SCENARIO ANALYSIS OF A LOW CARBON TRANSITION OF THE EU INDUSTRY BY 2050

Extending the scope of mitigation options

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eceee industrial summer study, 11th – 13th June, Berlin 2018

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II. Methodology

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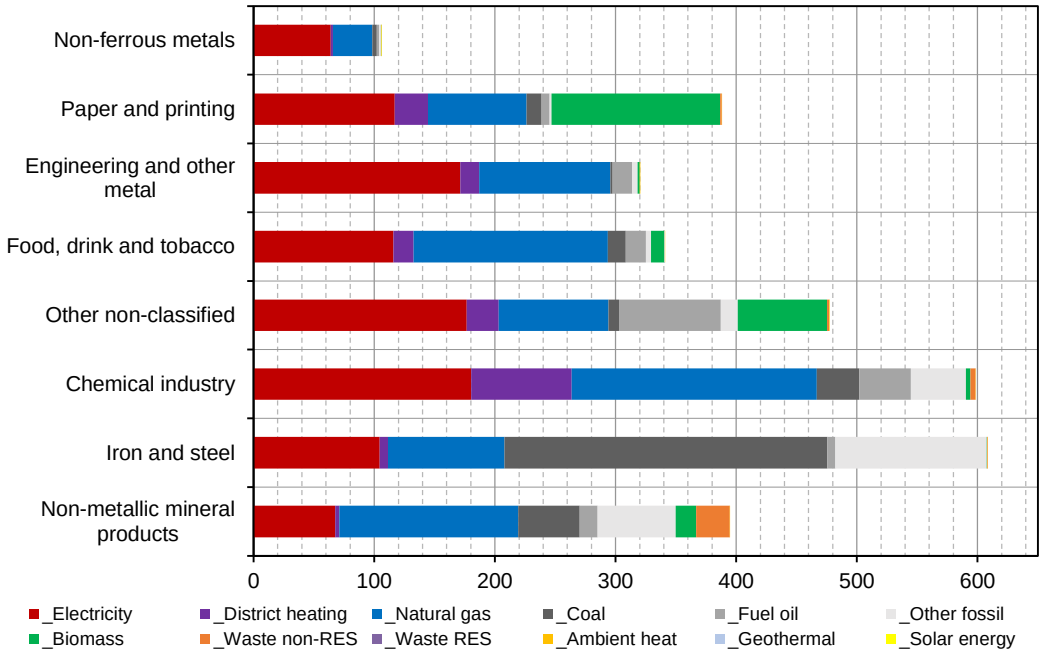
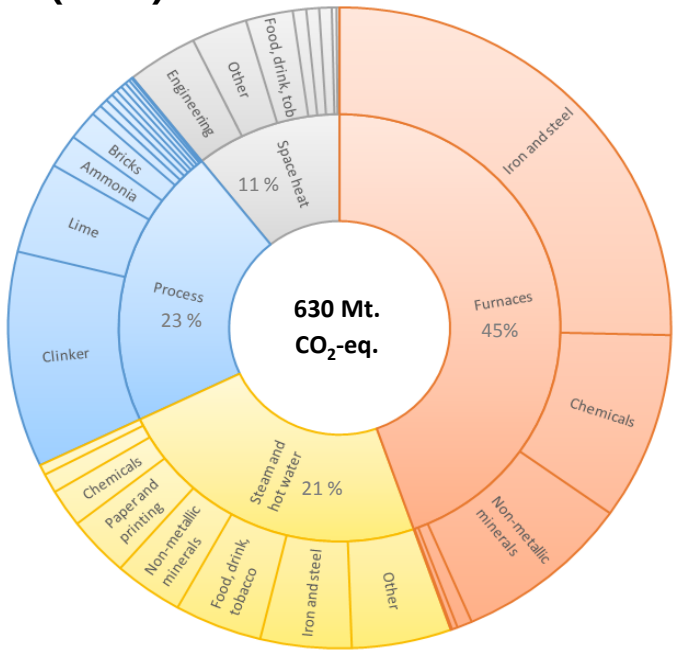
Status-quo: industry accounts for 25% of EU final energy consumption

