The potential role of renewable fuels in the decarbonization of hard-to-abate transport sectors

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Research context

The **energy transition towards sustainable systems** is facing important **challenges**

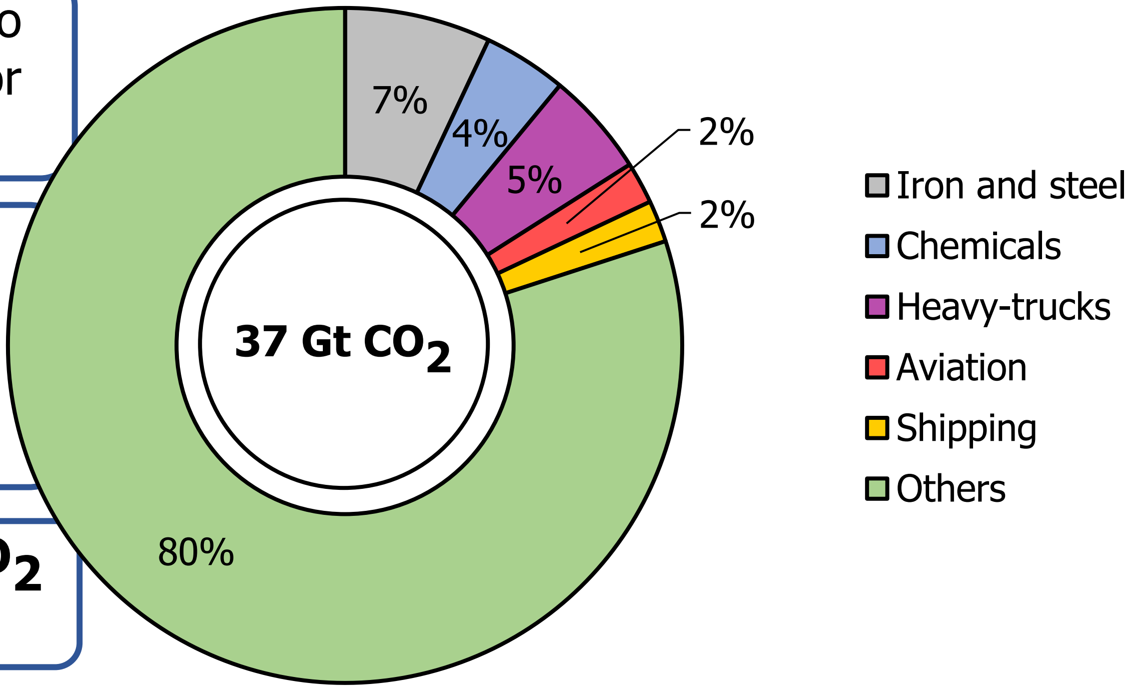
How could hard-to-abate sectors be efficiently decarbonized

IRENA: Decarbonising hard-to-abate sectors with renewables: Perspectives for the G7

1. **Hard-to-abate sectors:** their transition is not so straightforward, due to **lack of technologies** or **prohibiting cost**

2.
   - **Heavy industry:** cement, steel and chemical manufactures
   - **Heavy-duty transport:** heavy-truck, shipping and aviation

3. Accounting for roughly a **fifth of the total CO_2 emissions** (7.6 Gt)



Decarbonize hard-to-abate sectors through RENEWABLE FUELS

Aim of the activity

How renewable fuels may support the decarbonization of the hard-to-abate transport sectors

Adopting an **Energy System Optimization Model** (ESOM) to **Italian** energy system (TEMOA-Italy)

1

Green policies assumption:

- **Discourage** emission production
- **Reduce the competitivity** between traditional and renewable fuels

