Navigating the Roadmap for Clean, Secure and Efficient Energy Innovation

SET-Nav
Strategic Energy Roadmap

Decarbonizing Industry:

Extending the scope of mitigation options

Dr. Andrea Herbst, Dr. Tobias Fleiter, Matthias Rehfeldt

SET-Nav Regional Workshop Budapest, 26 February 2019

Fraunhofer ISI

OUTLINE

SET-Nav
Strategic Energy Roadmap

I. **Introduction**

II. Methodology

III. Pathways

IV. Results

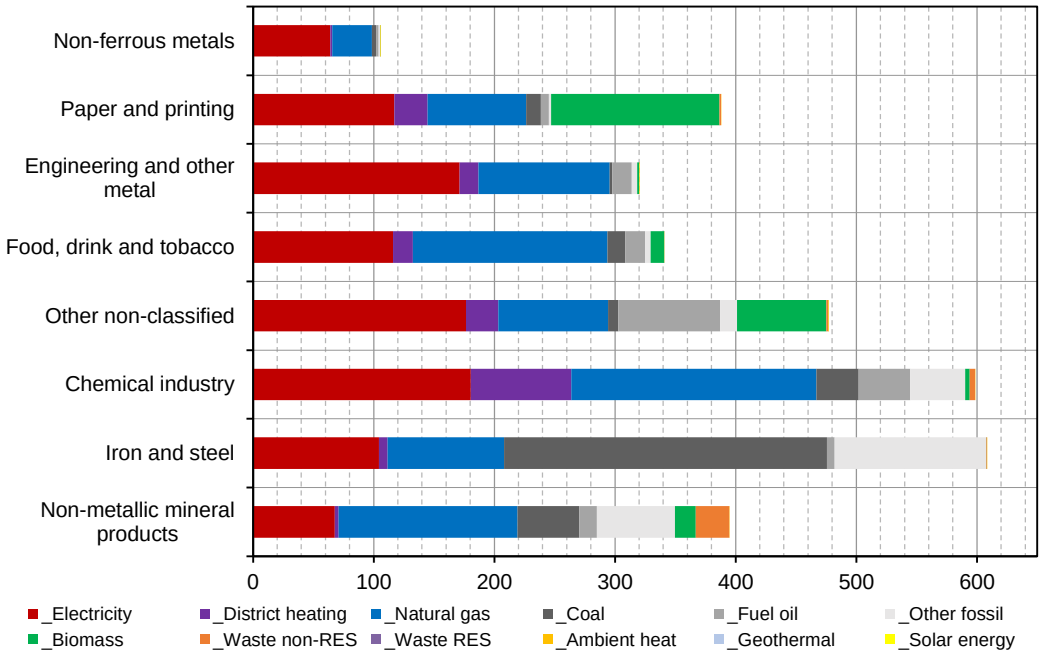
V. Conclusions

Fraunhofer ISI

Industry accounts for 25% of EU final energy consumption

- Dominant energy carriers: **gas, electricity, coal and oil**
- Current **policy** is **not on the right track to decarbonisation** and deep emission reductions require significant changes in the sector

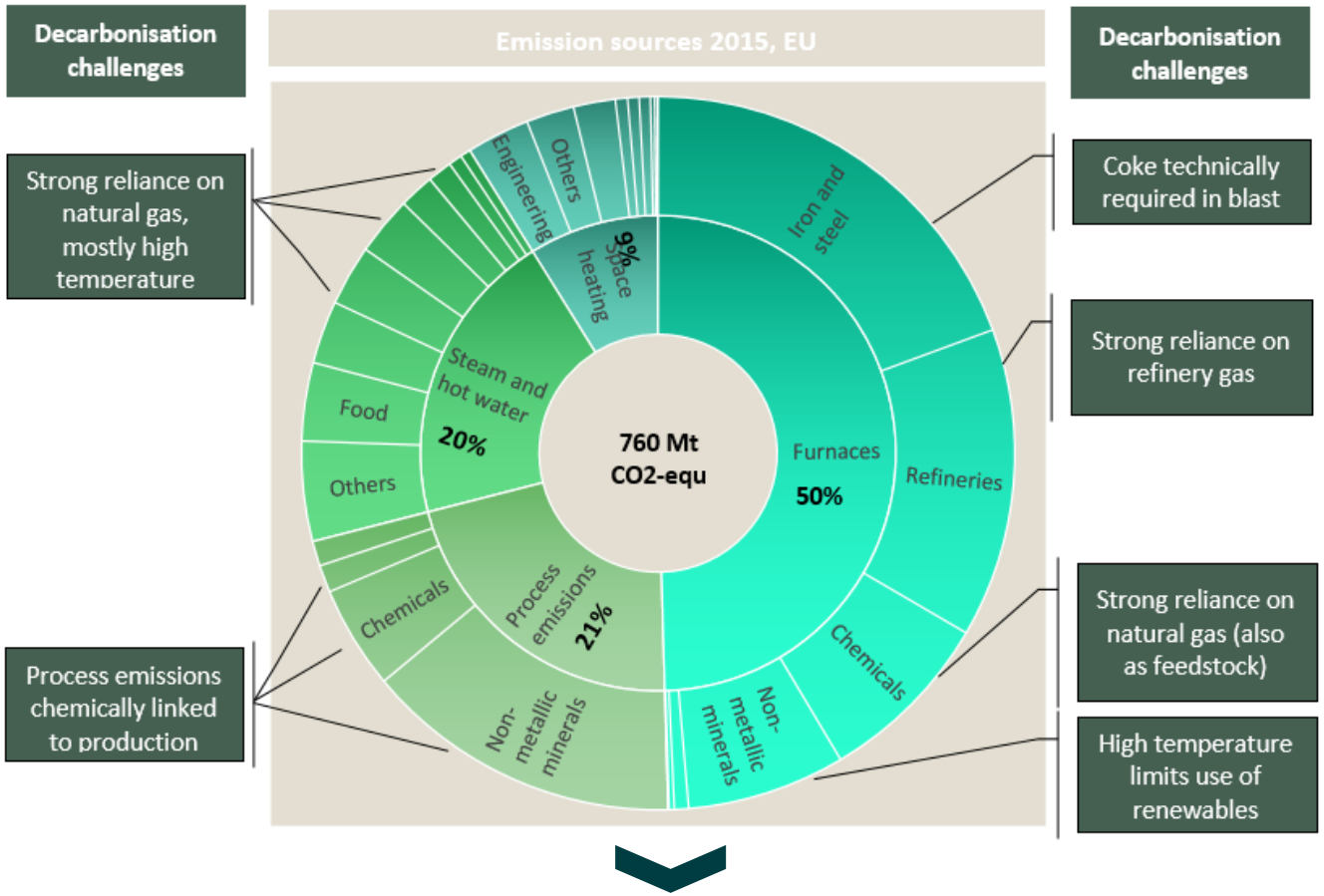
EU28 industrial final energy demand (2015)



