How far away is hydrogen? Its role in the medium and long term decarbonisation of Europe

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E4SMA

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Outline

- Policy context and research question
- Modelling approach
- Results
- Conclusions and further work
Strategic importance of hydrogen and fuel cells for EU energy and climate policies

http://www.fch-ju.eu
Research questions

- Hydrogen potential role in EU decarbonisation → need for system-wide assessment (competition)
- Hydrogen production
- What different roles
  - Hydrogen consuming sectors
  - Energy storage
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JRC-EU-TIMES model in a nutshell

- Energy System of **EU28 + CH, IS, NO**. Balkans as optional.
- **Improved version** (by JRC), based on earlier generations of pan-European TIMES models that have been developed in several EU funded projects, such as NEEDS, RES2020, REALISEGRID, REACCESS
- Model **fully owned and operated** by the JRC
- Model **validation** with Commission Services and external modelling experts
- **Designed for analysing the role of energy technologies** and their innovation for meeting Europe's energy and climate change related policy objectives
JRC-EU-TIMES key characteristics

- Model horizon is 2005-2050 (2075)
- 70 exogenous demands for energy services across 5 demand sectors (agriculture, residential, commercial, industry, and transport)
- Economic drivers from general equilibrium model GEM-E3 – with demand elasticities used for different drivers
- Supply sector (fuel mining, primary and secondary production, import and export)
- Representation of country-to-country energy flows, incl. endogenous electricity and gas trade, and import / exports with non-European regions
- 12 time slices (4 seasons, 3 diurnal periods)
- Country specific differences for characterisation of the conversion and end-use technologies and renewable potential (onshore wind, offshore wind, geothermal, biomass, biogas, hydro, marine energy, solar PV and CSP)
- Main outputs: stocks and activities with associated flows, investment costs.
High level flow-scheme of hydrogen chain
Hydrogen storage

- Hydrogen storage options and their delivery processes:
  - Underground storage, from centralised production
    - Blending for all sectors and residential gaseous H\textsubscript{2}
    - Tank storage, from centralised production
      - Gaseous H\textsubscript{2} industrial, liquid and gaseous H\textsubscript{2} for transport, gaseous H\textsubscript{2} for residential
  - Tank storage, from decentralised production
    - Gaseous H\textsubscript{2} for residential and transport

- Hydrogen storage competes with other storage options
- Small scale decentralised electrolysers play a role in system flexibility
Modelled scenarios

**CPI**
- 20-20-20 targets in 2020
- 40% target in 2030, annual EU ETS cap afterwards

**CAP**
- 20-20-20 targets in 2020, 40:27:27 targets in 2030, annual EU ETS cap afterwards

*max nuclear capacity as 2005 & announced expansions*

80% CO₂ reduction in 2050

* Until 2025 the only new nuclear power plants to be deployed in EU28 are the ones currently being built in FI and FR. After 2025 all plants currently under discussion in EU28 can be deployed but no other plants.
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Hydrogen generation technologies

Hydrogen production technologies - CPI

Hydrogen production technologies - CAP

- Alkaline Electrolyser, small size, decentralized
- Solar Steam Reforming of Methane, centralized
- Biomass Steam Reforming, centralized
- Coal Gasification + Carbon Capture, medium size, centralized
- Coal Gasification, medium size, centralized
- Alkaline Electrolyser, medium size, centralized
- Methane Steam Reforming, large size, centralized
- Biomass Gasification + Carbon Capture, medium size, centralized
- Coal Gasification + Carbon Capture, big size, centralized
- ICL Advanced Membrane Production Improv.05.
Hydrogen use

![Graph showing hydrogen use over time in PJ units for different sectors: Industry, Residential, Commercial, and Transport. The graph compares projections for 2030 and 2050.](image)
Electricity storage (inflow) and curtailment

- H₂ storage increases with EE target and long term cap (16/30TWh in 2050)...
- ...But remains relatively small in overall storage (2%-4% of inflow)
Hydrogen storage

**H2 storage - 2050**

Day/Night hydrogen storage - CAP 2030

Day/Night hydrogen storage - CAP 2050
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Conclusions

• Results in line with literature – support role of hydrogen in decarbonising energy system in Europe

• In a carbon-constrained world, hydrogen starts deployment around 2030…

• …but picks up in following decade: long-term CO₂ emission reduction target and energy efficiency target are needed

• Hydrogen production shifts to the use of biomass, despite competition with other sectors

• Transport and industry largest consumers – though contribution remains relatively low (11-5% of sectoral final energy consumption)

• Hydrogen storage and electrolysers have a role in providing system flexibility, though in this case limited
Further work

- Sensitivity analysis around cost and efficiency of hydrogen production
- Improved storage potentials
- Improved representation of electrolyser's role in storing excess electricity → preliminary results indicate a much larger role for electrolyzers, despite the low conversion efficiency
More information

Available under:
http://publications.jrc.ec.europa.eu/repository/handle/111111111/30469
Thank you!

The Commission's Strategic Energy Technologies Information System

SETIS
Information For Decision-making

Please visit the SETIS website:
http://setis.ec.europa.eu

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All RES elc + Solar thermal + CHP per MS; upper constraint of capital;

**JRC-EU-TIMES model structure**

**Demand projections (GEM-E3)**
End-use energy services & materials

**Policy constraints**
Emission reductions, energy consumption, ...

**Primary energy supply:** Mining, imports and renewable energy

**Transport:** road passengers & freight, rail, aviation Int + Gen, navigation Gen + Bunk

**Industry:**
- Iron & Steel
- Non-Fe metals
- Cl & NH4+
- Cu; Al; Other Chem.; Cement; Glass; Pulp & Paper; (...)

**Residential:** Rural / Urban / Apartment

**Commercial:** Large and Small

**Agriculture**

**Base year & New energy technologies**
Capacity, availability, efficiency, life, costs, emission factors

**EU primary energy potential (POLES, updates)**
- Solar, biomass, biogas, geo

**EU oil, coal, gas import prices**
(EU Roadmap 2050)

**Materials and Energy flows**

\[ NPV = \sum_{i=1}^{k} \sum_{j=1}^{m} (1 + d_{i,j})^{RIET} \cdot \text{ANNOCOST}(r, y) \]

**Minimise total system costs**

**Final energy prices**

- **energy supply & demand technologies**
- Emissions
- Costs
- Installed capacity

**ETRI + Nuclear individual plants from**
IAEA (PRIS), WNA

**Joint Research Centre**
Realistic representation of Variable RES

25% of the excess electricity that could be produced when continuously operating at maximum power of the combined variable RES.

Maximum Power of the combined variable RES in a timeslice/region

20% of Demand