ENGAGE
FEASIBILITY OF CLIMATE PATHWAYS

The EU on the pathway to carbon neutrality

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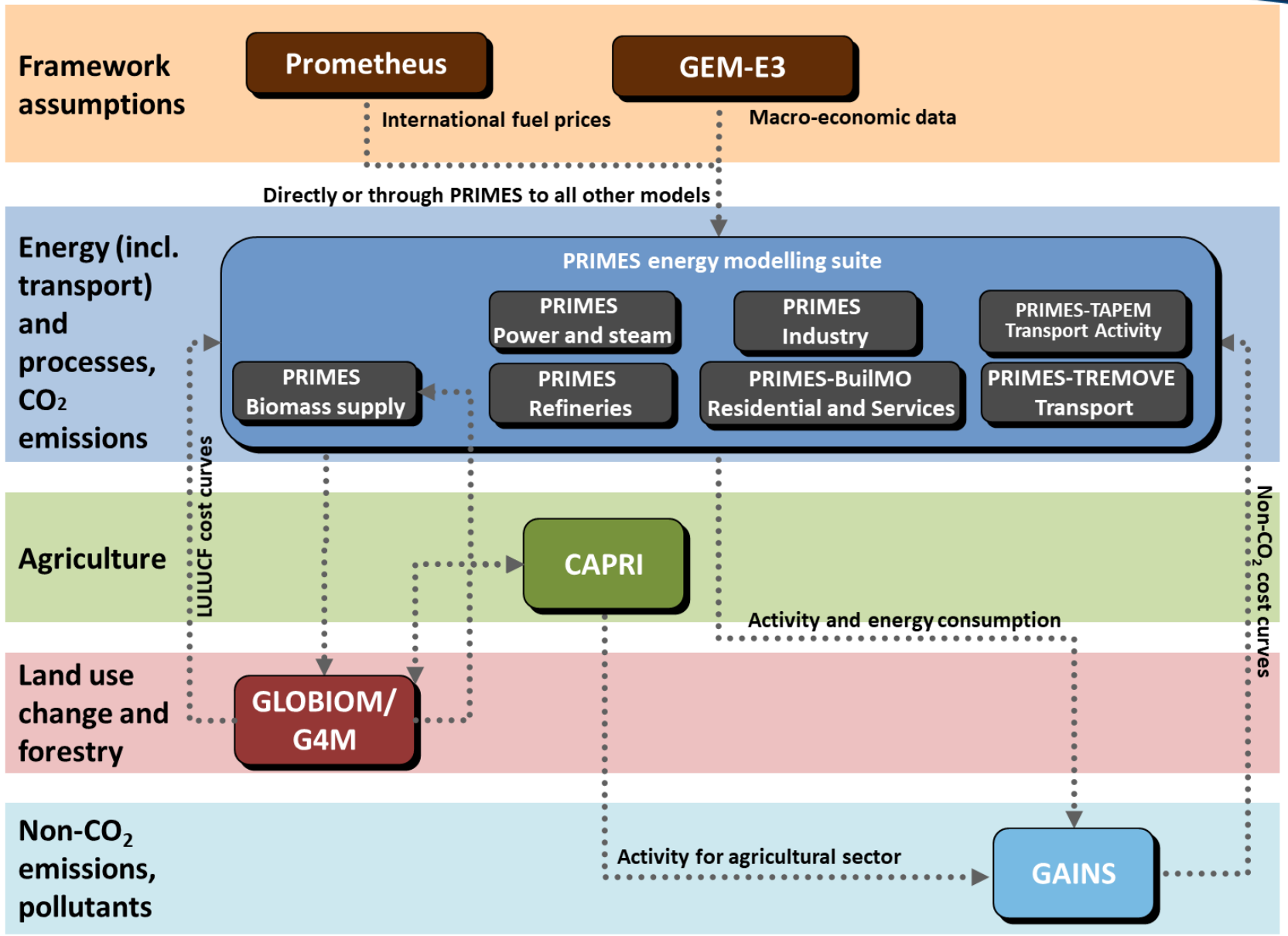
Key policy questions

Horizon 2030

- Setting the target for 2030 for the pathway to carbon neutrality
- What are the policy options available to achieve a 2030 targets?
- Which sectors are most affected by increasing the target in 2030?

