SESSION 8: PLENARY SESSION - FLEXIBILITY IN SECTOR COUPLING

Time: Wednesday March 29'th at 3:30 – 5:20 p.m.
Location: Catalina Ballroom Chair: Anders Bavnhøj Hansen, Chief Engineer, Energinet (Denmark)

Presentations followed by a panel debate:

- ENTSO-E/G Long-term Scenarios for a Sector Coupled System
  Antje Orths, Chief Engineer, Energinet (Denmark)

- Sector Coupling System Design Towards Carbon Neutrality and Market Challenges – a German Perspective
  Ralph Pfeiffer, Head of National and European Grid Planning Processes, Amprion GmbH (Germany)

- Power Market Solutions for a Highly Sector Coupled System - a US LMP Perspective
  Alex Rudkevich, President, Newton Energy Group

- Integrated Energy Sector Planning
  Carlo Brancucci, Co-founder/CEO, encoord

- System Development Towards a Highly Sector Coupled Energy System – Strategy and R&D Roadmap for Denmark
  Anders Bavnhoj Hansen, Chief Engineer, Energinet (Denmark)

ENTSO-E/G LONG-TERM SCENARIOS FOR A SECTOR COUPLED SYSTEM

ESIG Spring Technical Workshop 29.3.2023

Antje Orths (ano@energinet.dk)
Chief Engineer, System Development
Energinet System Operator

POLICY FRAMEWORK

EU POLICY FRAMEWORK

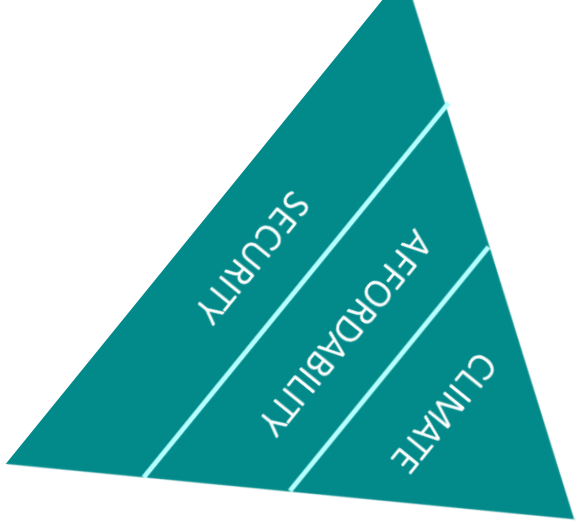
Legislation – GREEN DEAL, Fitfor55, REPowerEU

- Pace increased significantly: new EU legislation, packages, new targets, acceleration of procedures, re-visiting of not-that-old firm decisions (e. g. on nuclear, coal.)
- Everything impacts national legislation and discussions as well. ENTSOs received new tasks, barely able to solve one before input assumptions change again.
- Distance between moving targets and implementation of practical projects increases, putting reaching the European targets at risk. This is closely related to same discussions at national level.

Juli 21: FF55
non-binding target of **40%** energy from RES in overall energy mix by 2030, binding EU-level target for reducing final energy consumption by **36%** (Council)

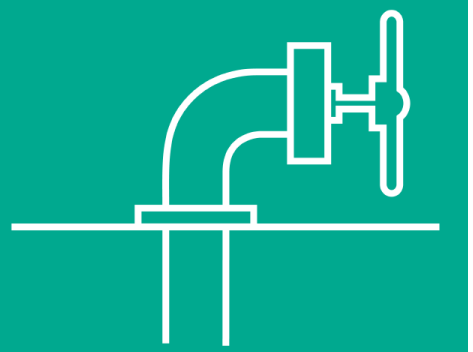
May 22: REPowerEU
non-binding target of **45%** energy from RES in overall energy mix by 2030 and **40%** efficiency gains.
(EP)

MAIN TOOLS



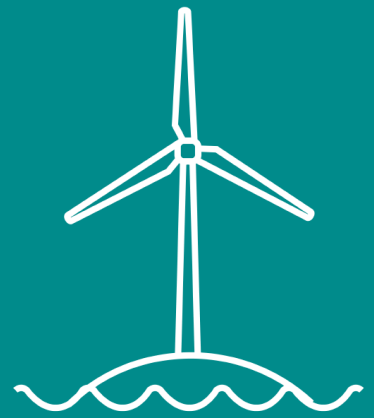
IN EUROPE

REPLACE GAS … AND BECOME ENERGY INDEPENDENT



FASTER RES EXPANSION

OFFSHORE AS RES-HUB FOR EU



USE OF H2 FOR HARD-TO ABATE SECTORS

JOINT ELECTRICITY AND GAS INFRASTRUCTURE PLANNING

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DRIVER FOR THE INTERLINKED MODEL

EC 347/ 2013 Art. 11, paragraph 8:

"By 31 December 2016, the ENTSO for Electricity and the ENTSO for Gas shall jointly submit to the Commission and the **Agency a consistent and interlinked electricity and gas market and network model including both electricity and gas transmission infrastructure as well as storage and LNG facilities, covering the energy infrastructure priority corridors and areas** and drawn up in line with the principles laid down in Annex V. After approval of this model by the Commission according to the procedure set out in paragraphs 2 to 4, **it shall be included in the methodologies.** "

WHAT HAPPENED SO FAR

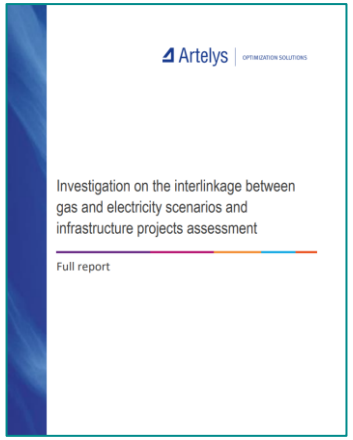
December 2016

ENTSO-E and ENTSOG submitted the required interlinked model to the EC and ACER for approval. The key element of the model was the joint development of scenarios

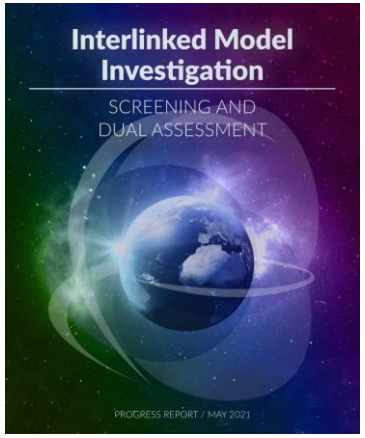
March 2017

ACER published its opinion on the ENTSO-E and ENTSOG's draft interlinked electricity and gas model

September 2019



May 2021



2023

Upcoming.