2

Focusing on the **decarbonization** of the **hard-to-abate transport sectors**

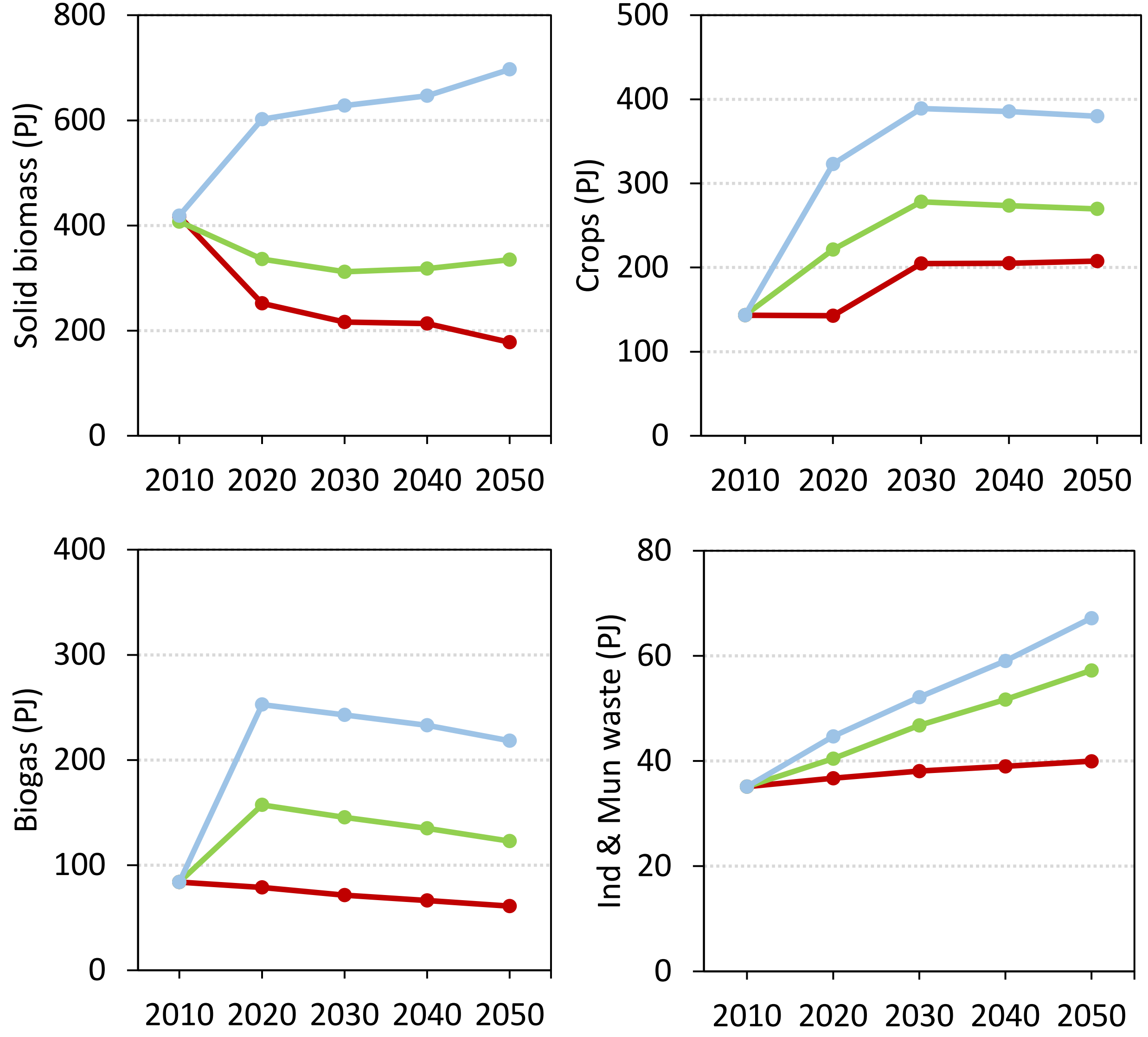
3

Compare the **green policy** outcomes and the **Net Zero Emission** target

Assumption: resource availability

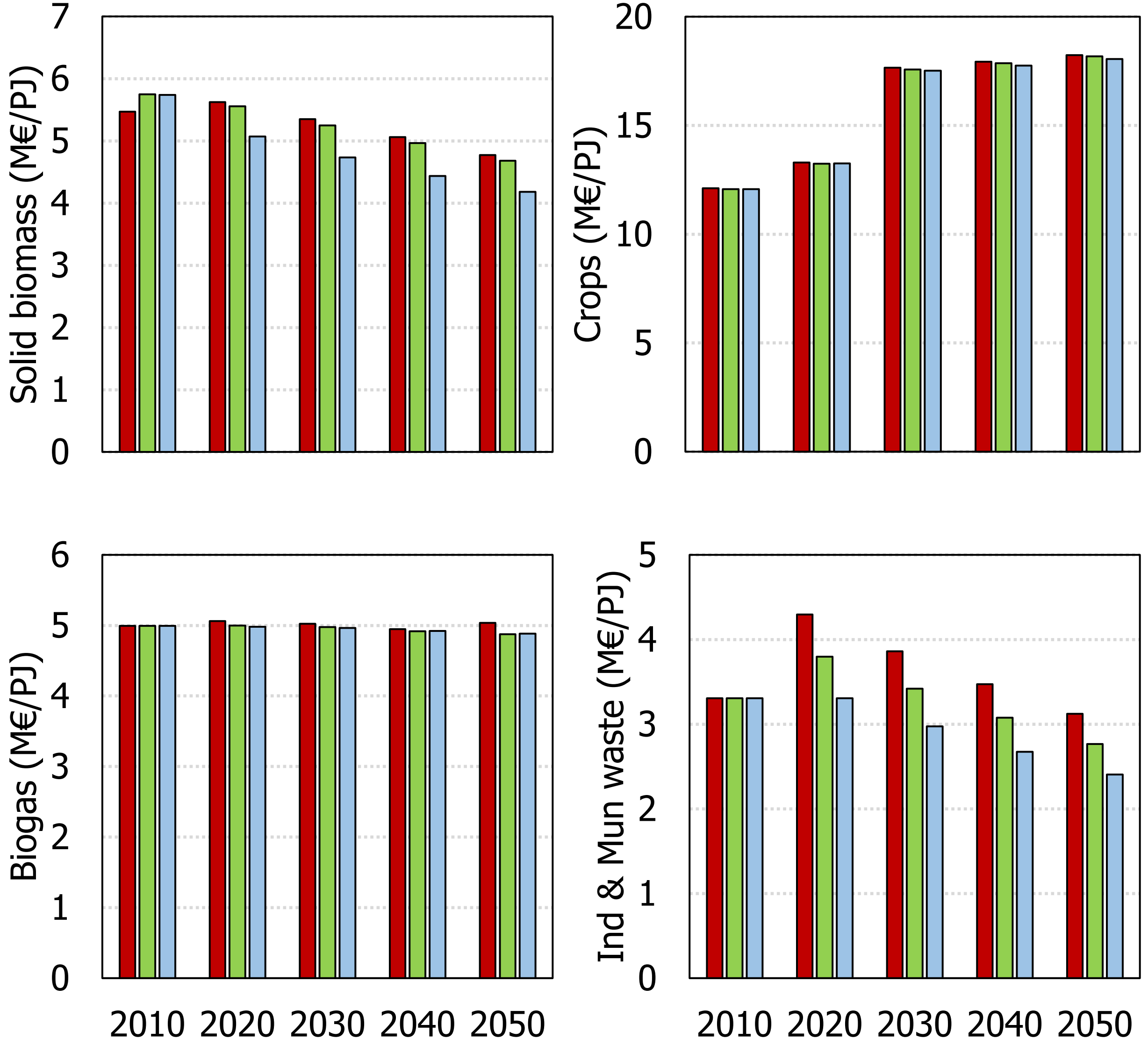
Bioenergy **gross potential**

low med high

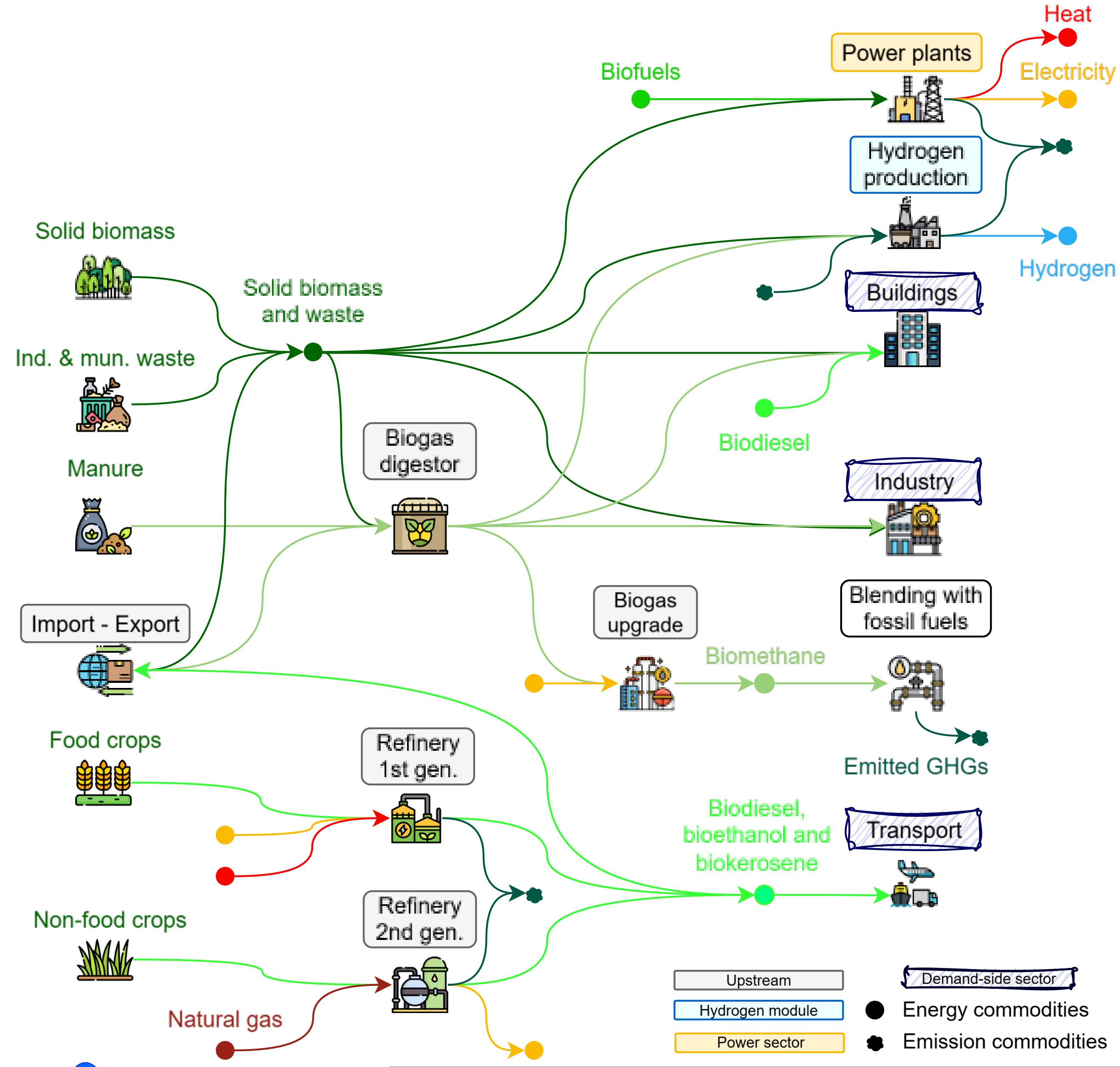


Average cost production

(**EU-JRC:** Bioenergy potentials for EU and neighboring countries)



Bioenergy supply chain in TEMOA-Italy



Techno-economic characterization of **biofuels production processes**

Process	Input commodity	Output commodity	Efficiency	INVCOST $\left(\frac{M€}{PJ}\right)$	Life (y)
Crushing^{+}	Rapeseed crops	Vegetable oil	0.54		50
Transesterification^{+}	Vegetable oil	Biodiesel	0.94	1.5 – 1.3	20
Fermentation^{+}	Starchy crops	Bioethanol	0.34	22.6 – 15.7	20
	Sugar crops		0.11	8.2 – 5.7	20
Chemical^{+}	Ethanol	ETBE	0.92		20
Hydrotreatment^{+}	Vegetable oil	HVO	0.81	19.0 – 14.3	20
Thermochemical and biochemical^{++}	Grassy crops	Biodiesel	0.63	112.6 – 84.4	20
		Biokerosene			
		Bioethanol	0.37	87.2 – 65.4	20

$^{+}$ **1st generation refinery**

$^{++}$ **2nd generation refinery**

Assumptions: Hurdle Rate and Emission Trading System (ETS)

Hurdle Rate

Minimum rate of return required on a project or investment

(Higher risk, higher hurdle rate)

Technology producing renewable fuels:
- ❖ Ammonia
- ❖ Biofuels (e.g. biodiesel)
- ❖ Hydrogen
- ❖ Synthetic fuels (e.g. synthetic methanol)

Hurdle Rate ranging between **8% and 15%**

Hurdle Rate reduction

20% of the original value (**2H**)	**40%** of the original value (**4H**)

Emission Trading System

European Emission Trading System (ETS)

EU Emissions Trading System (EU ETS) - European Commission

Pay for the greenhouse gasses emission

Current CO2 price in Europe 65 €/tCO2e
Sectors: industrial, power and fossil fuel extraction

(Ref: Price | Carbon Pricing Dashboard)