- Dominant energy carriers: **gas, electricity, coal and oil**
- Challenge: **direct CO2 emissions** (energy- and process-related)
- 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)



EU 28 direct industrial emission by type of use (2015)



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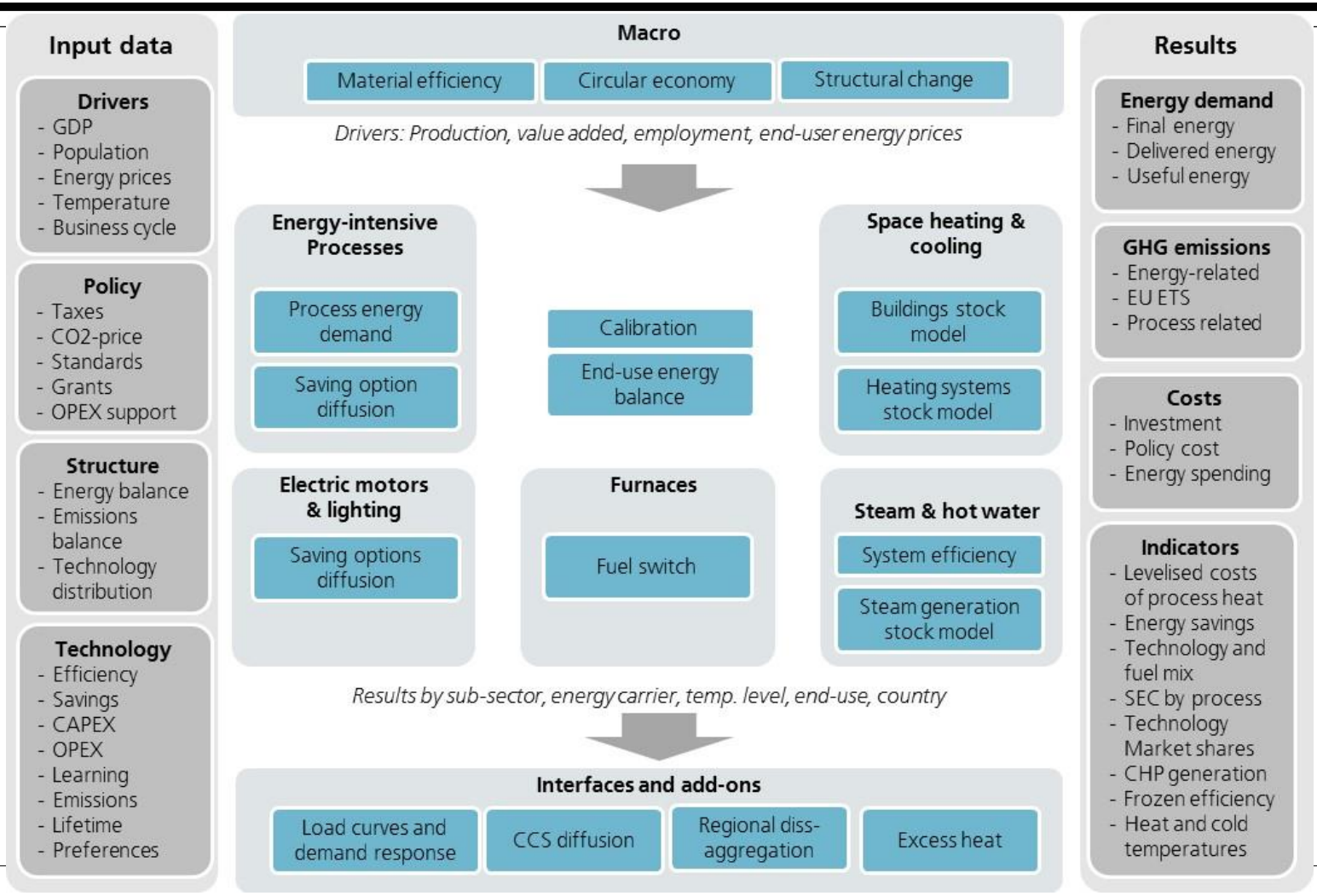
FORECAST: bottom-up simulation model