Report on ILM

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DRIVER FOR THE INTERLINKED MODEL

EC 2022/869 Art. 11:

"10. By 24 June 2025, […], the ENTSO-E and the ENTSOG shall jointly submit to the Commission and the ACER a **consistent and progressively integrated model** that will provide consistency between single sector methodologies based on common assumptions **including electricity, gas and hydrogen transmission infrastructure** as well as storage facilities, liquefied natural gas and electrolysers, […] drawn up in line with the principles laid down in Annex V.

11. The model referred to in paragraph 10, shall cover at least the relevant sectors' interlinkages at all stages of infrastructure planning, specifically scenarios, technologies and spatial resolution, infrastructure gaps identification in particular with respect to cross-border capacities, **and projects assessment**."

ENTSO-E'S MAIN PRODUCTS AROUND ENERGY SYSTEM PLANNING

Seasonal Outlooks (link)

twice a year publication giving a pan European assessment of security of supply ahead of winter and summer periods, with proposed remedial actions to answer potential issues.

December 22

European Resource Adequacy Assessment (ERAA)

A pan-European monitoring assessment of power system resource adequacy of up to 10 years ahead. It is based upon state-of-the-art methodologies and probabilistic assessments, aiming to model and analyse possible events which can adversely impact the balance between supply and demand of electric power.

Nov 22

Scenario Building Report (link)

They describe possible European energy futures up to 2050. Scenarios are not forecasts: they merely set out a range of possible futures used to test future electricity and gas infrastructure needs and projects.

Octg 2021, April 22

Ten-Year Network Development Plan (TYNDP)

one of the main legally mandated deliverables of ENTSO-E on which pan-European investment decisions are taken.