Source: FORECAST

TODAYS AVAILABLE TECHNOLOGIES ARE NOT SUFFICIENT FOR DECARBONISATION

SET-Nav
Strategic Energy Roadmap



- Deep decarbonisation not possible via BAT energy efficiency and traditional fuel switch
- Innovative low-carbon technologies are needed

Fraunhofer ISI

OUTLINE

SET-Nav
Strategic Energy Roadmap

I. Introduction

II. Methodology

III. Pathways

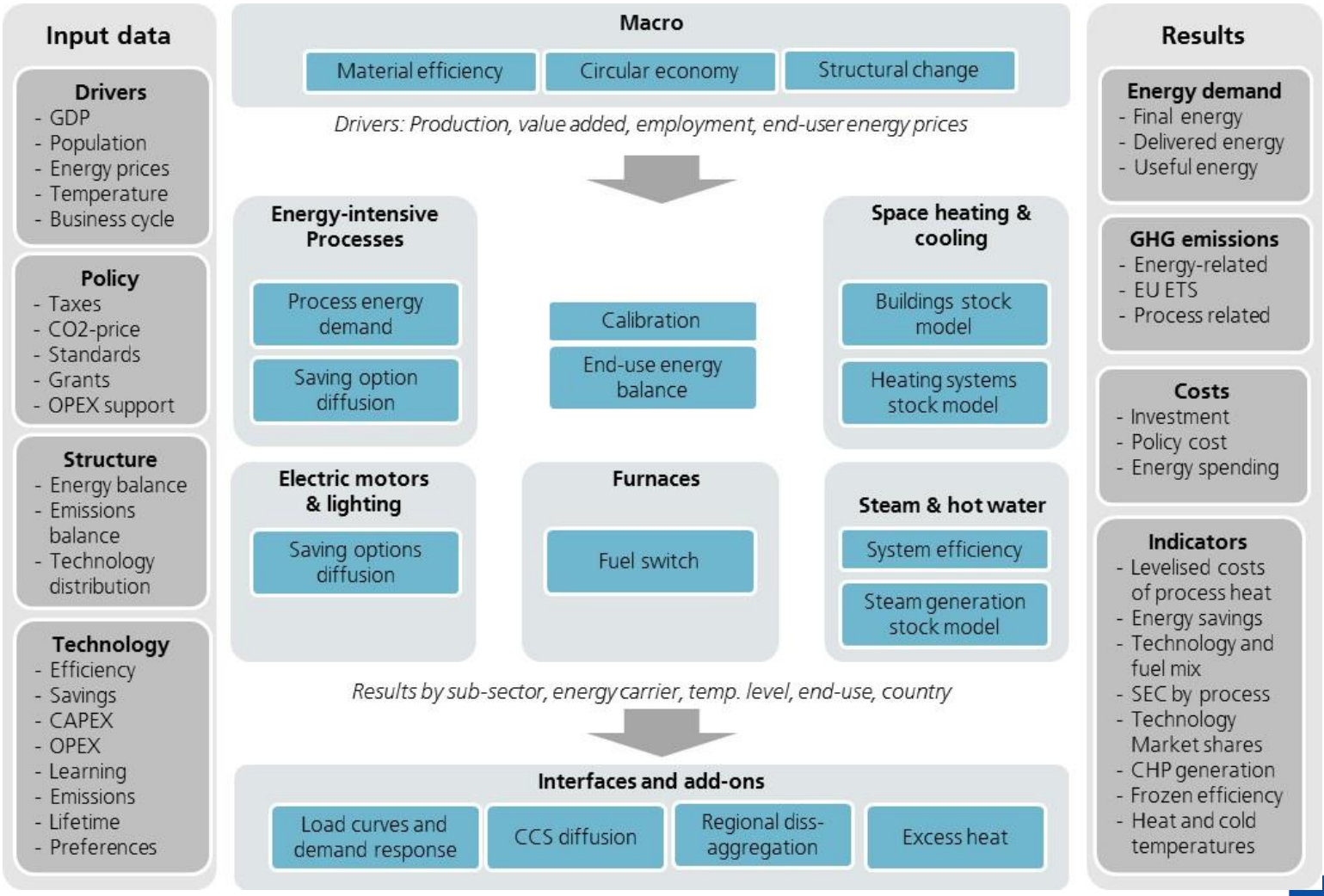
IV. Results

V. Conclusions

Fraunhofer ISI

FORECAST:
BOTTOM-UP SIMULATION MODEL

FORECAST
FORecasting Energy Consumption Analysis and Simulation Tool



Fraunhofer ISI

OUTLINE

SET-Nav
Strategic Energy Roadmap

I. Introduction

II. Methodology

III. Pathways

IV. Results

V. Conclusions

Fraunhofer ISI

Pathway characterization by mitigation option

Clusters of mitigation options	REF	Directed Vision/ National Champions	Diversification/ Localisation
Incremental efficiency improvement	Energy efficiency progress according to current policy framework and historical trends.	Faster diffusion **of incremental process improvements** (BAT & INNOV ≥TRL 5).	Faster diffusion of **incremental process improvements** (BAT & INNOV ≥TRL 5).
Fundamental processes improvement **energy efficiency, process emissions**	-	-	**Radical process improvements** (INNOV ≥TRL 5)
Fuel switching to RES towards decarbonized electricity and/or hydrogen	Fuel switching driven by energy prices and assumed CO_2-price increase	Fuel switching to **biomass** and **power-to-heat** (<500°). Use of existing technologies (no radical changes in industrial processes technologies). More district heating demand.	Stronger fuel switching to **biomass, power-to-heat and power-to-gas** technologies. **Radical changes** in industrial process technologies drive fuel switch (e.g. switch to **hydrogen**). Lower demand for district heating.
Carbon capture and storage (CCS)	-	**CCS** for major energy-intensive point sources.	-
Recycling and re-use	Slow increase in recycling rates based on historical trends.	Stronger switch to **secondary production.**	Stronger switch **to secondary production.**
Material efficiency and substitution	Based on historic trends.	Less efforts in material efficiency & substitution	Decrease in **clinker factor**. Increase in **material efficiency & substitution**.