FORECAST
FORecasting Energy Consumption Analysis and Simulation Tool



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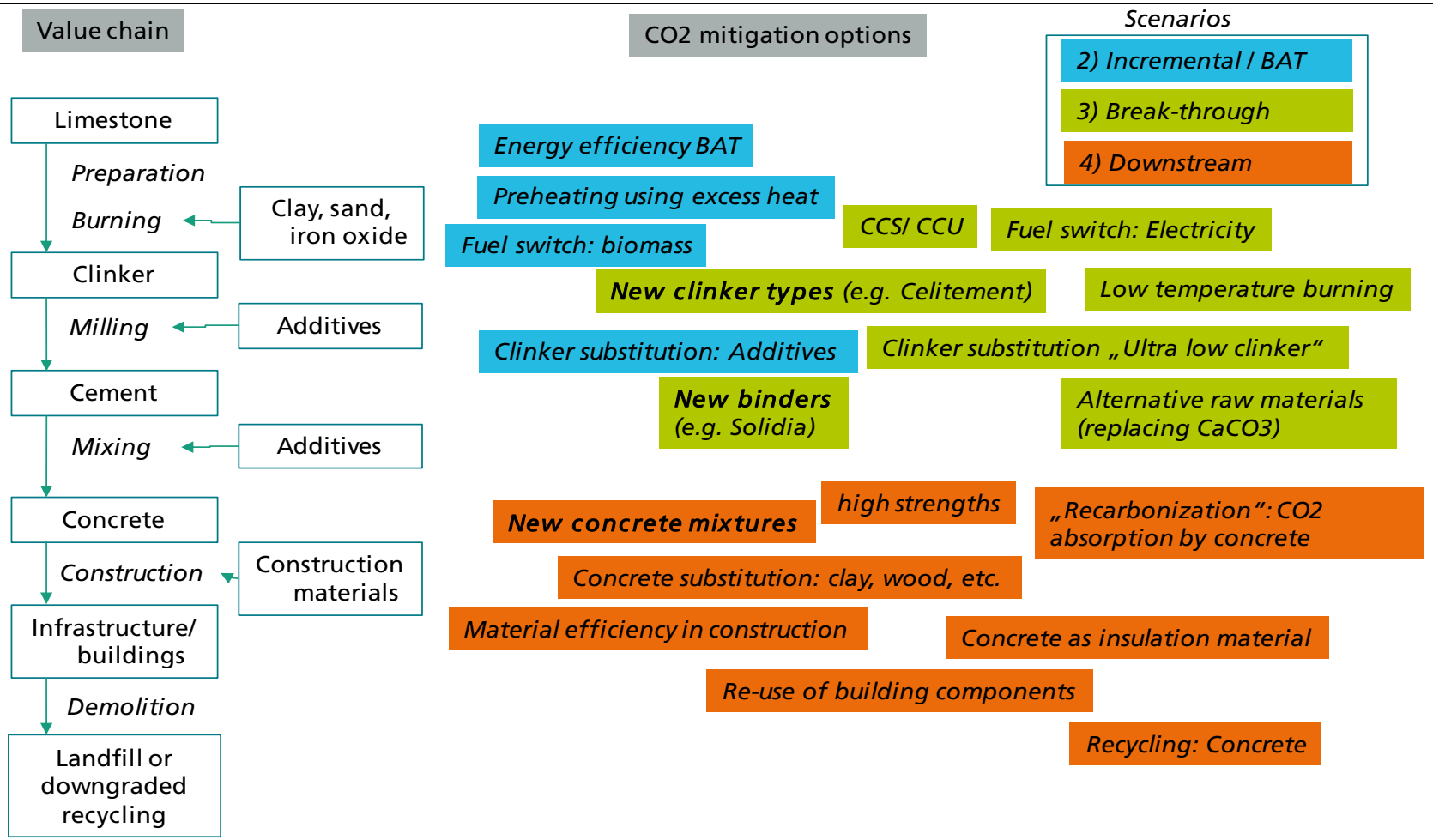
Scenario characterization by mitigation option