August 22 January 23

THE JOINT ENTSOS SCENARIOS

Three Scenarios for the TYNDP 2022

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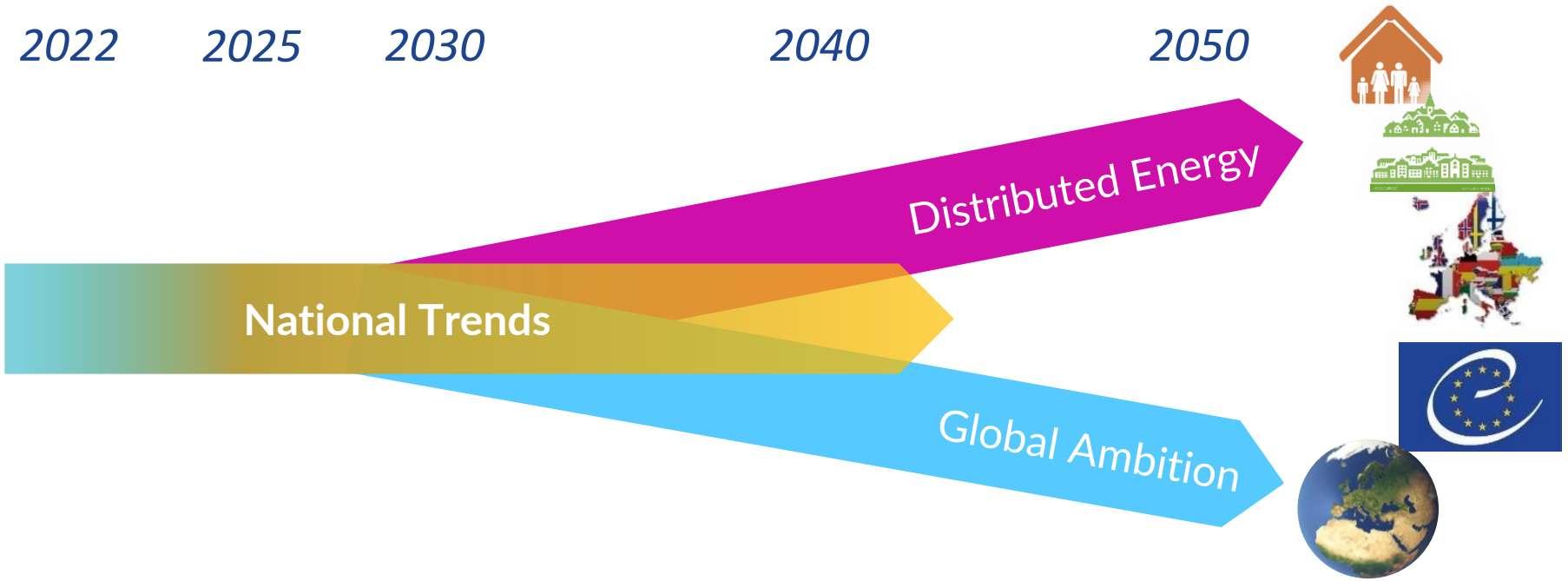
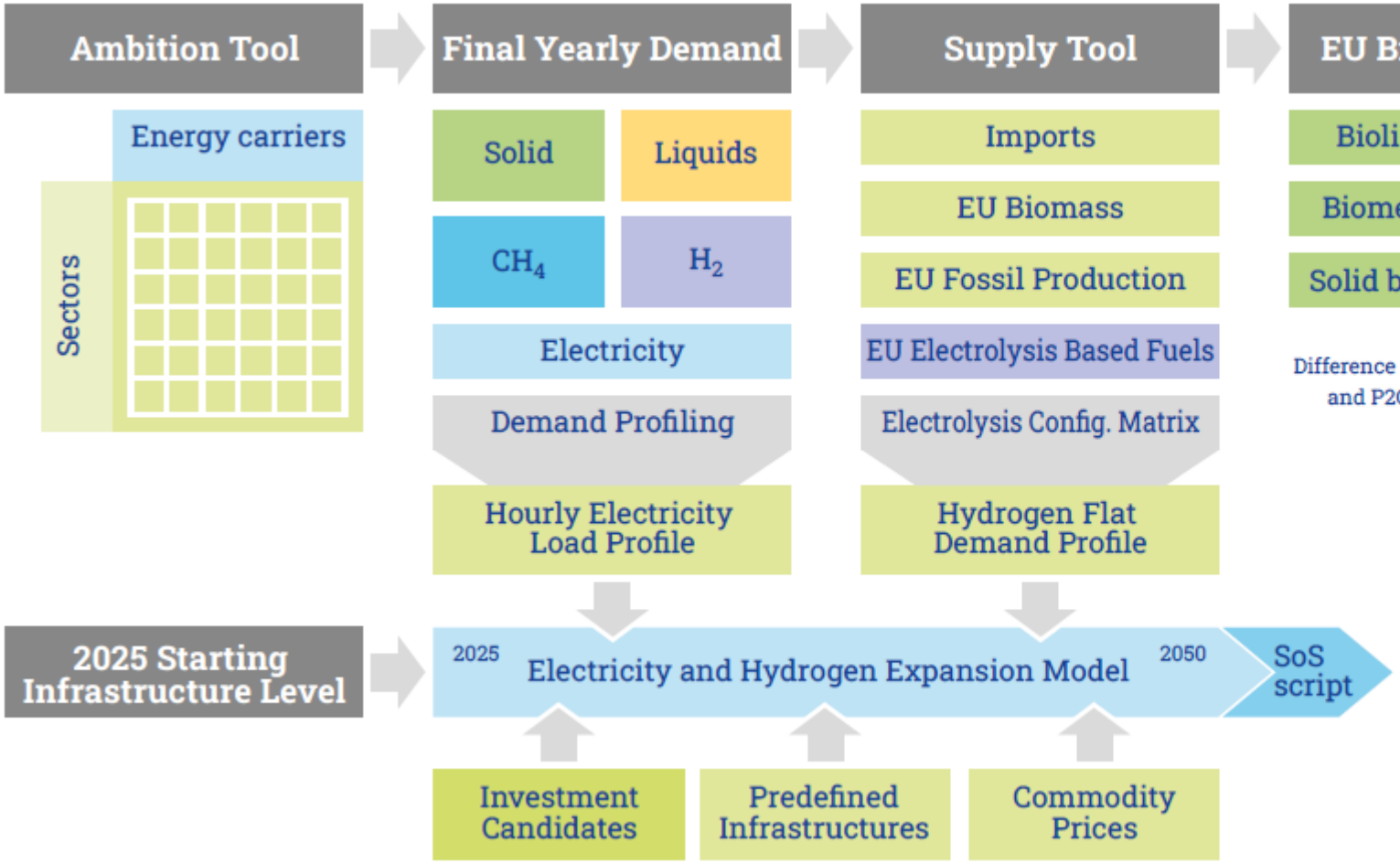


Higher European autonomy with renewable and decentralised focus

Aggregation of national policies and strategies as stated end of 2020

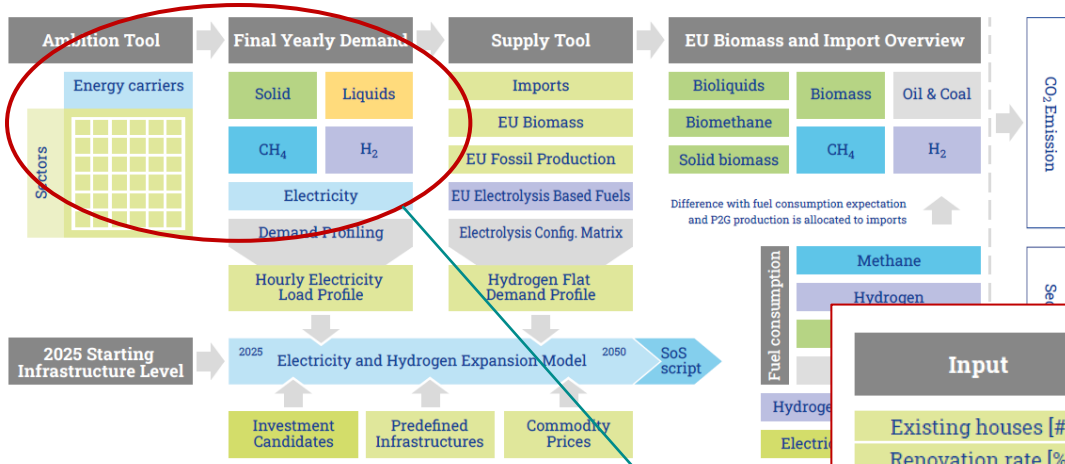
Global economy with centralised low carbon and RES options