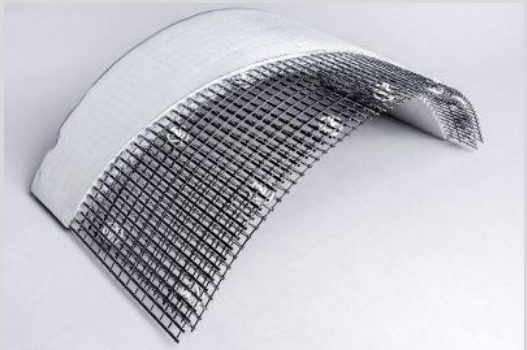
Break-through innovations with different levels of maturity are under development

Source: Towards the EU ETS Innovation fund workshops (online available), Dechema 2017

Break-through innovations with different levels of maturity are under development

Solidia concrete
recarbonating cement for precast concrete

Carbon concrete (C3)
Carbon nanofibres reinforced concrete replacing steel concrete



Source: http://www.graspapier.de/

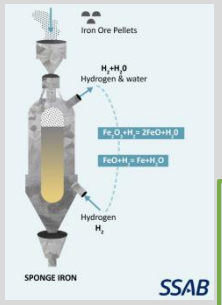
Source: Towards the EU ETS Innovation fund workshops (online available), Dechema 2017

Break-through innovations with different levels of maturity are under development

SET-Nav Strategic Energy Roadmap

Siderwinn (ArcelorMittal)
Fully electric steelmaking via electrolysis

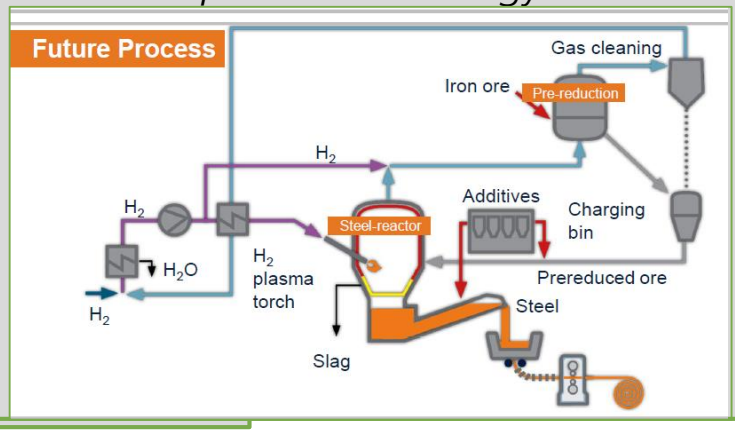
Hybrit (SSAB)
H2 direct reduction of iron ore with EAF



https://www.greencarcongres
04/ssab.html

Source: http://www.g

SuSteel (VoestAlpine)
H2 based reduction of iron ore using plasma technology



Source: Towards the EU ETS Innovation fund workshops (online available), Dechema 2017

Fraunhofer ISI

Break-through innovations with different levels of maturity are under development

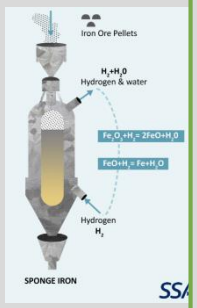
SET-Nav Strategic Energy Roadmap

Siderwinn (ArcelorMittal)

Fully electric steelmaking via electrolysis

Hybrit (SSAB)

H2 direct reduction of iron ore with E



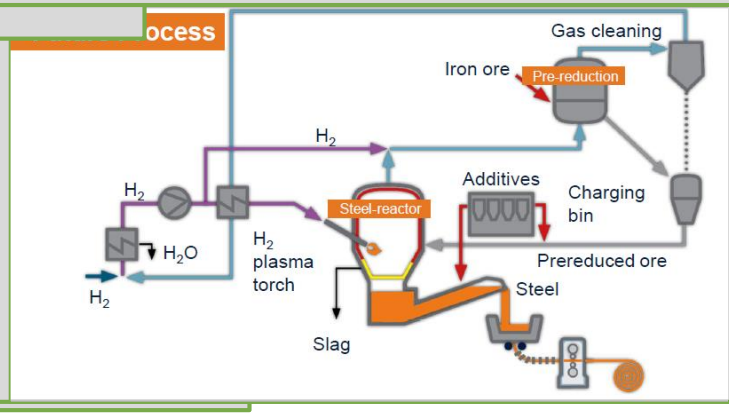
https://www.greencarcongress.com/2018/04/ssab.html

Source: http://www.g

Grass paper (Creapaper)

Grass based fibres replacing wood fibres

Source: http://www.graspapier.de/



Source: Towards the EU ETS Innovation fund workshops (online available), Dechema 2017

Fraunhofer ISI

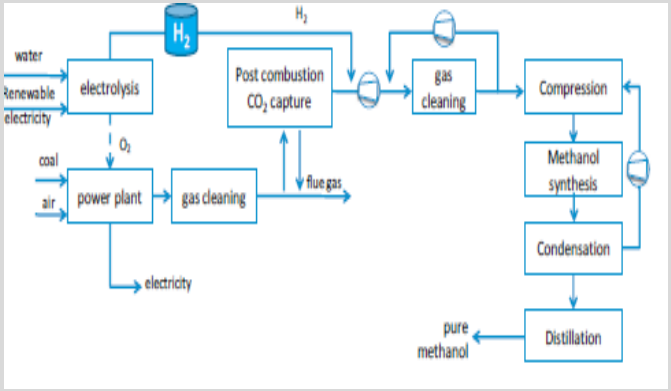
Break-through innovations with different levels of maturity are under development

SET-Nav Strategic Energy Roadmap

Siderwinn (ArcelorMittal)
Fully electric steelmaking via electrolysis

Hybrit (SSAB)
H2 direct reduction of iron ore with E

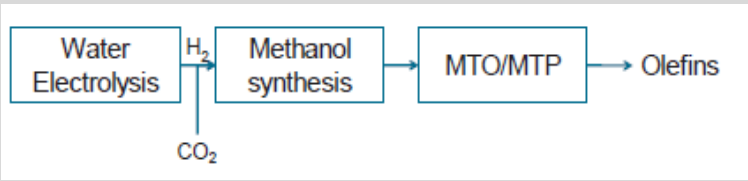
H2 Methanol
RES H2 from water electrolysis plus hydrogenation of CO2 as carbon source



Grass paper (Creapaper)
Grass based fibres replacing wood fibres

Source: http://www.graspapier.de/

H2 Methanol to Olefins
Ethylene and propylene production from RES H2 methanol



Source: http://www.