Clusters of mitigation options	REF	TRANS-CCS	TRANS-IPT
Incremental efficiency improvement	Energy efficiency progress according to current policy framework and historical trends.	Faster diffusion of **incremental process improvements** (BAT & INNOV ≥TRL 5).	= TRANS-CCS
Fundamental processes improvement **energy efficiency, process emissions**	-	-	**Radical process changes** (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	**Financial support** for RES technologies: **Fuel switching to biomass and electricity (<500°).** Use of existing equipment (no radical changes in industrial processes technologies).	**High financial support** for RES technologies: 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**).
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** (e.g. electric steel, secondary aluminium).	= TRANS-CCS
Material efficiency and substitution	Based on historic trends.	Decrease in clinker factor. **Increase in material efficiency & substitution**.	= TRANS-CCS

Without CCS new production processes, RES-H2/methane, PtH, Mat-Eff.. are necessary



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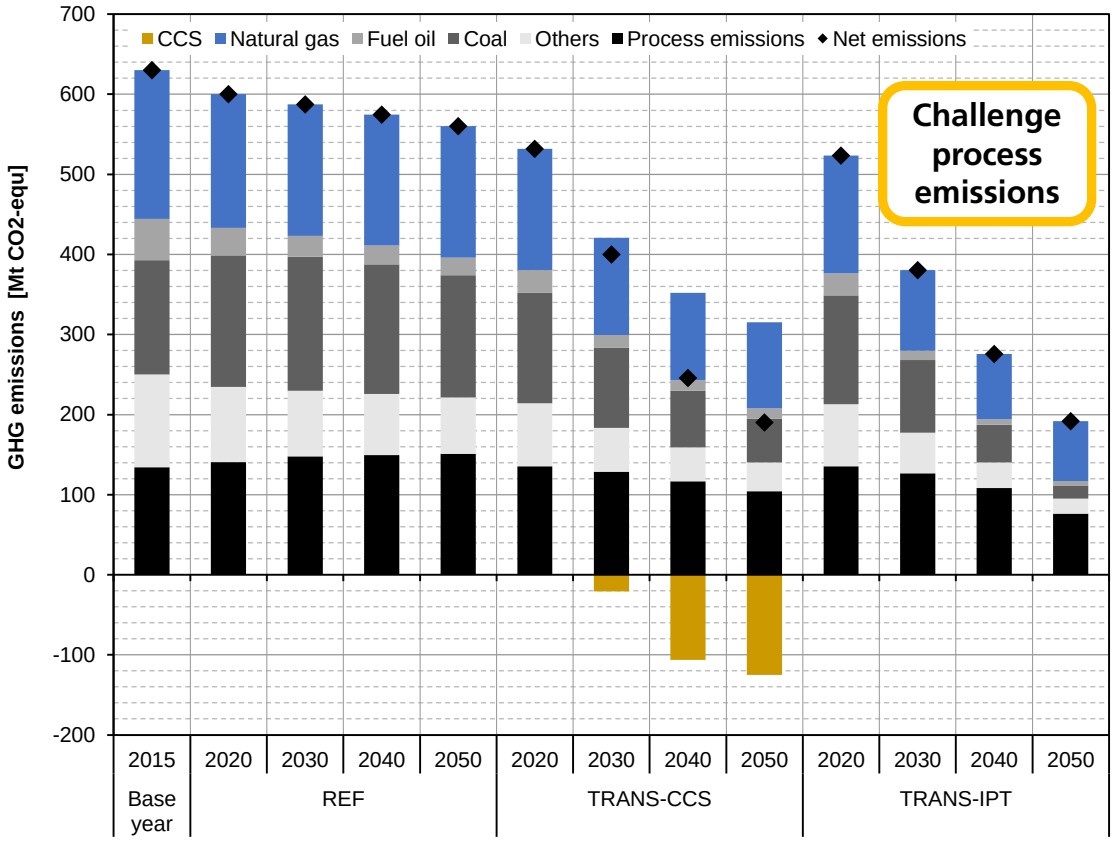
Very high level of ambition enables a high reduction in industrial CO2 emissions