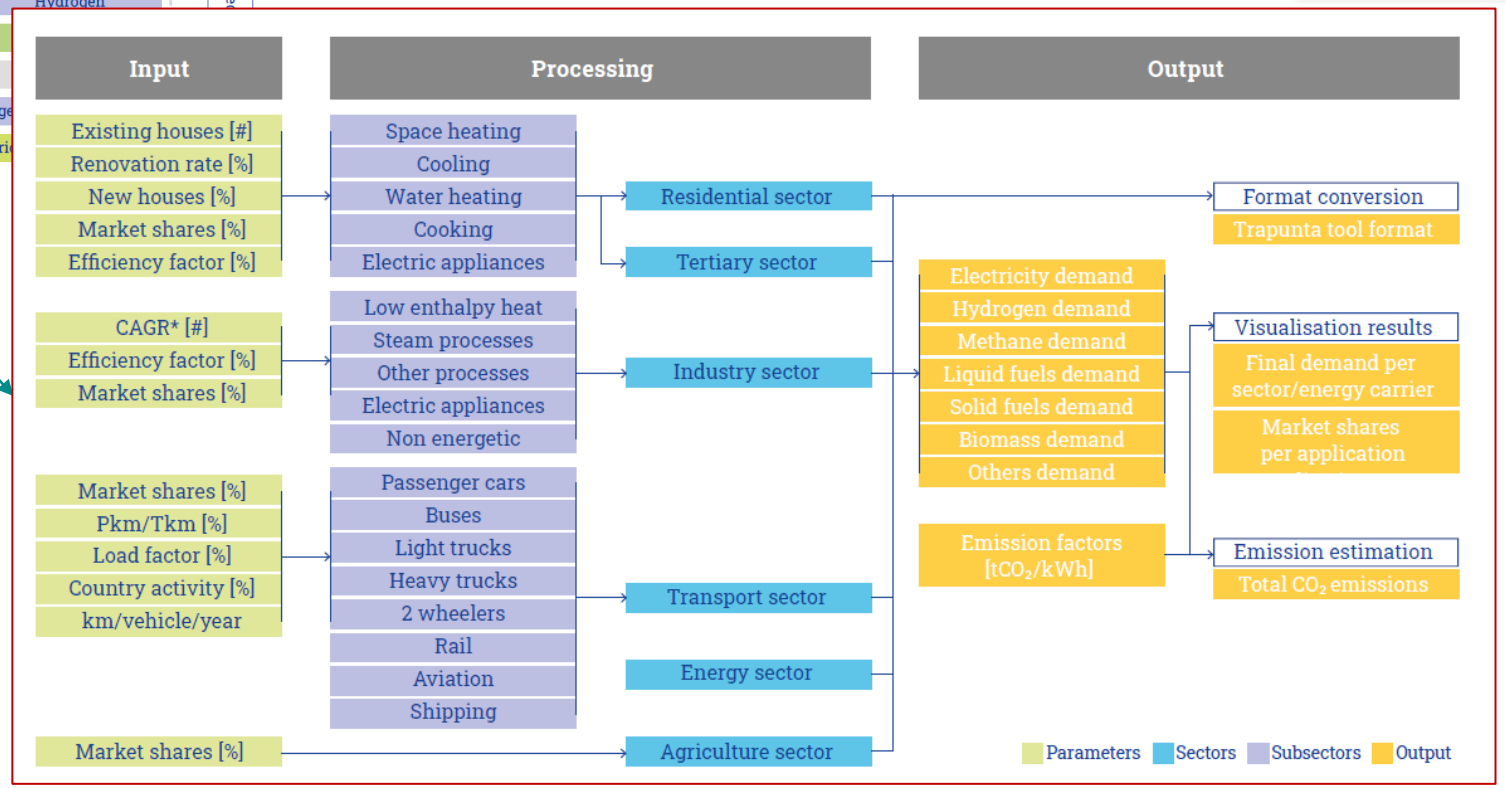
BUILDING BLOCKS FOR TOP-DOWN SCENARIOS



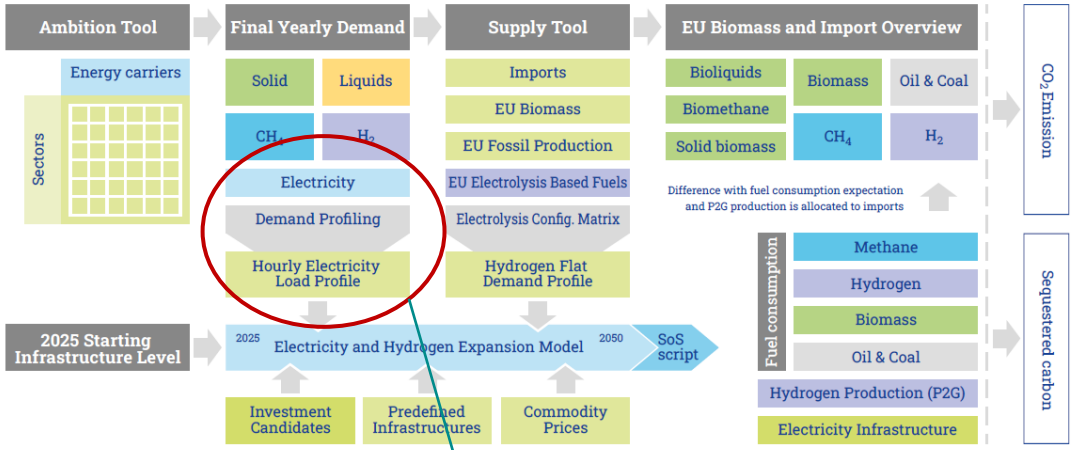
74 p

SCHEMATIC OVERVIEW AMBITION TOOL





ELECTRICITY DEMAND PROFILE BUILDING STEP



Step 1	Step 2	Step 3	Step 4	Step 5
Install TRAPUNTA	Download country folder structure & country trained TRAPUNTA models from WG D&M	Download and install: PECD data EV profiles Holiday profile	Use the latest Ambition Tool files Rename into convention PEMMDB-[xx]_{storylinename}	Run TRAPUNTA to create the output: Hourly demand profiles