Horizon 2050 and beyond

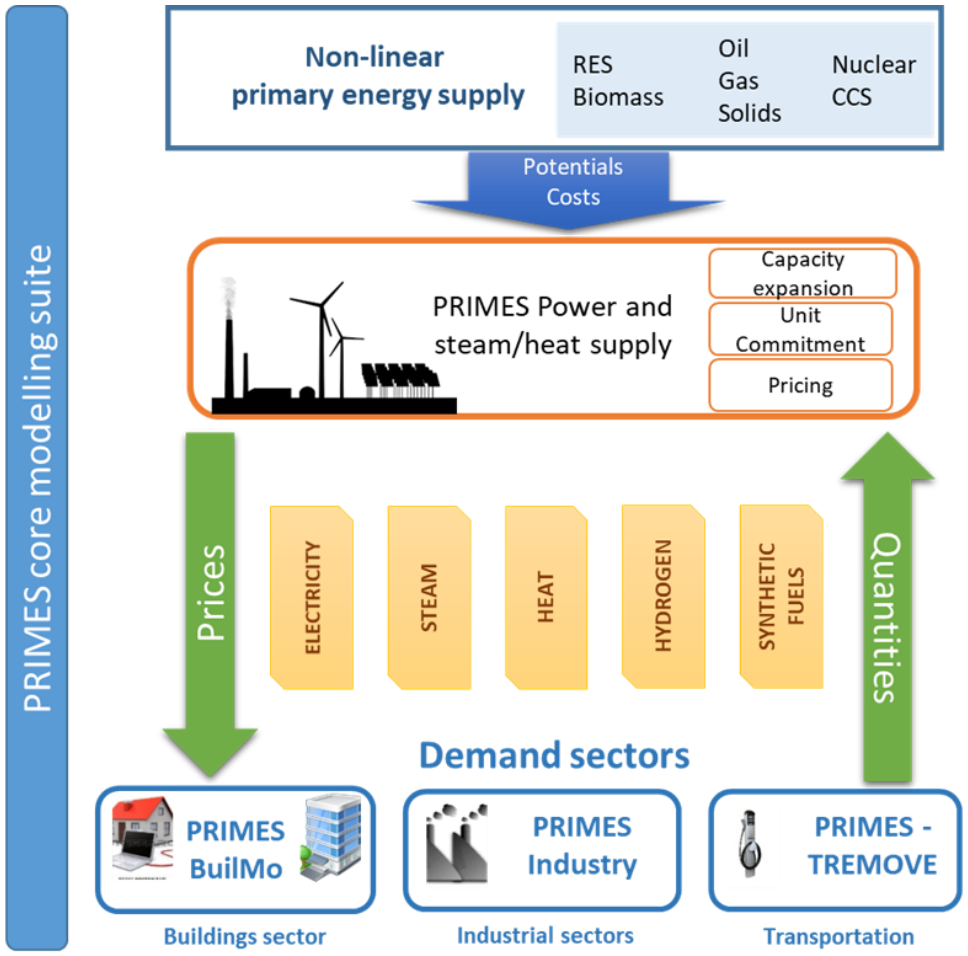
- Is climate-neutrality by 2050 in the EU viable and sustainable in the long run?
- How to achieve carbon neutrality?
- Can conventional technologies achieve carbon neutrality?
- If not, what additional elements to promote in addition to conventional policies and technologies?
- Is climate neutrality affordable?



- A suite includes many models each focusing on a specific sector: each model follows an approach that is adequate for the sector
- The modelling suite uses the prices of multiple market equilibrium as explicit drivers of the linkage of the sub-models; the EUCLIMIT modelling suite can model various pricing and competition conditions and explicit price-related policies.
- Inclusion of a large set of policy instruments, covering market and non-market interventions, technology standards, infrastructure development and measures that aim at influencing behaviours

PRIMES

- Model structure:
  - **Modular system:** one module per sector
  - **Microeconomic foundation with engineering representations**
- Aim:
  - Simulate structural changes and long-term transitions
- Focus:
  - **Market-related mechanisms**
  - Representation of **policy instruments for market, energy and emissions**, for policy impact assessment
- Technology database:
  - Energy technology database has a standard format and is open access



Temporal resolution: to 2070, in 5-year time steps
Geographic resolution: 27 EU MS +UK+ 10 European non-EU countries
Mathematically: concatenation of mixed-complementarity problems with equilibrium conditions and overall constraints (e.g. carbon constraint with associated shadow carbon value) - EPEC

Demand side modelling challenges

Time horizon 2050

Circular economy

- What is the potential for decreasing energy demand through circularity?
  - Recycling and modularity
  - Primary and secondary production of metals
  - Literature still under development

Energy efficiency

- Examine the potential of increasing the efficiency of the transport system (e.g. car sharing, improved scheduling)
  - Heat recovery capabilities in industry
  - Deep renovation strategies in buildings

Buildings

- Representation of non-market barriers, idiosyncratic behaviors: Detailed segmentation of households and dwelling types
- Long payback periods of renovation investments: Nested choice of other energy equipment, depending on the choice for heating and insulation

Industry

- Decarbonize process emissions
- Direct use of carbon-free hydrogen in industrial uses; Upper limit to the electrification of industrial uses
- 1-3 investment cycles till 2050
- High segmentation of industrial sectors, energy uses, technologies, Dynamic and intertemporal modelling of capital vintages, technology and fuel choice

Transport

- Decarbonisation of long-distance mobility
- Inclusion of novel technologies (electric aircrafts, hydrogen vessels, electric trucks)
- Inclusion of new energy carriers (hydrogen, e-fuels, advanced biofuels)
- New trends: sharing