Source: Towards the EU ETS Innovation fund workshops (online available), Dechema 2017

Fraunhofer ISI

OUTLINE

SET-Nav
Strategic Energy Roadmap

I. Introduction

II. Methodology

III. Pathways

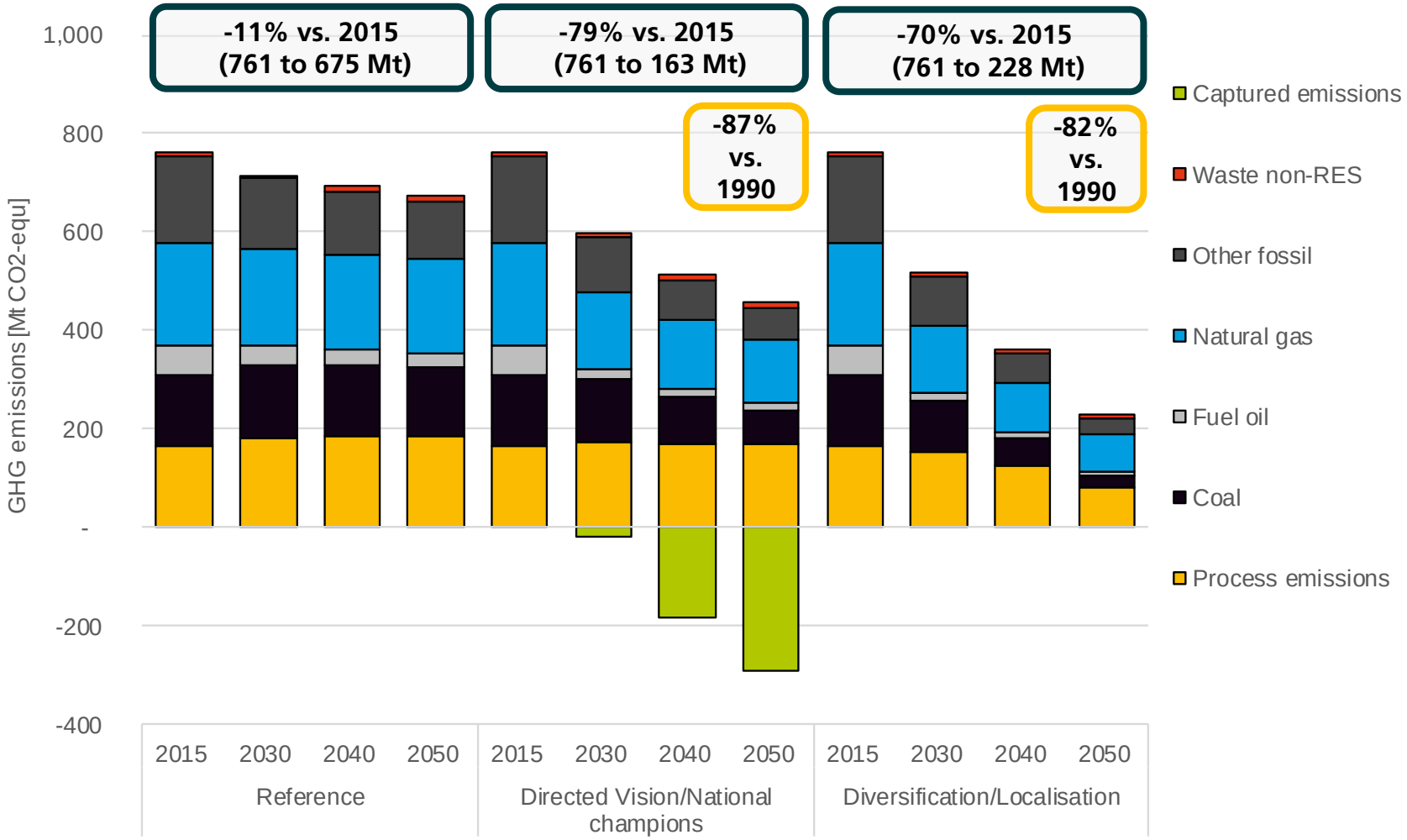
IV. Results

V. Conclusions

Fraunhofer ISI

VERY HIGH LEVEL OF AMBITION ENABLES A HIGH REDUCTION IN CO_2 EMISSIONS [EU28]