MODELLING TOPOLOGY – PROSUMERS AND P2X

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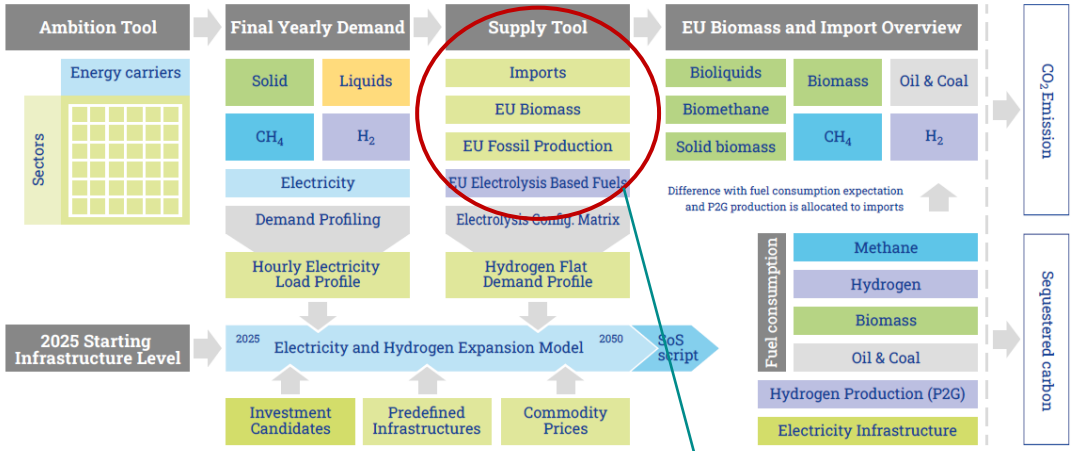
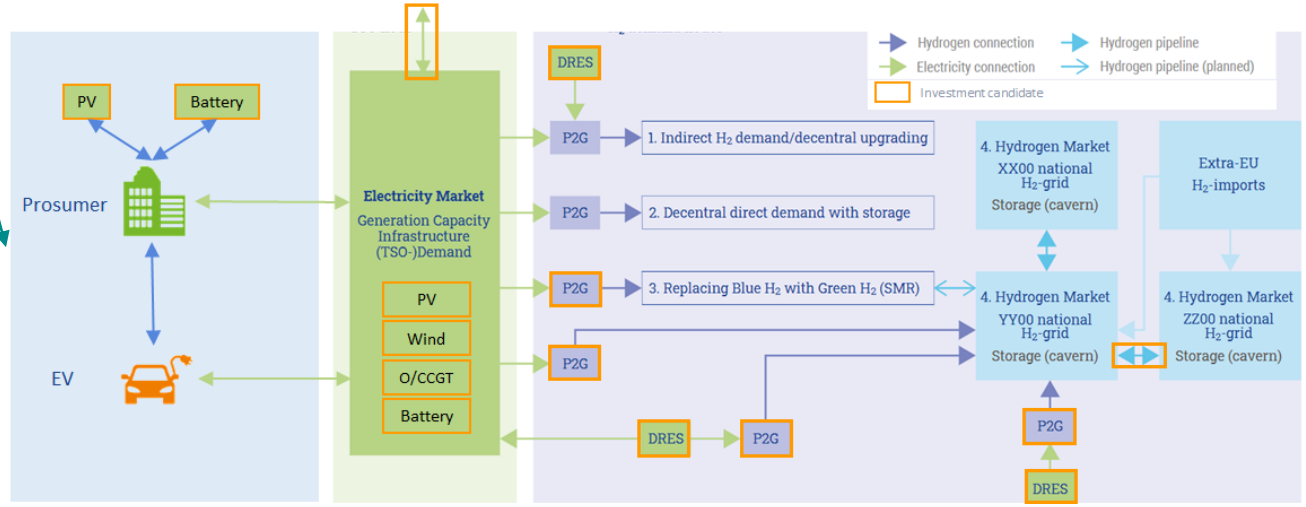
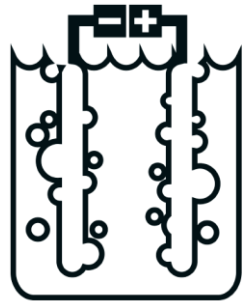
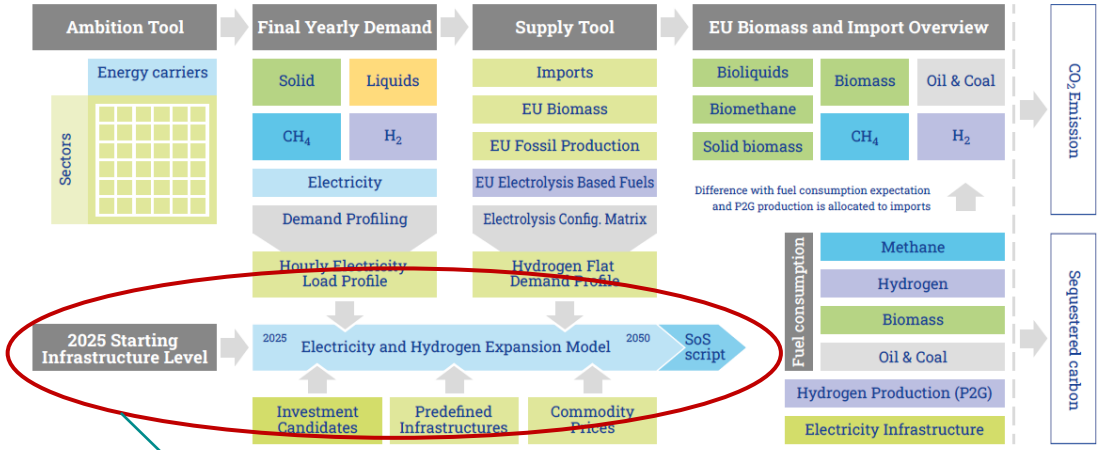






BUILDING THE SUPPLY OVERVIEW



- Application of el and h2 profiles from previous step
- **Aim**: define level and location of capacity (generation, flexibility, P2G) consistent with scenario storyline & cost assumptions.
  - investment model is given the degree of freedom to expand electricity and hydrogen interconnectors, it deems economically viable
- => gives an indication of how grid capacities in certain borders could develop in the scenarios under a European optimisation of the energy system based upon the assumptions used.
- (TYNDP IoSN is not part of the scenario building exercise, but separate step)