Residential-Renovations

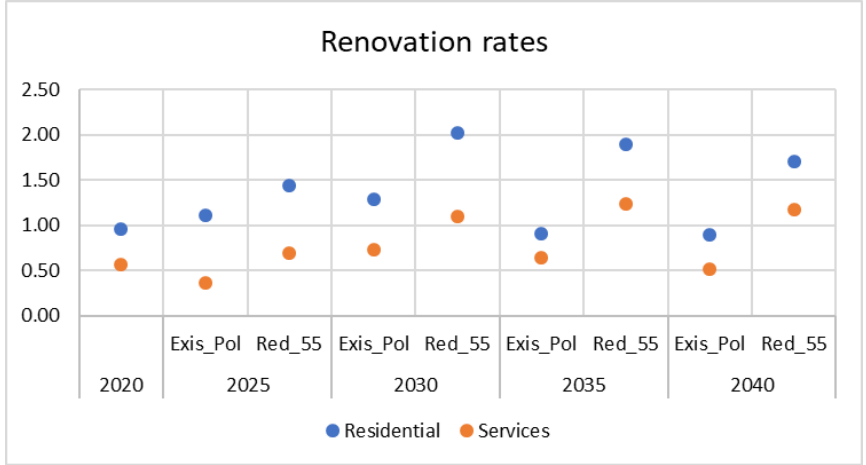
- Crucial that the pathway of the energy transition takes into account distributional issues (e.g. energy poverty)
- The model developments include a system with income classes
- Results to help address policy gaps to address transition

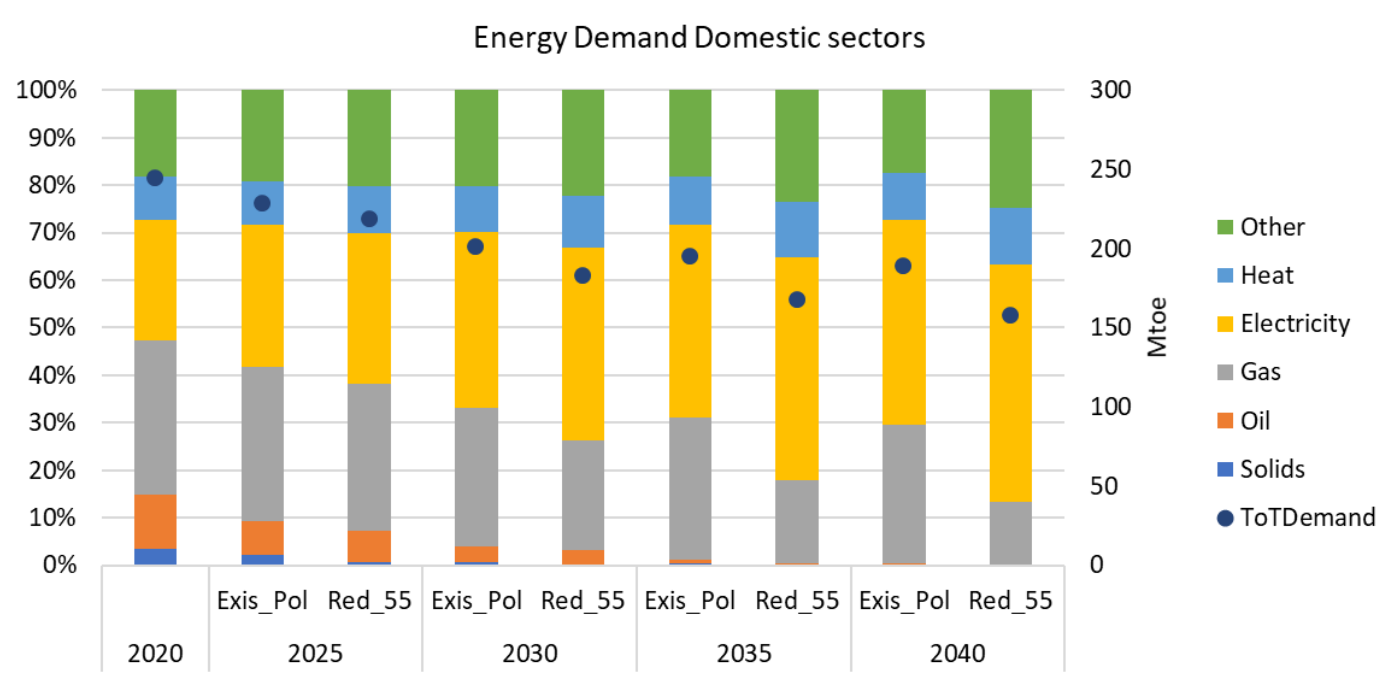
https://ec.europa.eu/energy/data-analysis/energy-modelling/eu-reference-scenario-2020_en