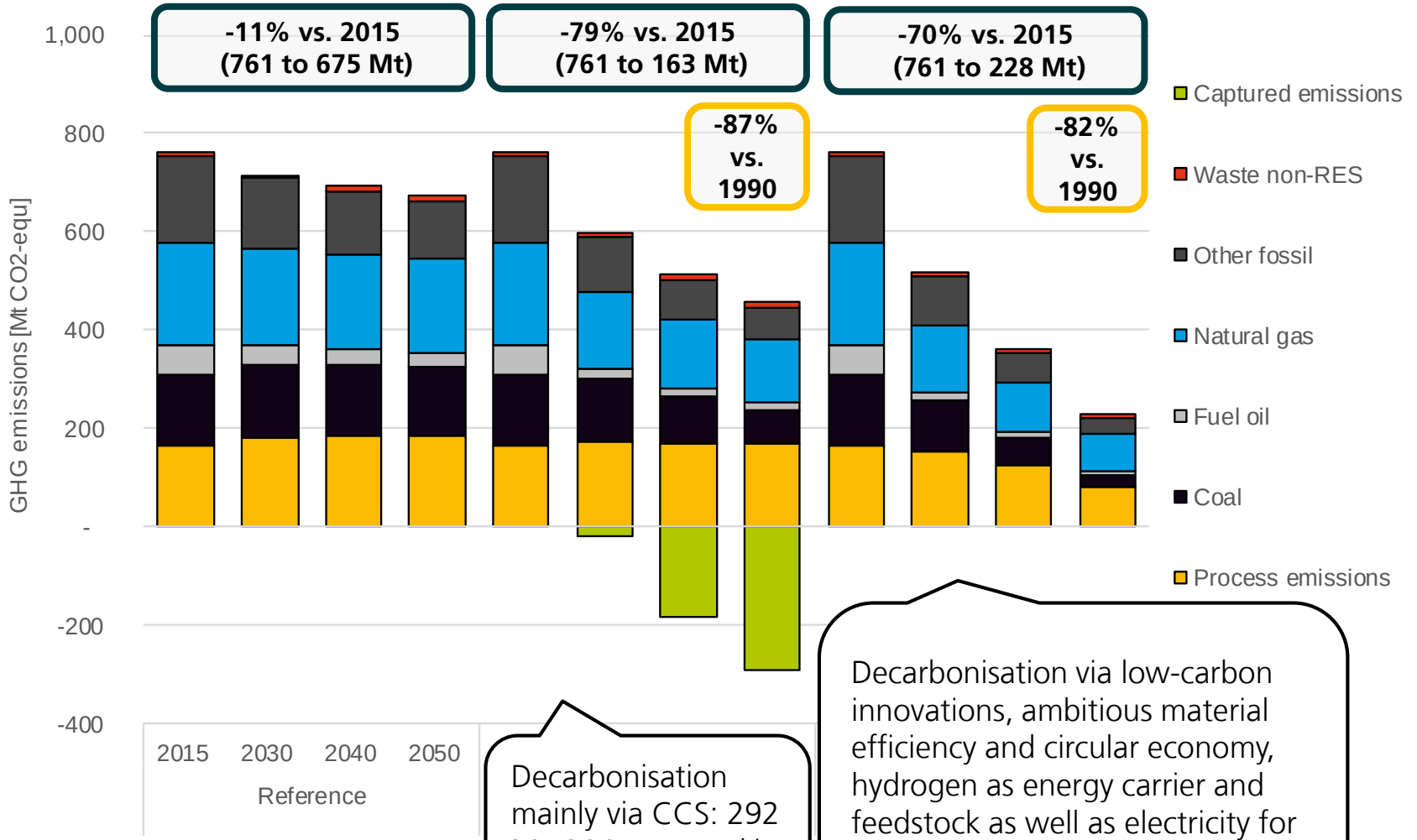
SET-Nav
Strategic Energy Roadmap



Fraunhofer ISI

Very high level of ambition enables a high reduction in CO_2 emissions [EU28]

SET-Nav Strategic Energy Roadmap

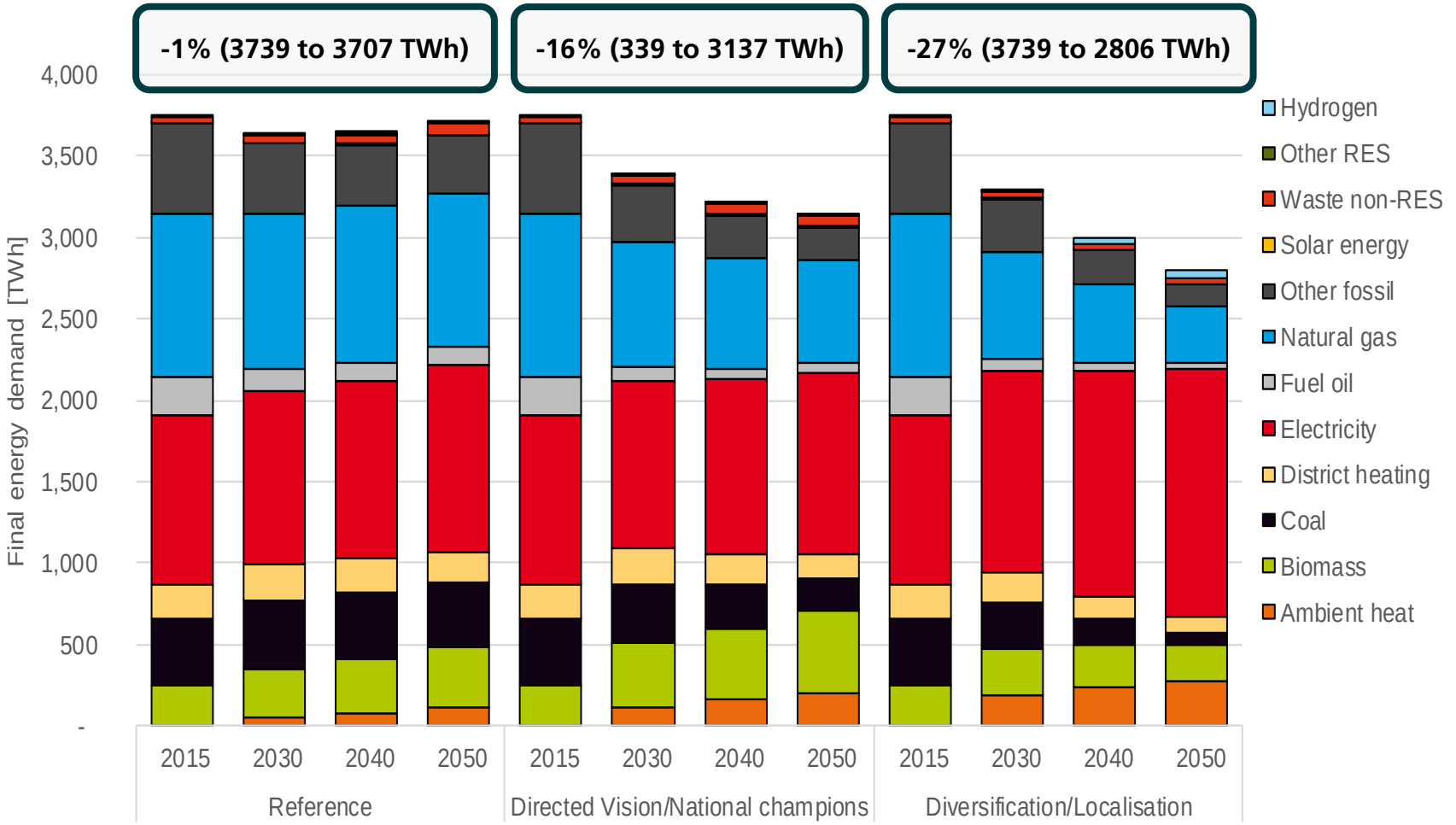


Decarbonisation mainly via CCS: 292 Mt CO2 captured in 2050

Decarbonisation via low-carbon innovations, ambitious material efficiency and circular economy, hydrogen as energy carrier and feedstock as well as electricity for process heating