DISPATCH AND EXPANSION MODELLING

Dispatch:
Minimize variable cost objective function

$$\sum_{\text{System}}^{\text{X years}} \text{Variable OPEX} + \sum_{\text{System}}^{\text{X years}} \text{Fuel cost} + \sum_{\text{System}}^{\text{X years}} \text{CO}_2\text{ emissions cost} + \sum_{\text{System}}^{\text{X years}} \text{VOLL}$$

Expansion:
Minimize objective function along time horizon

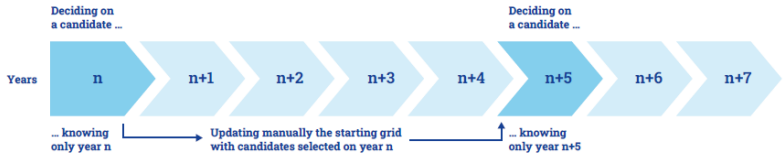
$$\sum_{\text{Candidate}}^{\text{X years}} \text{CAPEX} + \sum_{\text{Candidate}}^{\text{X years}} \text{Fixed OPEX} + \sum_{\text{System + Candidates}}^{\text{X years}} \text{Variable OPEX} + \sum_{\text{System + Candidates}}^{\text{X years}} \text{Fuel cost} + \sum_{\text{System + Candidates}}^{\text{X years}} \text{CO}_2\text{ emission cost} + \sum_{\text{System + Candidates}}^{\text{X years}} \text{VOLL}$$

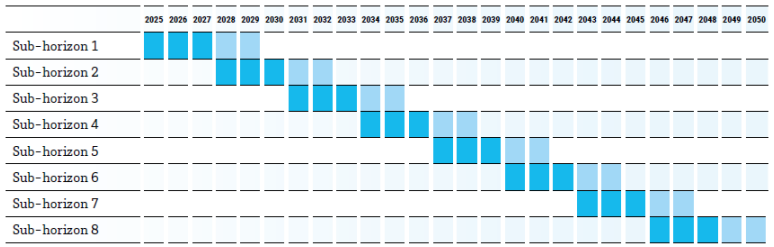
Run for several CYs,

- include starting grid situation, infrastructure candidates for investment or decommissioning, Demand along time horizon, set of economic parameters

Run with multi-temporal approach

- Improves visibility on the path to follow towards 2050
- 8 clusters à 5 years with 2 years overlap used
- Overlap provides visibility on evolution of key parameters: (carbon price, el-demand etc).





FINAL ENERGY DEMAND + ELECTRICITY DEMAND

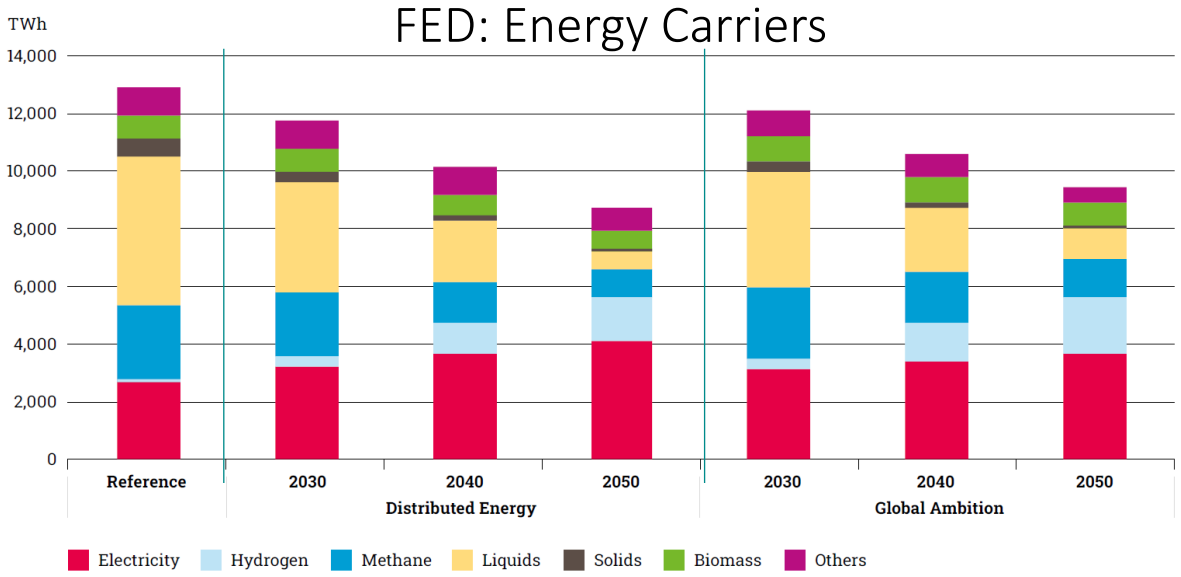


Figure 3: Final energy demand per carrier (energy and non-energy use for feedstock) for EU27