Timehorizon 2030

Moving to 55%: buildings

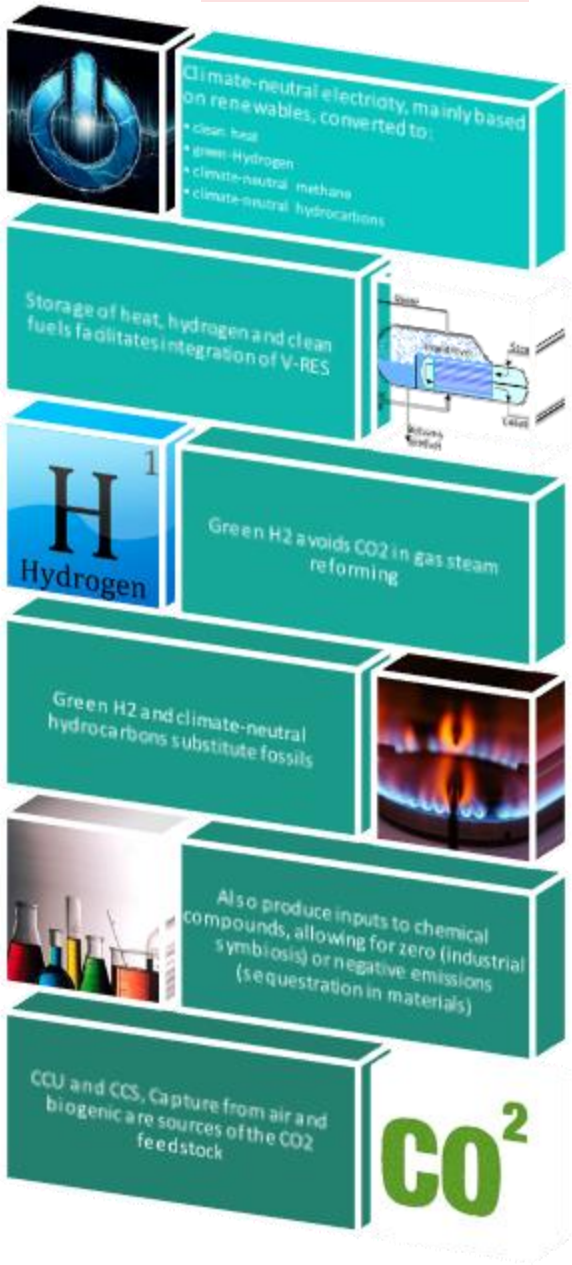
- Rates of renovation of old buildings will have to increase considerably from 1% to almost 2% renovation per annum
- Also to shift from light to deep energy-related renovation
- The renovation strategies submitted by the MS must be enhanced
- Emission reductions are driven by:
  - ⇒ Renovation
  - ⇒ Fuel-switching: to electricity and direct RES
- Policies to reduce market and non-market barriers need to be put in place