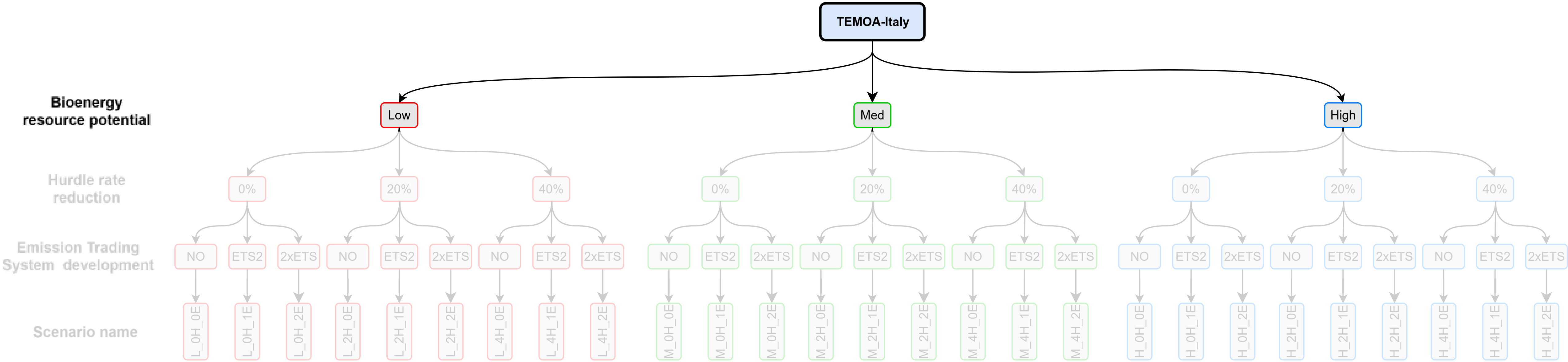
ETS assumption: 80 €/tCO2e (2030), 150 €/tCO2e (2050) (from EU Reference Scenario 2020 - European Commission)

ETS expansion

ETS2 from EU Commission (extend to road vehicles and buildings) (**1E**)	**Double the ETS** (assumption, sectors covered in both ETS and ETS2) (**2E**)

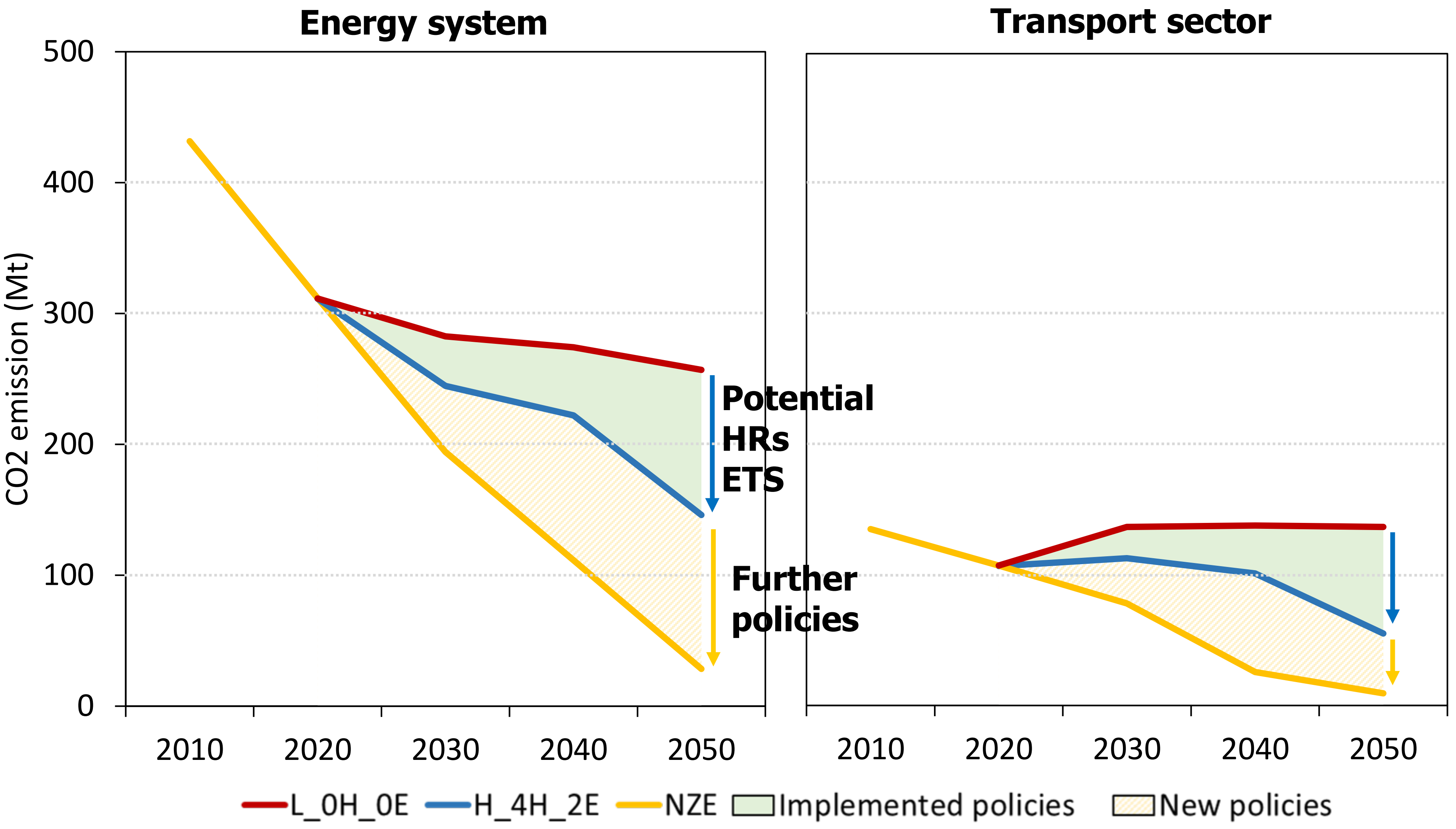
Scenario tree and Net Zero Emission

Scenario Tree: considering **3 resource potential** scenarios (**low**, **med** and **high**), **3 hurdle rate** reduction scenarios (**0%, 20%** and **40%**) and **3 ETS development** scenarios (**Current, ETS2** and **2xETS**)



Net Zero Emission (NZE): investigate the **decarbonization of the energy system** in accordance with **FitFor55** European plane and the **Italian long-term strategy** of greenhouse gases emissions reduction
(28 Mt of residual CO2 emission in 2050)
Considering 3 potential scenarios: **low**, **med** and **high**