Energy efficiency: the EU can significantly reduce its energy demand by 2050

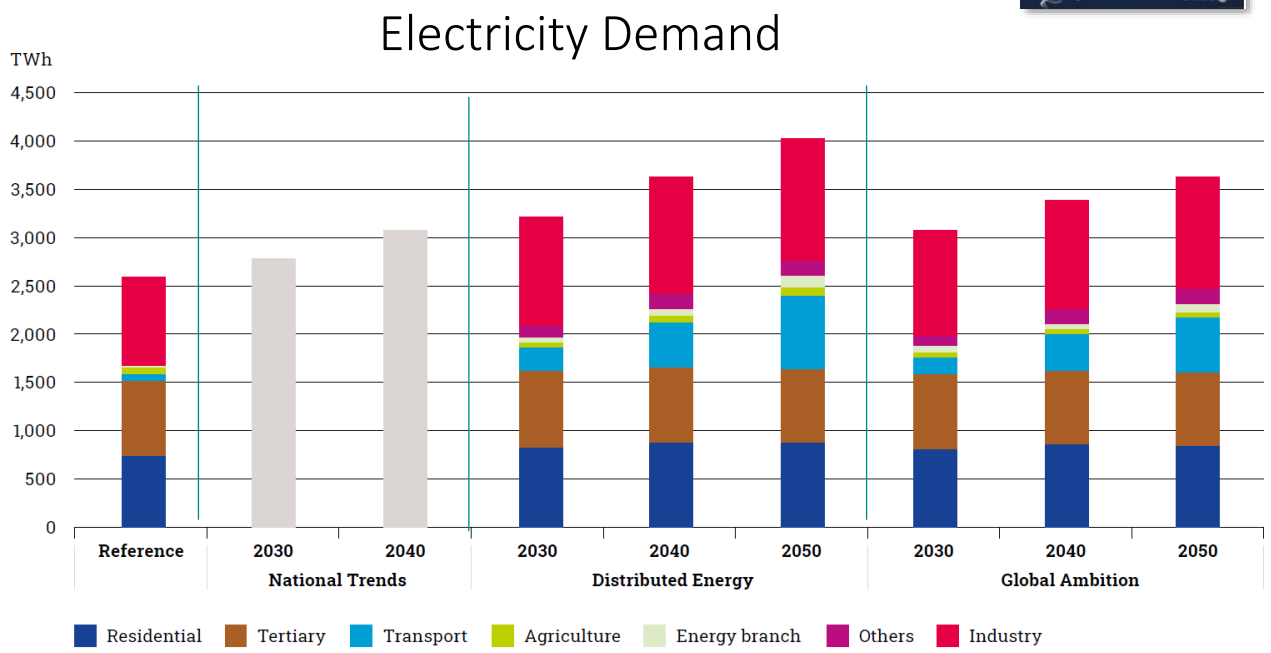


Figure 8: Final electricity consumption (excluding transmission and distribution losses) for EU27

HYDROGEN DEMAND / SECTOR AND ELECTROLYSER CAPACITY - EUROPE

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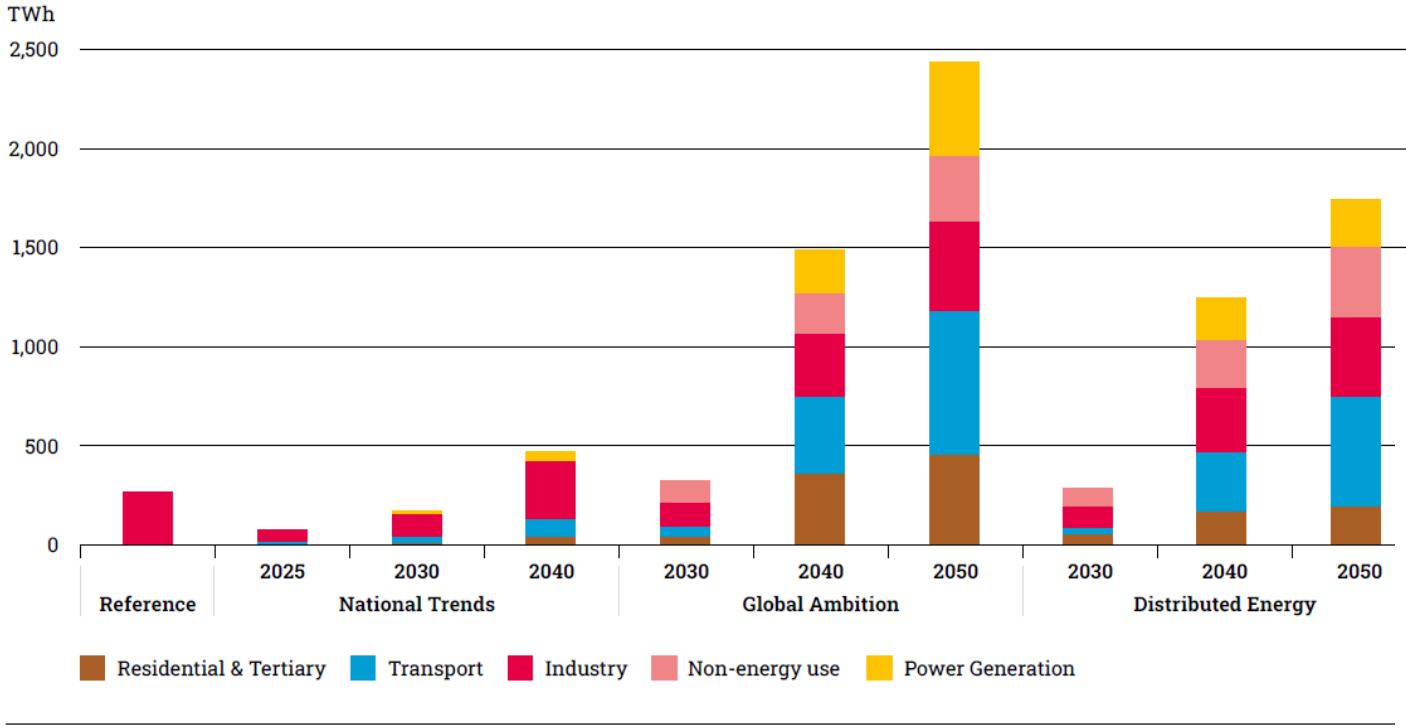

Figure 14: Hydrogen demand per sector for EU27 (excluding hydrogen from by-products and for conversion [P2M/P2L])