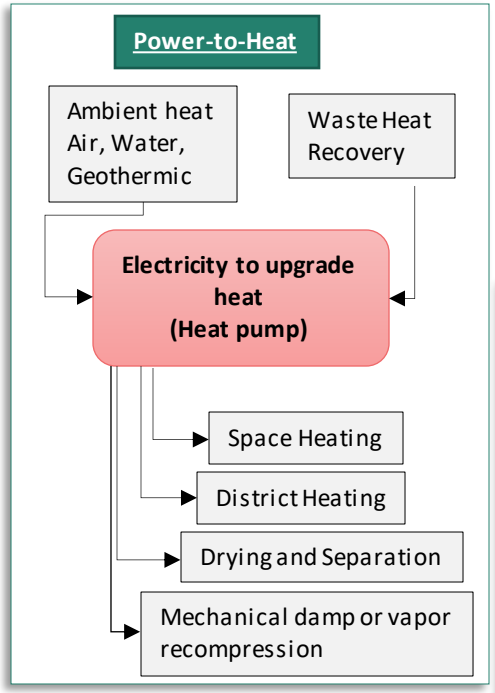


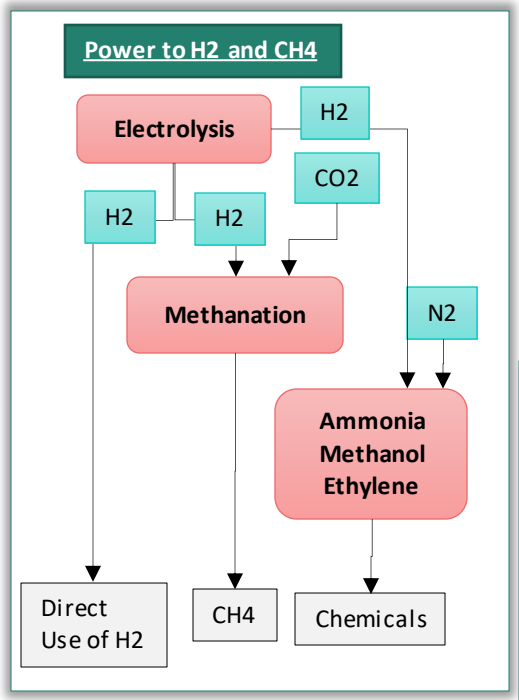


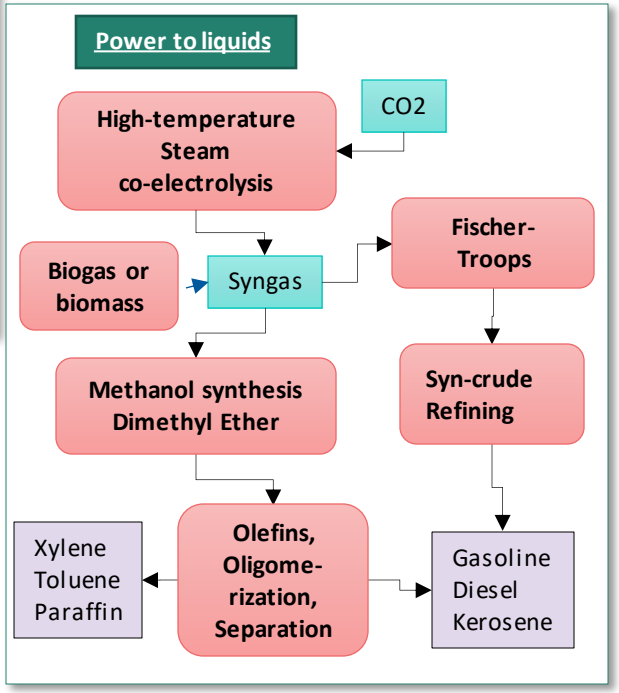
Sectoral Integration

Building blocks

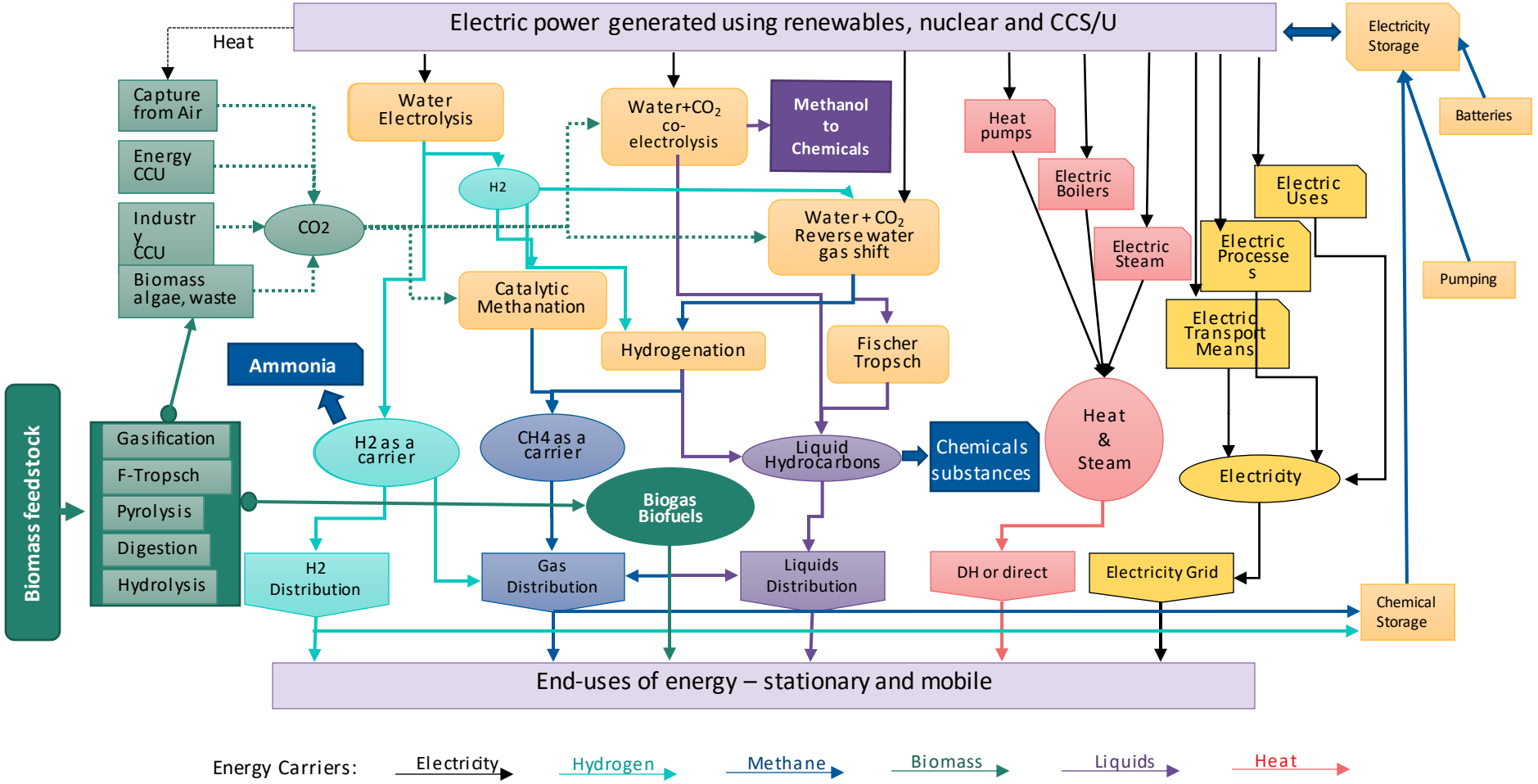








Illustrative low carbon energy carrier pathways



Supply side challenges

Time horizon 2050

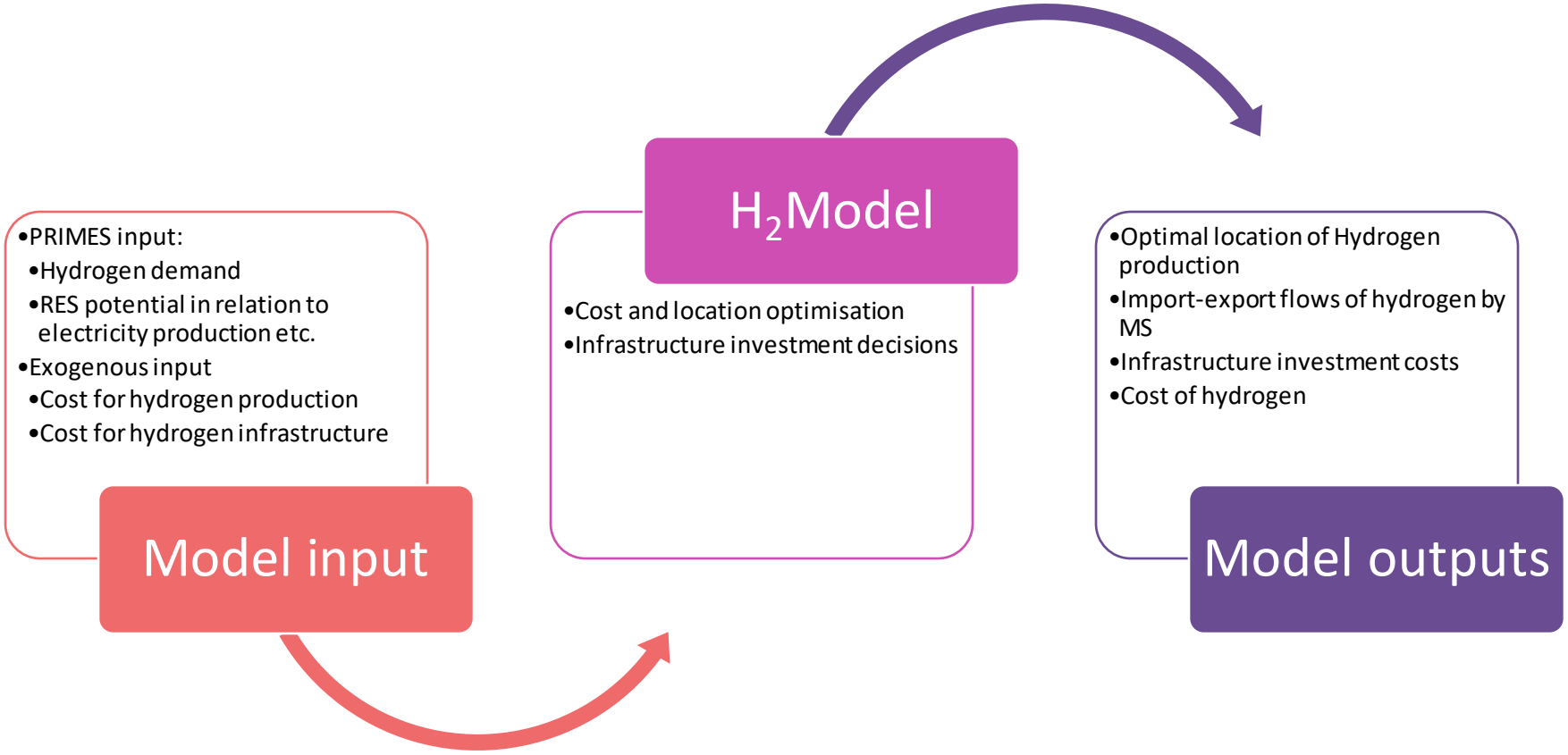
Power and Heat

- Demand for flexibility because of extreme RES (85%)
- Differentiated unit commitment from capacity expansion
- Integrated simulation over the European interconnected system using flow-based allocation
- Synergies with the industrial sector
- Simultaneous simulation of electricity, distributed heat and industrial steam (boilers, CHP, district heating)