Results: Total CO2 emissions



NZE CO2 target in 2050: **28 Mt**

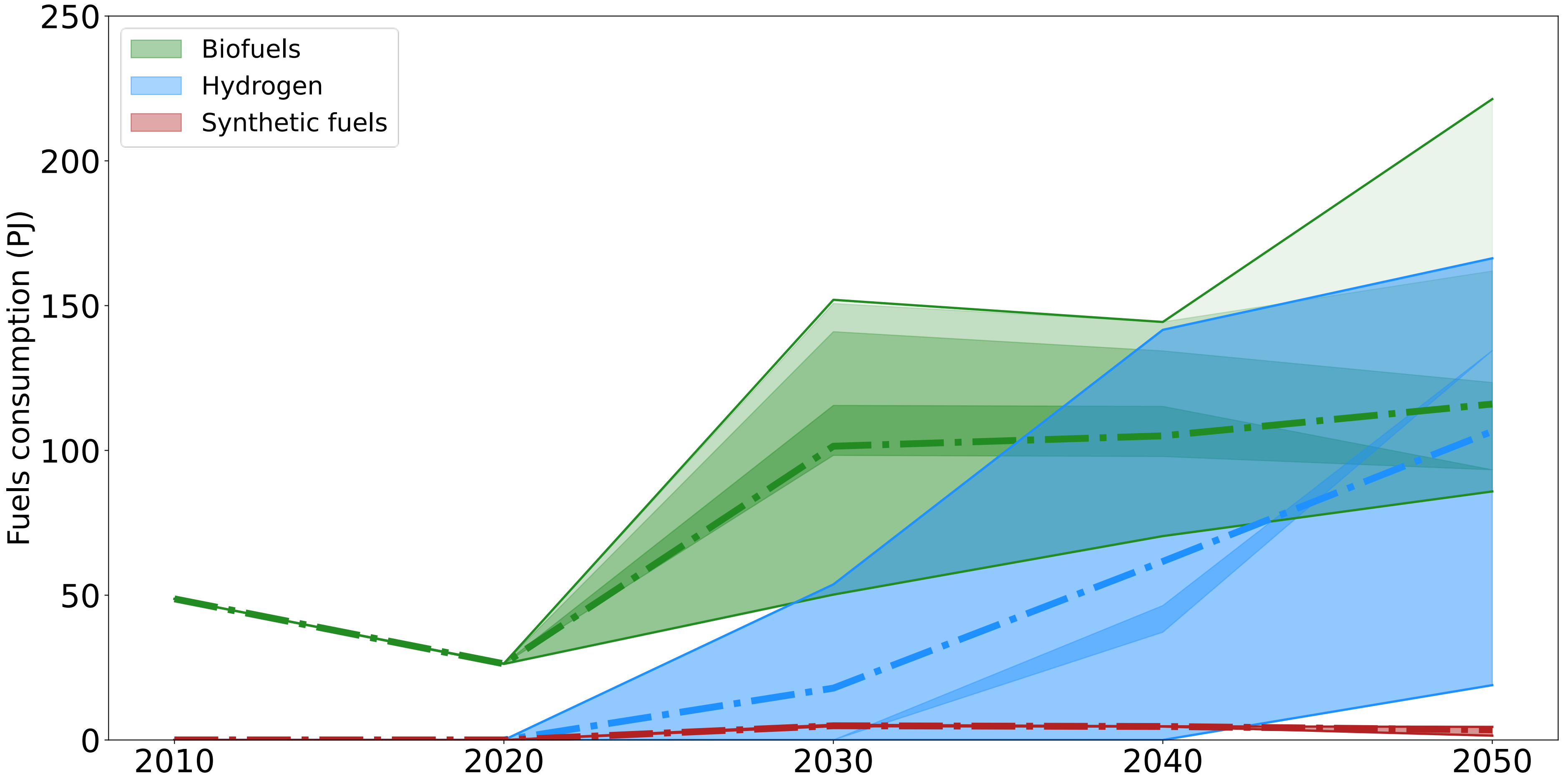
Considering **high** potential, **40%** hurdle rate reduction and **doubling** the **ETS** (**H_4H_2E**): **146 Mt** in 2050

Considering **low** potential, **0%** hurdle rate reduction and **current ETS** (**L_0H_0E**): **257 Mt** in 2050

To achieve the NZE decarbonization target is necessary to introduce further policies

