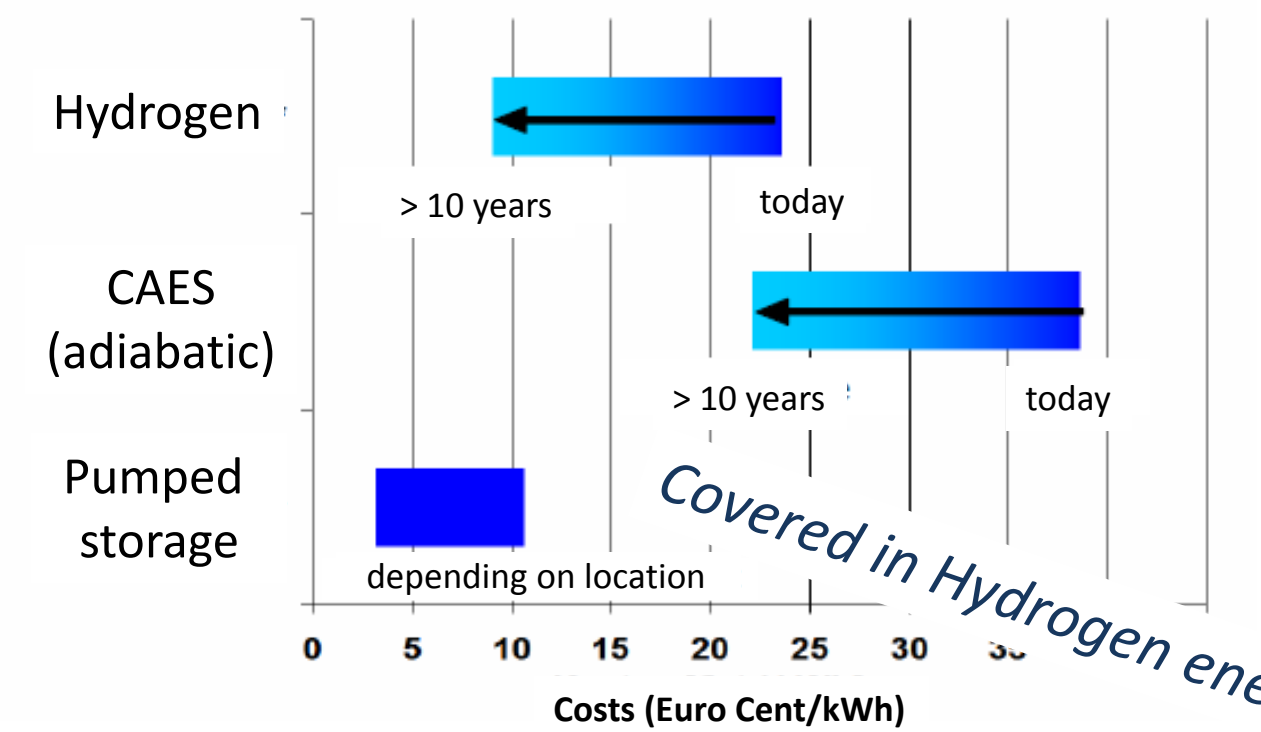
1 GW for 8h (8 GWh), 1 cycle per day



Source: VDE-Study: Energy storage in power supply systems with a high share of renewable energy sources

Comparison of storage cycle costs: Weekly operation

500 MW for 200h (100 GWh), 2 cycles per month



Covered in Hydrogen energy roadmap

Source: VDE-Study: Energy storage in power supply systems with a high share of renewable energy sources