Production of new fuels and storage

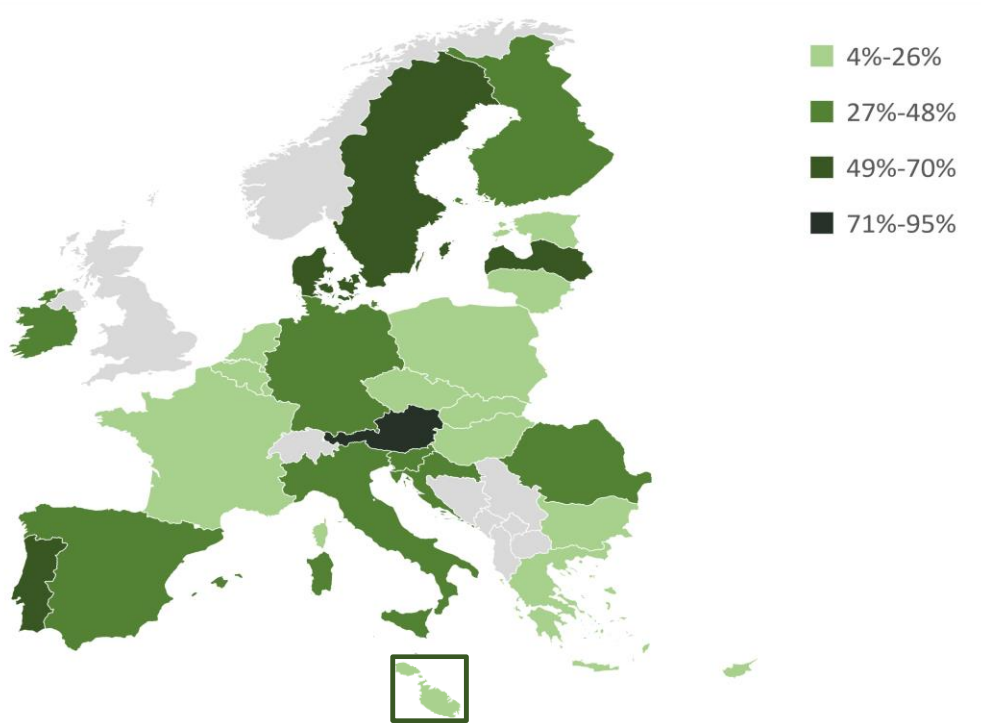
- Multiple storage options (batteries, pumping, hydrogen, e-gas)
- Co-production of multiple products: location of production and consumption, infrastructure