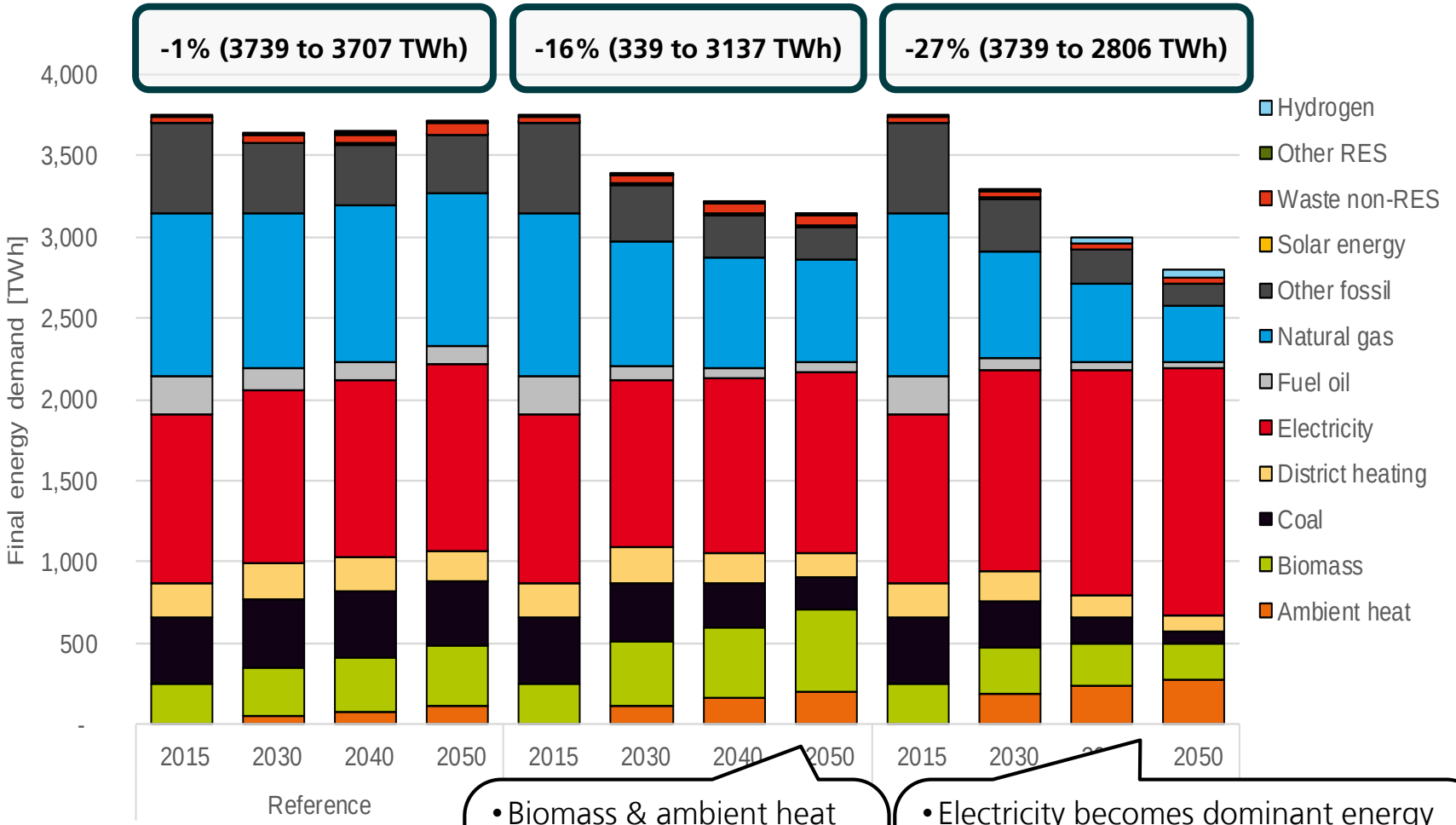
Fraunhofer ISI

Reduction in final energy demand less pronounced than emissions [EU28]



Reduction in final energy demand less pronounced than emissions [EU28]