Energy storage analysis

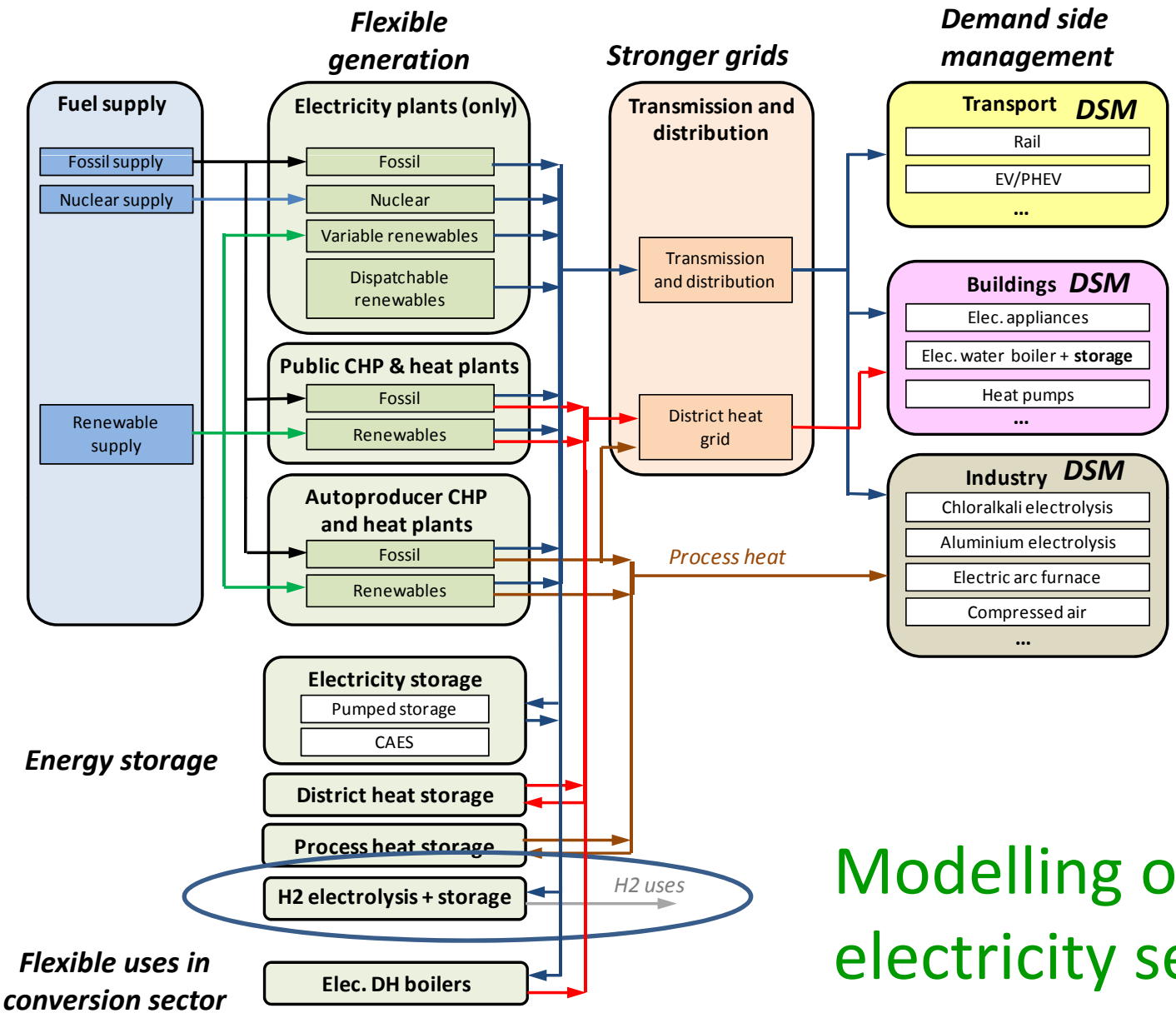
- **Enhanced ETP-TIMES model (long-term; horizon up to 2050):**
  - 4h-load segments for a typical day (6 per day, four typical days per year)
  - Large-scale storage: electricity, thermal, hydrogen
  - Considering other flexibility options for the electricity system:
    - Flexible generation technologies
    - Inclusion of demand response, e.g. V2G

  → Investment decisions in generation technologies and first estimate on storage needs; better capturing impact of operational aspects on capacity needs

↓

- **Dedicated TIMES model for operational analysis (short-term; one year):**
  - 1h-timeslice resolution
  - Analysing operation of electricity system within a year for specific region with investment decisions for generation technologies from long-term model
  - Additional operational constraints (ramp-up/-down, min load, min up/down times)

  → Improved analysis on storage needs and role of competing flexibility options



Modelling of the electricity sector

Challenges of the H_2 analysis on the supply side

- **Lack of complete information on captive (on-site) generation** at refineries and chemical plants today
- **Development of H_2-related technologies** in terms of their technical and economic characteristics as well as scale
- **H_2 infrastructure**: **spatial and scale aspects** only covered to some degree in global ETP-TIMES model, possible approaches:
  - Expanding transport infrastructure model
  - Relying on existing national studies
- **H_2 as flexibility option for the electricity sector**:
  - Assessing synergies with storage needs for end-use consumption
  - Role of natural gas infrastructure (power-to-gas)
  - Competing options for flexibility (flexible generation, other storage technologies, demand response, larger balancing area)

Thank you!