New trade hydrogen model

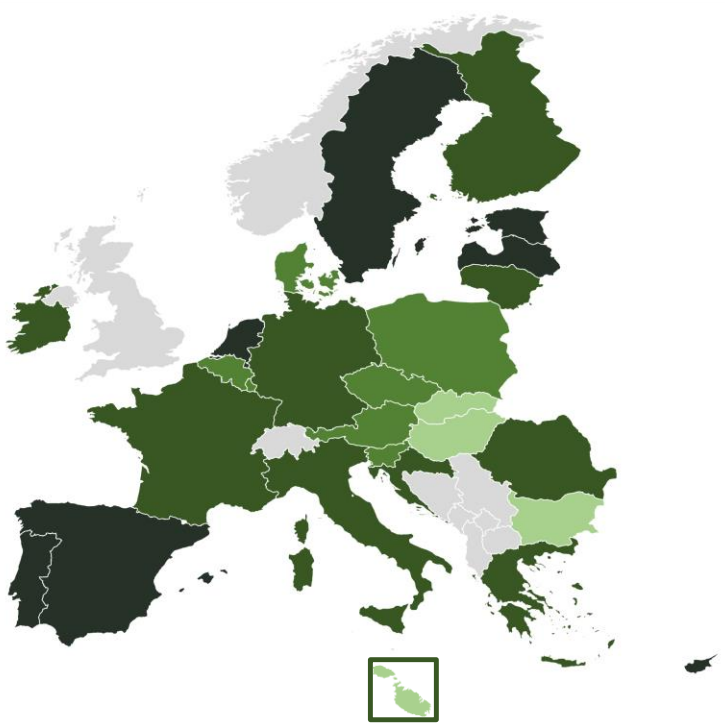


RES-E share Reference scenario

2015



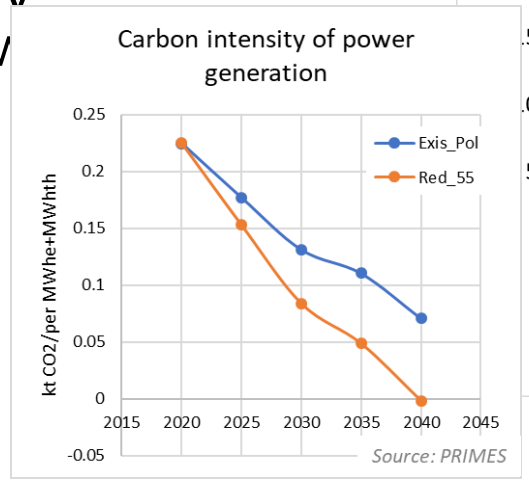
2030

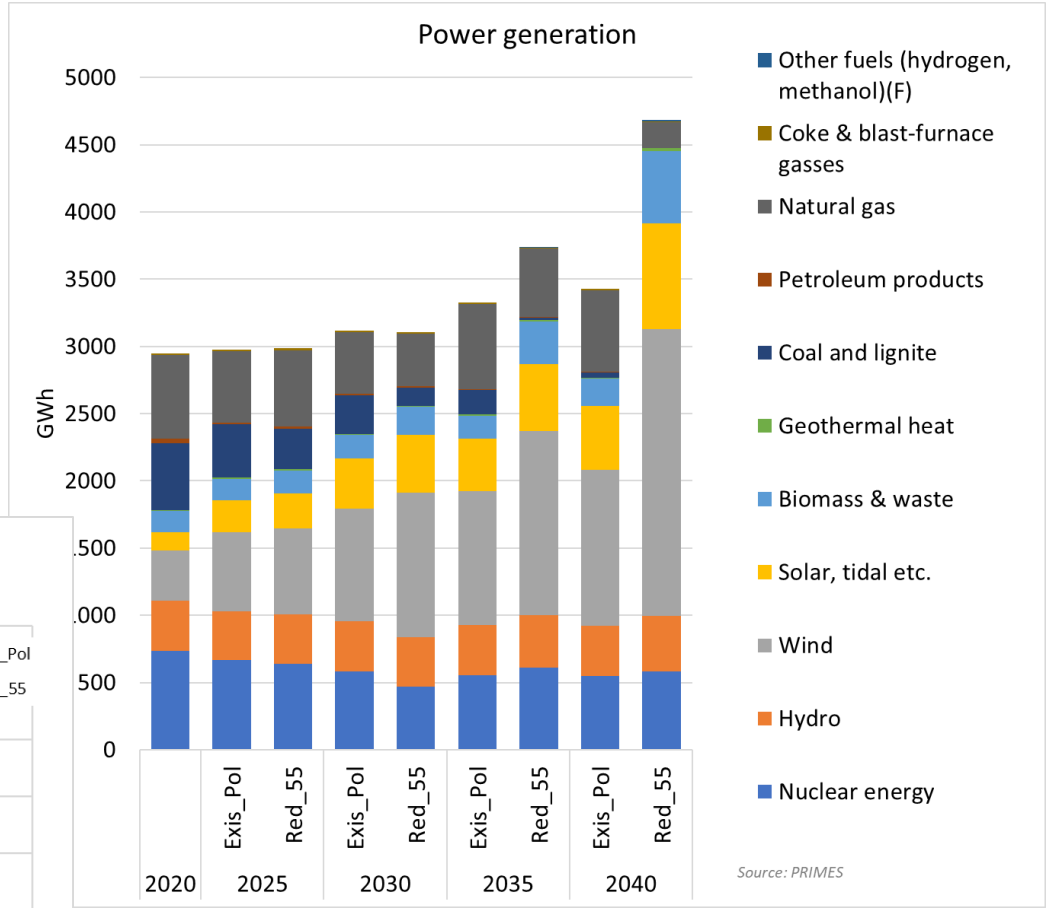


Time horizon 2030

Moving to 55%: power generation

- Increase in electricity demand
  - ⇒ Electricity is fundamental – heat pumps and e-mobility electrify demand
- In the long-term e-fuels decarbonize demand further and ensure storage
- Generation relies on RES, with wind and solar increasing impressively
- Prices signals and regulatory infrastructure needs to allow speeding up of emission reduction
- Carbon neutrality would be reached by 2040





Concluding remarks

Targets

- ***"Climate-neutrality"*** => net phase-out of all GHG emissions (Höhne et al., 2015).
- ***"Carbon neutrality"*** => net zero CO2 emissions.

Strategy

- ***Pillars:*** *Energy Efficiency, Renewables, Carbon pricing*
- ***2030:*** *-55% GHG, 40% RES (RES-E > 60%), -9% Energy use*
- ***2050:*** *Net zero GHG emissions*

Roadmap

- ***Decarbonise Power Generation*** => Renewables +Storage, mainly
- ***Electricity as a zero carbon carrier in transport and heat*** => electrification
- **Produce** ***green (carbon-neutral) gaseous and liquid fuels*** => where electrification not possible
  - ***Biomass origin (limited potential)***
  - ***Electricity origin: Hydrogen from renewables***
  - ***CO2 from biogenic and air capture origins***
  - ***Fossils origin: Requires underground storage of CO2 (unavailable) otherwise not climate neutral***
- ***Optimize overall efficiency to avoid excessive increase in electricity challenged by RES potential!***