EU 28 industrial CO2 emissions by EC and scenario



Reference:

- Slight improvements visible (e.g. process switch in the steel industry)

Mitigation scenarios:

- Reduction in industrial CO2 emissions:
  ~-70% by 2050 compared to 2015
  ~-83% by 2050 compared to 1990

- Abatement of **process-related emissions more difficult:**
  CCS, radical process changes (e.g. H2-steel, H2-ammonia, low-carbon cement types, ..)

Source: FORECAST

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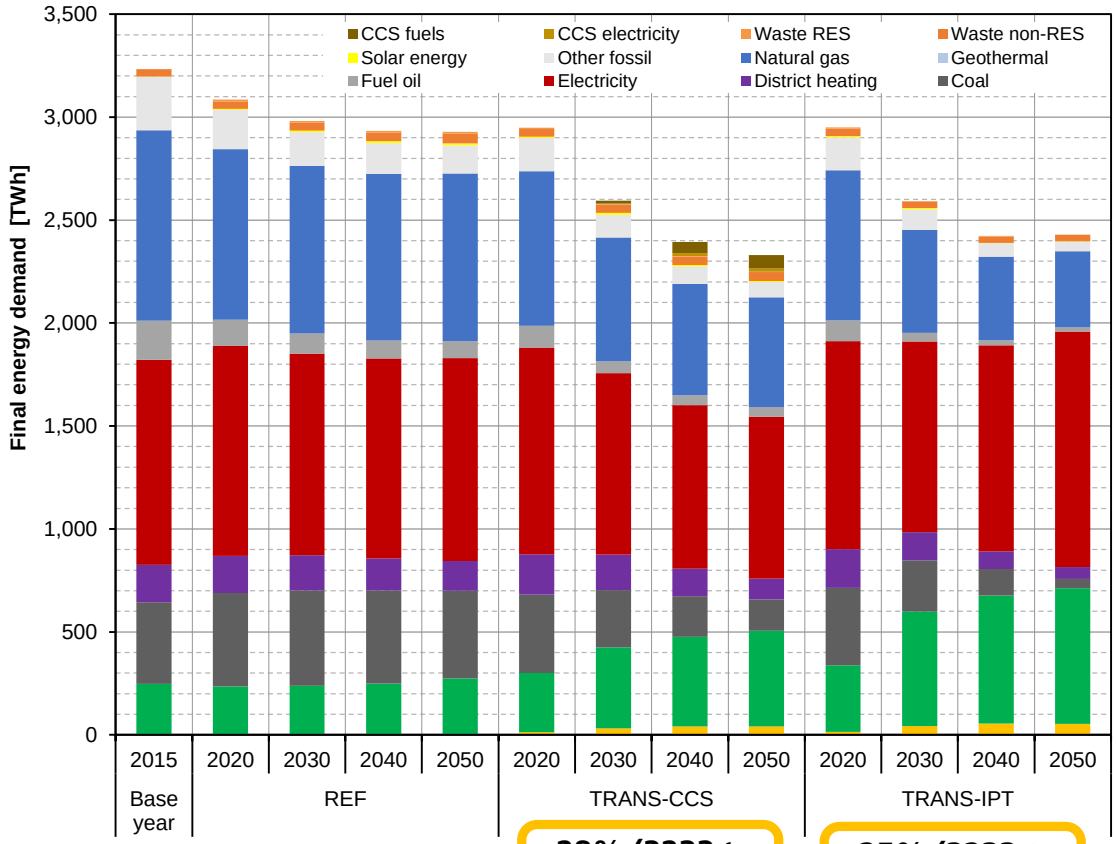
Two contrary trends can be observed in the evolution of industrial energy demand