SET-Nav Strategic Energy Roadmap

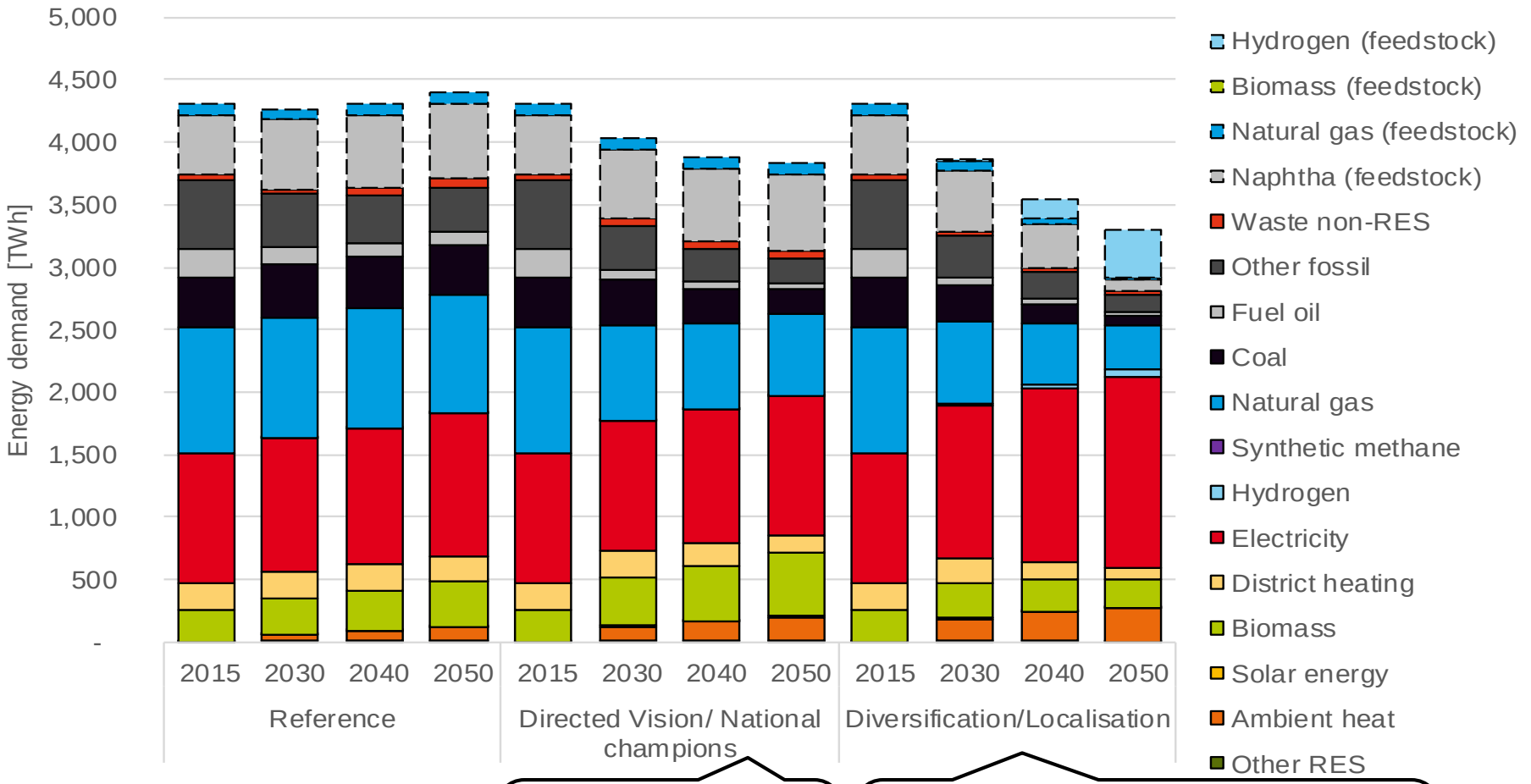


- Biomass & ambient heat gain shares.
- Fuel oil is nearly phased out by 2050 & coal is falling substantially.

- Electricity becomes dominant energy carrier by 2050
- E.g. new uses for process heat: steel electrolysis, flat glass electric furnace, etc.

Fraunhofer ISI

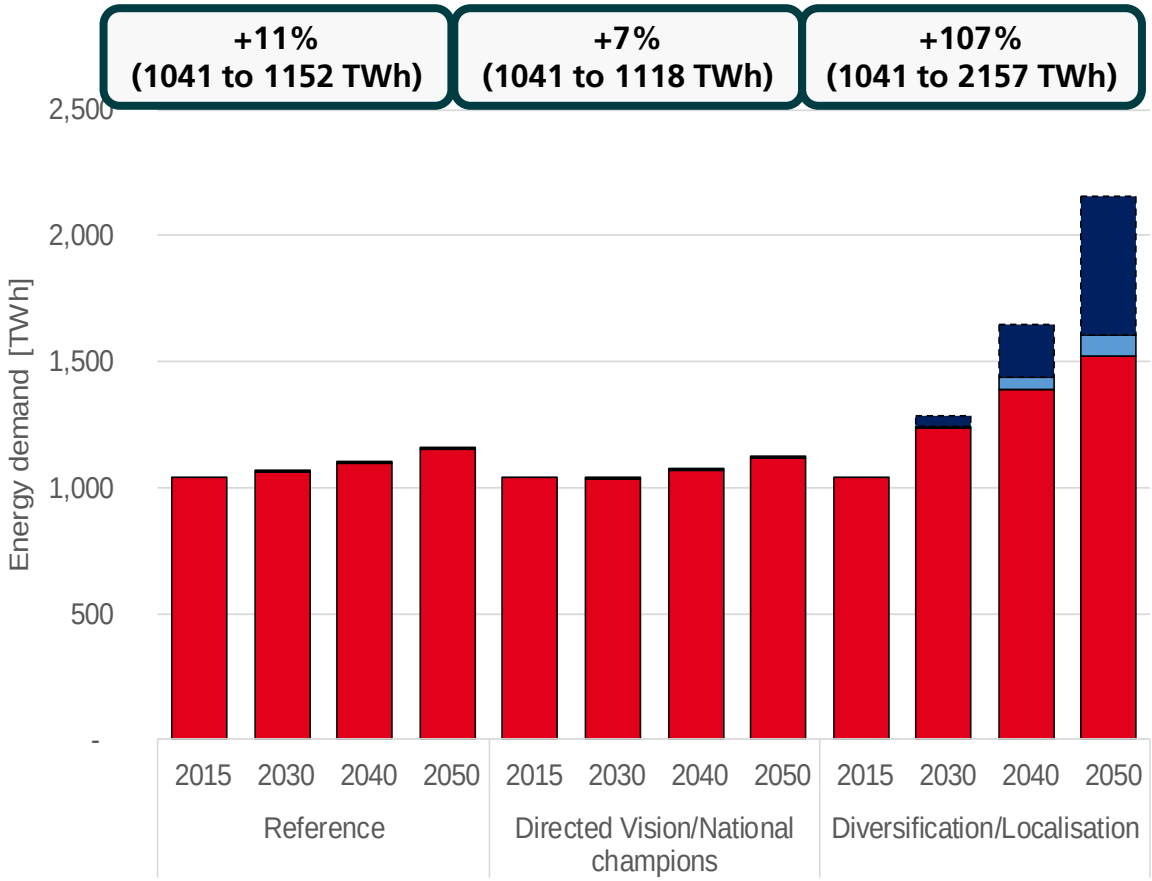
RES H2 FEEDSTOCK DEMAND CHANGES ENERGY BALANCE BOUNDARIES [EU28]