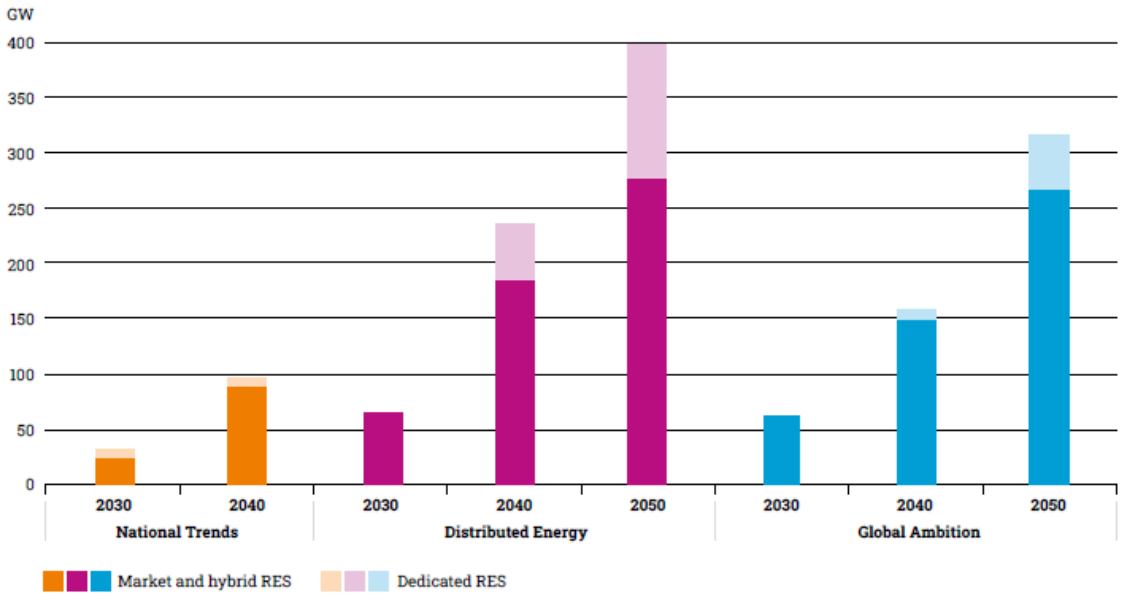

Figure 33: Electrolyser capacity for EU27 (The configurations are explained in the scenario methodology guidelines)

Energy production

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Ambitious development of renewables across Europe

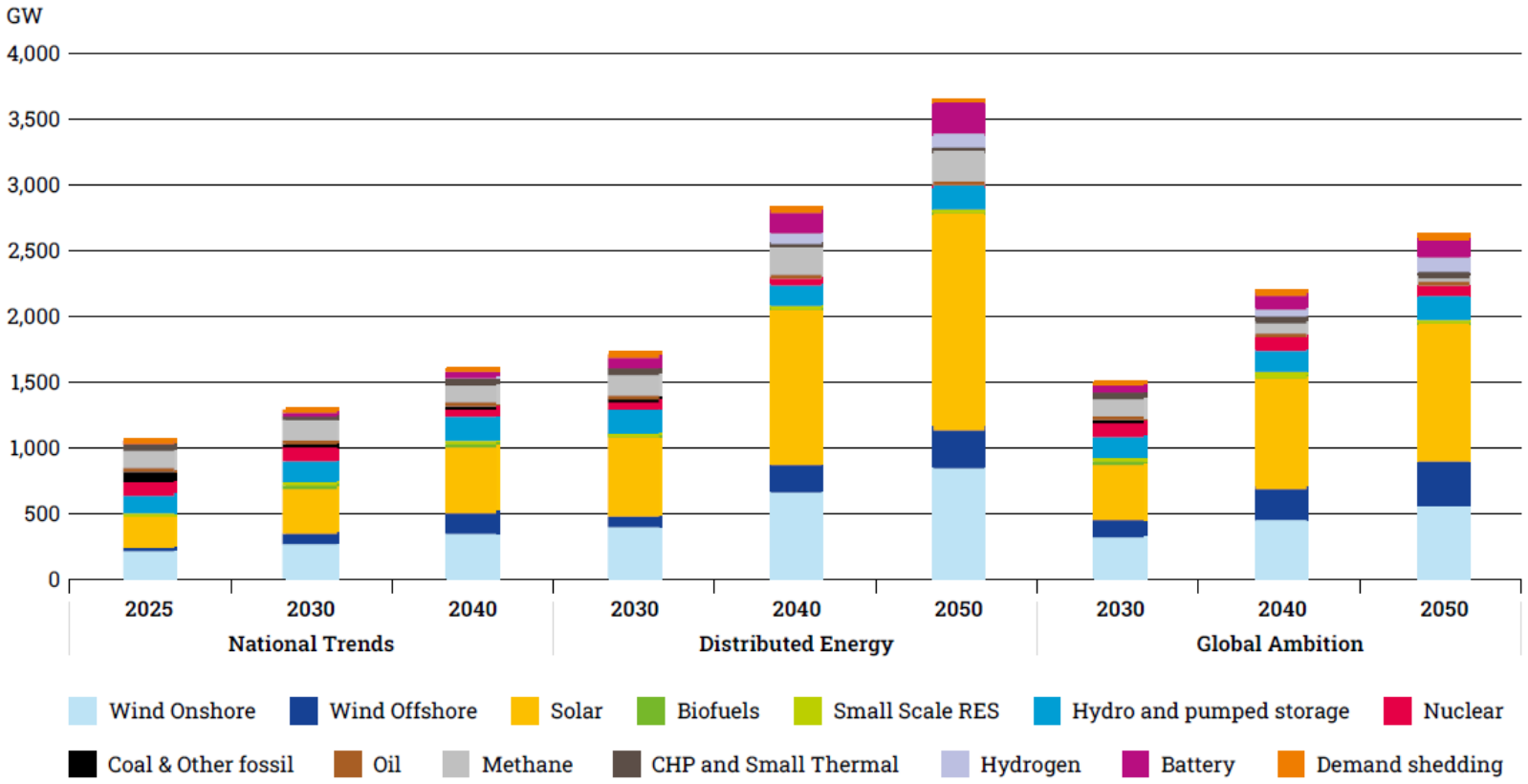

Figure 24: Capacity mix for EU27 (including prosumer PV, hybrid and dedicated RES for electrolysis)

THANK YOU!

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