Results: Transport sector fuels consumption

Scenario tree fuel consumption



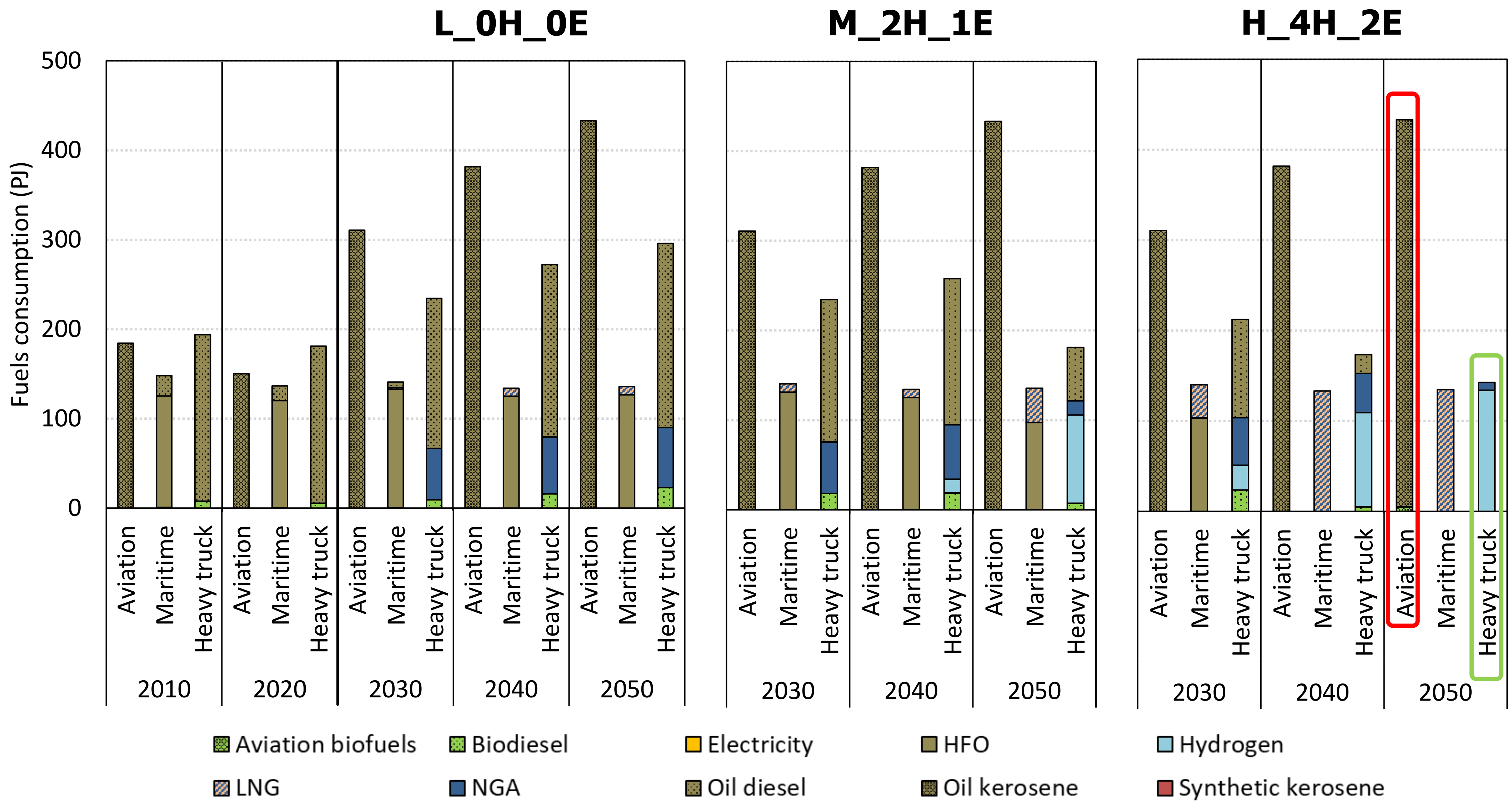
Alternative fuels consumption

Dashed lines: average consumption

- **Biofuels consumption:** average consumption 116 PJ (in 2050), max consumption 221 PJ (in 2050), **all biodiesel**
- **Hydrogen consumption:** average consumption 107 PJ (in 2050), max consumption 166 PJ (in 2050), **all from natural gas and biomass steam reforming**
- **Synfuels consumption:** average consumption 4 PJ (in 2050)

Results: Aviation, maritime and heavy truck fuels consumption

Scenario tree fuel consumption



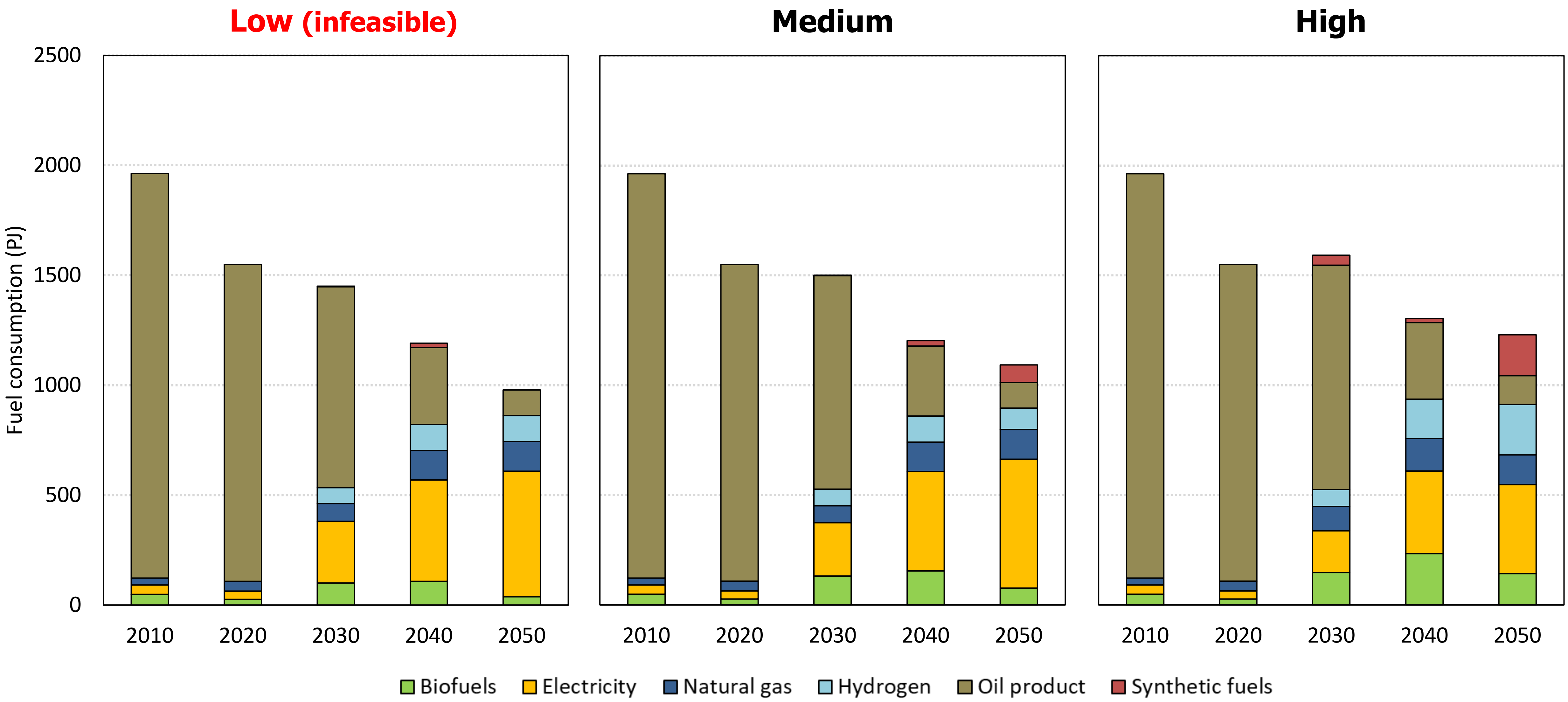
When **NO green policies** are implemented, **fossil fuels** are the **main alternative.**