EU 28 industrial final energy demand by EC and scenario



Source: FORECAST

Mitigation scenarios:

- **Demand decreases** due to integrated process improvements and fuel switch
- **Large volumes** of renewable **electricity** will be needed due to radical process changes

Trans-IPT scenario:

1144 TWh of electricity in 2050 (+15% compared to 2015)

Trans-CCS scenario:

787 TWh of electricity in 2050

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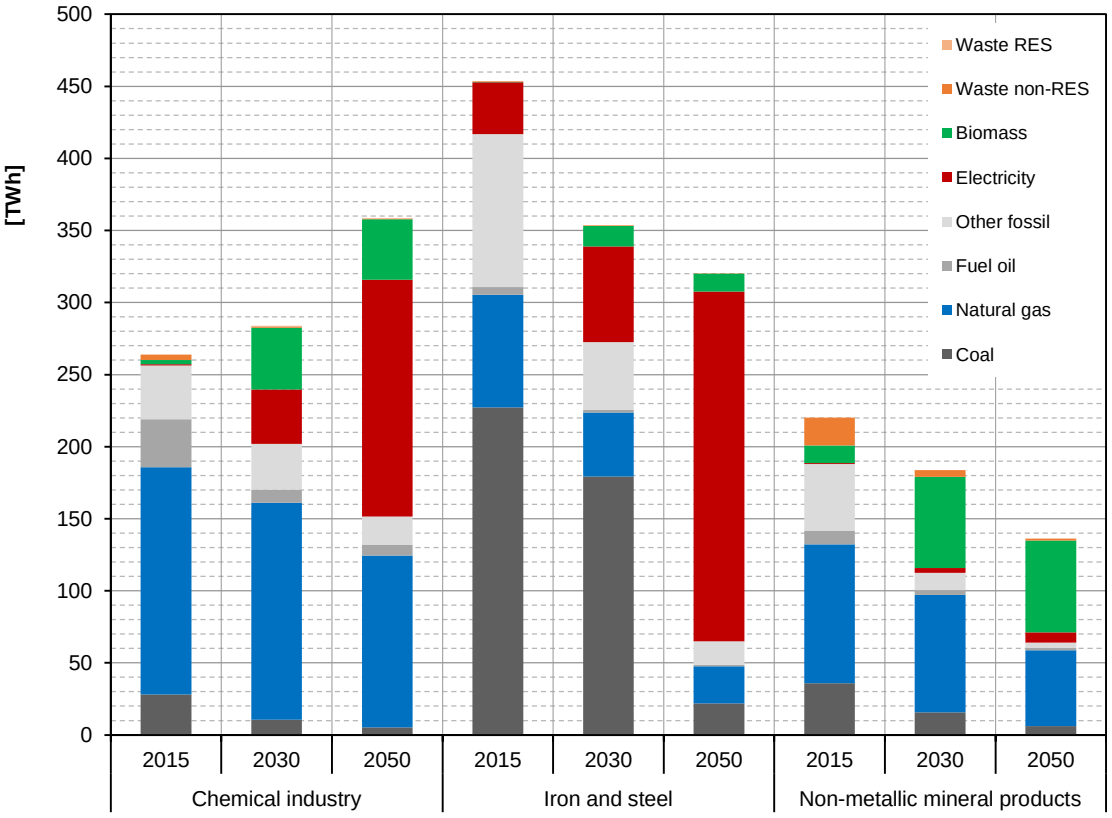
Strong shift towards biomass and electricity for process heating via furnaces