- Feedstock for chemicals still based on fossil fuels

- Feedstocks are dominated by RES hydrogen for the production of ammonia, methanol and methanol-based ethylene

Large volumes of renewable electricity will be needed [EU28]



Hydrogen (feedstocks) for ammonia, methanol and ethylene (**549 TWh** in 2050)

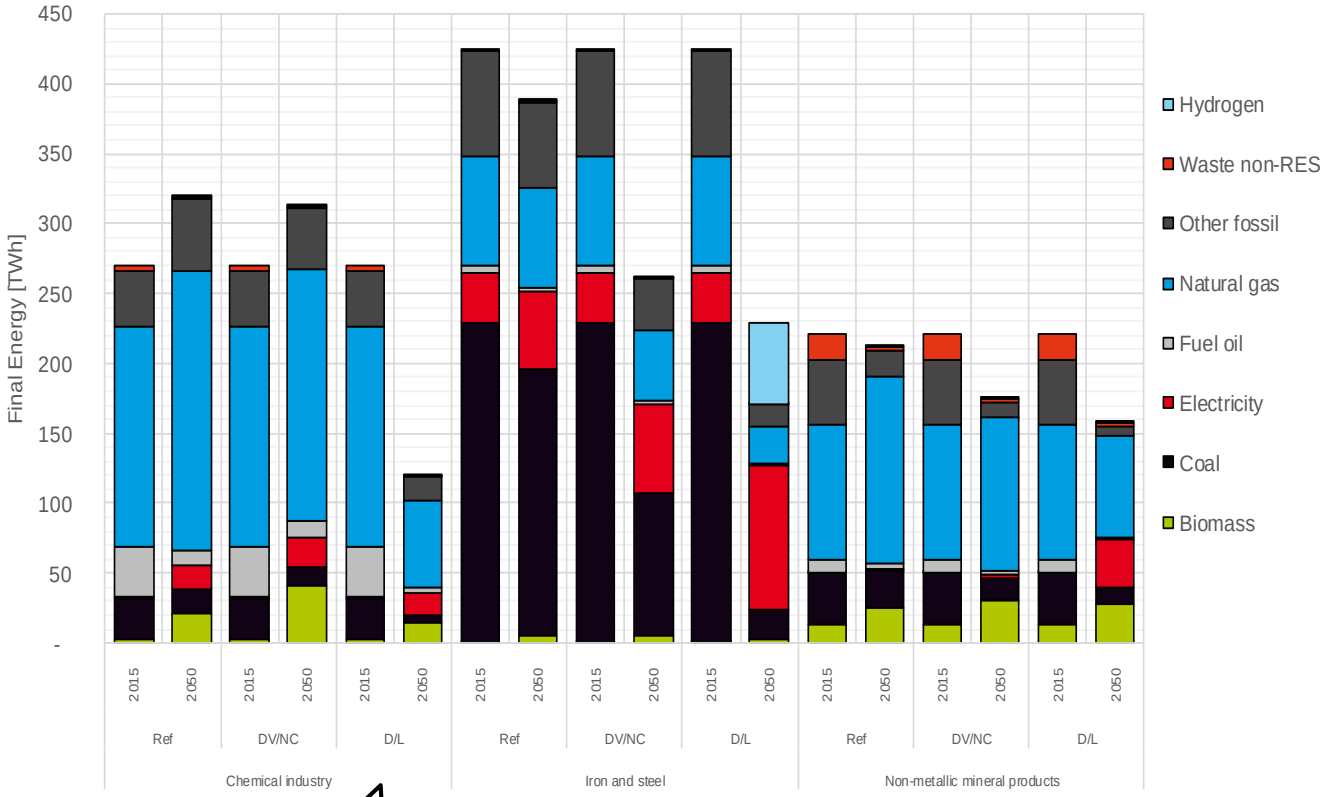
Hydrogen is mainly used in the steel industry with H2-DR replacing oxygen steel (**83 TWh** in 2050)

Process heating in all sectors (glass electric furnace, steel electrolysis, etc.)

Shift towards electricity & Biomass for process heating via furnaces [EU28]

SET-Nav Strategic Energy Roadmap

EU 28 final energy demand for process heating (>500°C)



+384 TWh
H2 feedstock

High financial support for biomass

Biomass is used where **technically possible** (e.g. cement & lime)

Increase in **electricity** driven by **process switch**: e.g. electric furnaces (glass,steel), DR electrolysis

Use of **hydrogen** in steel production replacing BOF

Across all sectors and scenario still a **substantial amount** of **natural**

OUTLINE

SET-Nav
Strategic Energy Roadmap

I. Introduction

II. Methodology

III. Pathways

IV. Results

V. Conclusions

Fraunhofer ISI

Summary: Innovations facilitate decarbonisation of EU industry

SET-Nav
Strategic Energy Roadmap

1 Introduction

- Available technologies not sufficient for decarbonisation of EU industry

2 Innovations

- Many low-carbon process innovations are under development
- They differ strongly in maturity and distance to market

3 Pathways

- >80% decarbonisation is possible – even without CCS, but requires:
  - Process innovations,
  - CO2-free secondary energy carriers,
  - Innovations in material efficiency and circular economy

4 Policy

- Support for RES and energy efficiency
- Extending the ETS with a minimum price path to provide long-term certainty
- Public RD funding for low-carbon innovations
- Targeted public procurement to support low-carbon products
- CO2 tax to provide incentives for companies outside the ETS
- Policies to boost material efficiency & circular economy as well as energy efficiency

Fraunhofer ISI

Many thanks for your attention!

Dr. Andrea Herbst
Competence Center Energy Technology and Energy Systems
Fraunhofer Institute for Systems and Innovation Research ISI
Breslauer Straße 48, 76139 Karlsruhe, Germany
Tel.: +49 (0) 721 6809 -439
E-Mail: andrea.herbst@isi.fraunhofer.de
http://www.forecast-model.eu

The analysis was executed within the EU project SET-Nav (Navigating the Roadmap for Clean, Secure and Efficient Energy Innovation), which received funding from the European Union's Horizon 2020 research and innovation programme [GA-No. 691843]. For further information, see: http://**www.set-nav.eu/.**