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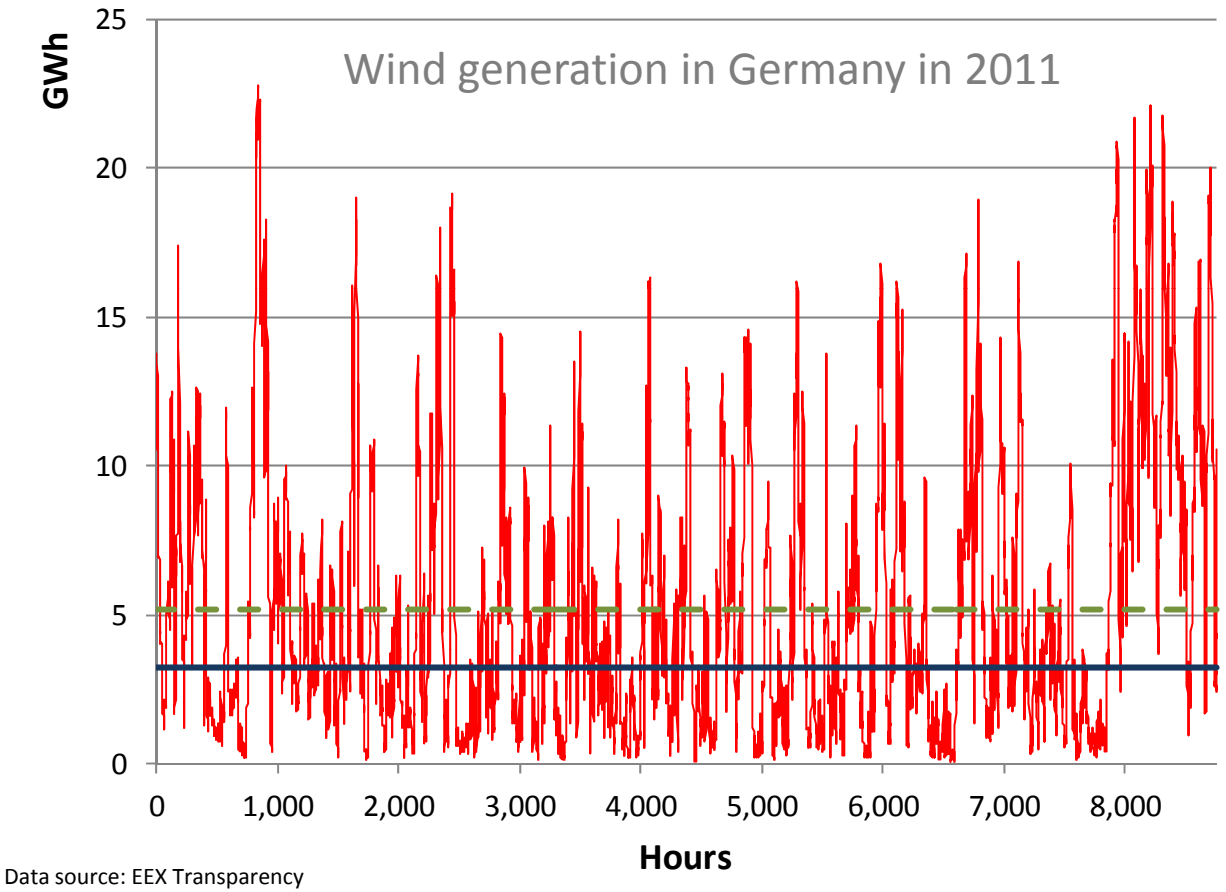
Example: Variability of wind



Data source: EEX Transparency

- Transforming variable wind generation of 2011 in constant base load generation would require a storage capacity of 3 TWh (largely based on long-term H_2 storage)
- For comparison: around 0.040 TWh of pumped storage capacity today
- Theoretical example, as other flexibility options, notably flexible generation, are not considered