By applying green policies, **progressive fossil fuels reduction.**

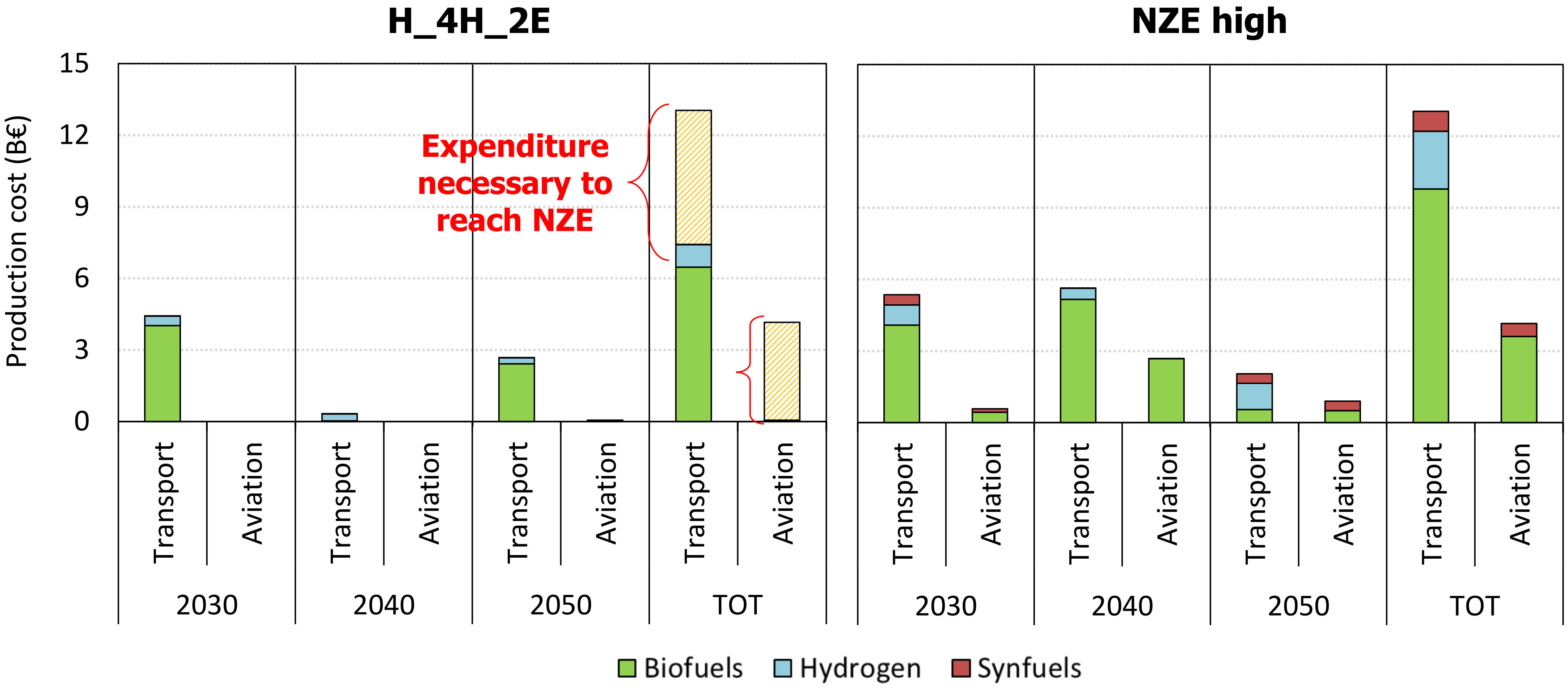
The maximum result achieved: hydrogen development in heavy **trucks,** while **aviation** still relying on **fossil fuels**

Results: Transport sector fuels consumption

NZE fuel consumption

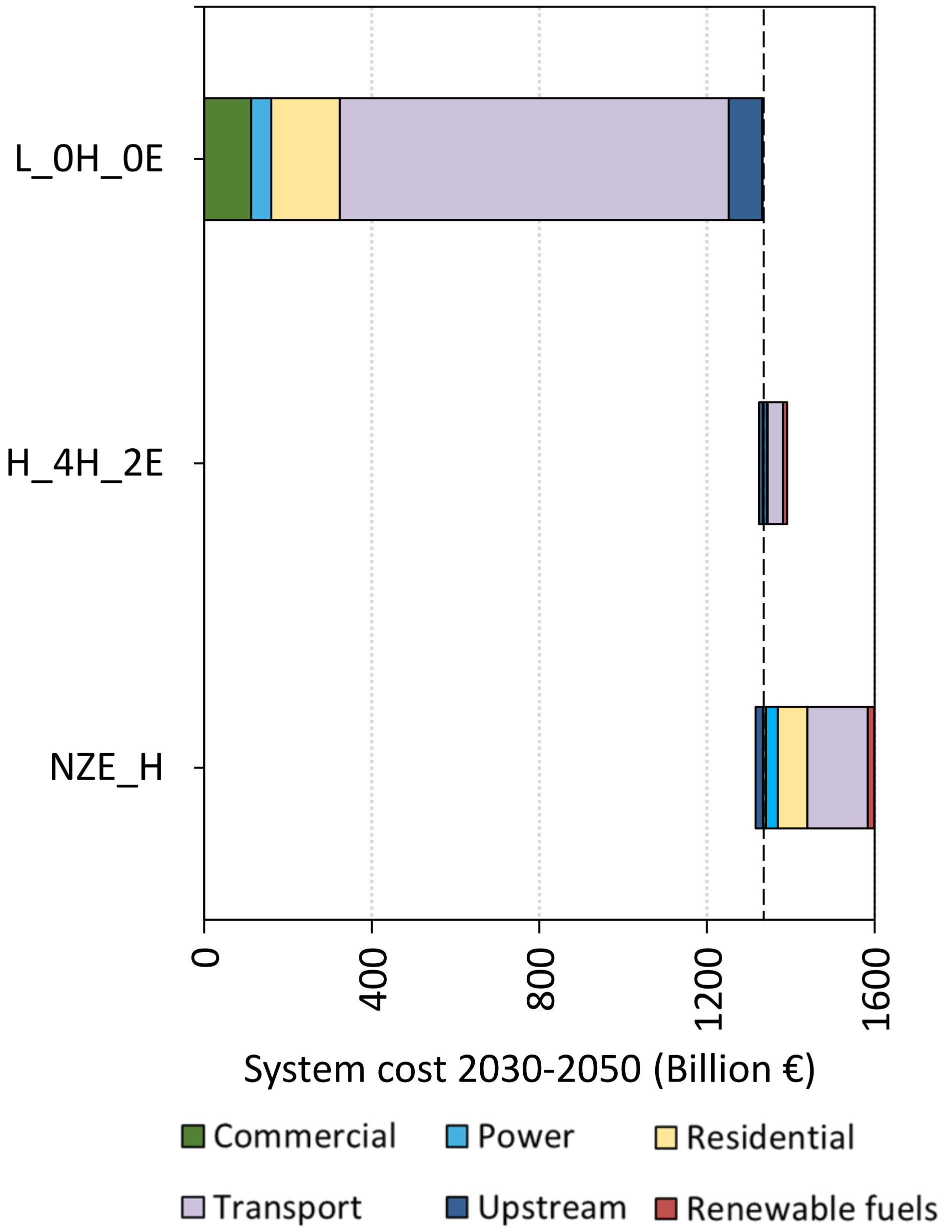


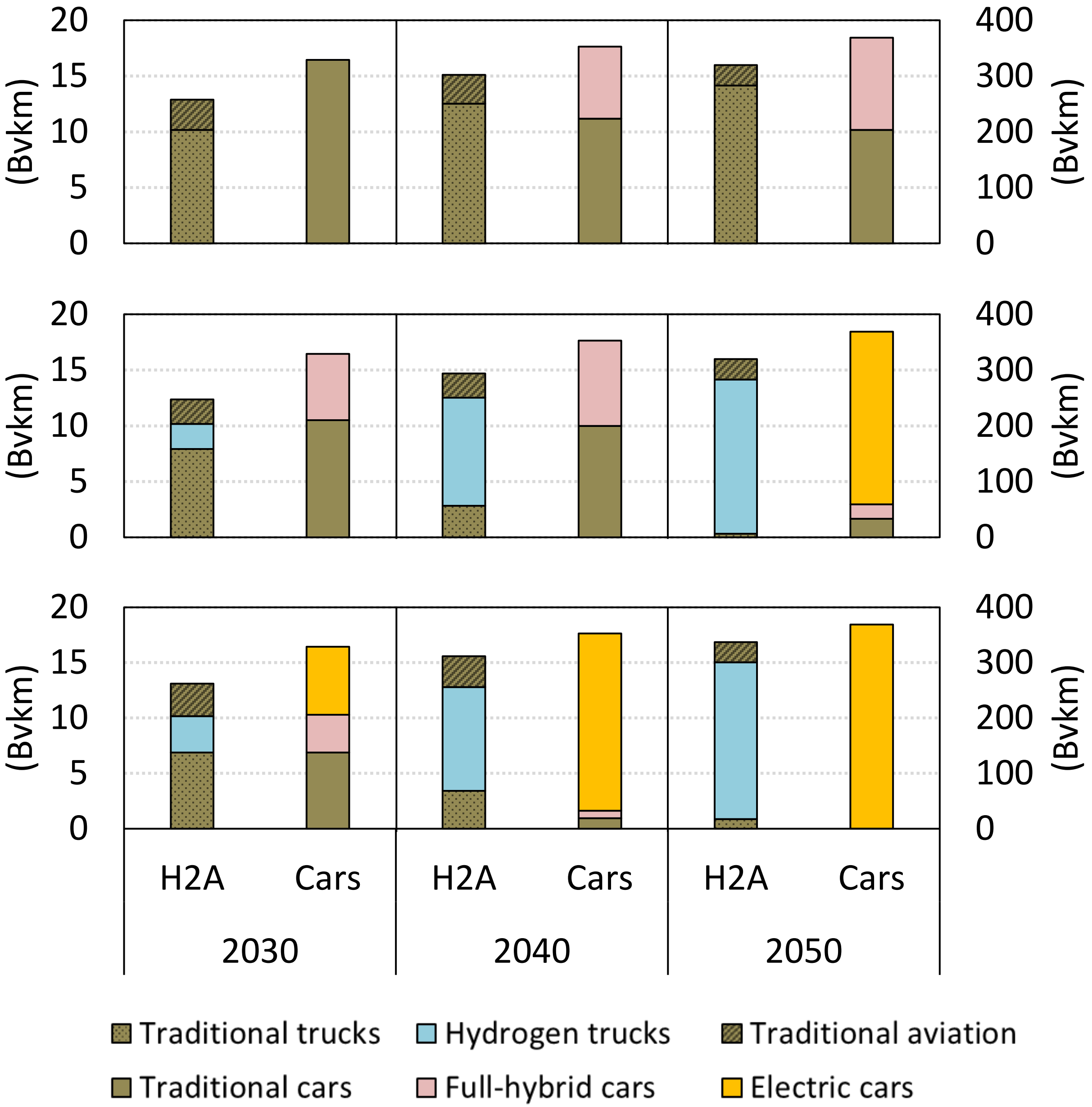
Results: renewable fuels production cost



To achieve the same level of **renewable fuels consumption** observed **in the NZE** scenario it is necessary to **increase the production capacity**, with an **expenditure** of almost **6 billion €** (3 billion € for aviation) in the future years.

Results: Total energy system costs and transport technology mix





Relying on **fossil fuels**

Slow transition toward electric vehicles

To be achieved require higher **investments** and **policies**

Thank you
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