EU 28 final energy demand for process heating in furnaces



TRANS-IPT scenario:

- **High financial support for biomass**
- Biomass is used where **technically possible** (e.g. cement & lime)
- Increase in **electricity** driven by **radical changes**: e.g. the use of **hydrogen** in steel production replacing BOF
- Across all sectors and scenario still a **substantial amount of natural gas** is used

Source: FORECAST

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Transition scenarios show that industry can reduce its CO2 emissions drastically

- **Deep emission cuts require substantial changes** in the iron and steel, cement and chemicals industries, but also **support for RES and energy efficiency** in other sectors and companies.
- Radical shifts in steel and chemicals towards the use of **RES-hydrogen might increase electricity use drastically**.
- **Biomass is the most important RES in industry**, particularly in the medium term. However, **biomass resource potentials and their sustainability are limited** (competition with other sectors).
- **RES-based electricity (PtH) can play a more important role**, particularly if electricity generation has very low emission levels. However, electricity is **not yet cost-competitive with biomass** even in the most ambitious transition policy scenario.
- Replacing biomass by electricity would require policies to **reduce the operation costs of PtH.**
- **Improved material efficiency and the circular economy have a huge mitigation potential.** However, it is still unclear what an effective policy mix would look like and this probably encompasses a wide range of individual measures.

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Policy mix needs to be adjusted in order to effectively support R&D activities

- **Extending the ETS with a minimum price path** (i.e. a floor price) could provide more long-term clarity and the certainty needed for investors in low-carbon innovations.
- **Public RD funding** will be necessary to accelerate the market introduction of innovative low-carbon processes (e.g. Innovation Fund).
- **Targeted public procurement** can support the market introduction of low-carbon products by establishing niche markets.
- **CO2 tax** as the central element of a broader energy tax reform could provide the incentives needed for fuel switching (especially for companies outside the ETS).
- Increase **policies to boost material efficiency and a circular economy** (e.g. evaluate building codes and regulative framework in construction to facilitate efficient (re-use) of materials).
- Implement **policies to overcome barriers to energy efficiency** (energy management schemes, audits, soft loans, and energy service market).

Scenario analysis of a low carbon transition of the EU industry by 2050

Many thanks for your attention!

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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/.**

Diffusion of radical process changes in the TRANS-IPT scenario

Product	Technology	2015	2030	2040	2050
Cement	Less carbon cement 30	0%	5%	5%	10%
	Low carbon cement 70	0%	2%	5%	20%
	Low Carbon cement 50	0%	1%	10%	20%
	Conventional cement	100%	92%	80%	50%
Steel	DR H2 plasma steel	0%	0%	45%	100%
	DR RES electrolysis	0%	0%	0%	0%
	Conventional BOF	100%	100%	55%	0%
Glass	RES Electric glass melting	0%	25%	40%	50%
	Conventional container glass/flat glass	100%	75%	60%	50%
Chemicals	Methanol H2	0%	5%	50%	100%
	Conventional Methanol	100%	95%	50%	0%
	Ammonia H2	0%	5%	50%	100%
	Conventional ammonia	100%	95%	50%	0%

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Without CCS new production processes, EE-Methan/H2, PtH, Mat-Eff, necessary

Materials industry

downstream

Clusters of mitigation options	Incremental change (modernization)	Fundamental change (mostly replacement of plant)
Integrated process improvements energy efficiency, reduction in process emissions	Aluminum: Inert anodes/wetted-cathodes Steel: Top gas recycling Steel: Smelting reduction	
	Paper: Foaming of fibrous materials Paper: Enzymatic pre-treatment Paper: Black liquor gasification Paper: New drying techniques Aluminum/copper: Magnetic billet heating Aluminum: HAL4e Steel: Near net shape casting Glass: Oxy-fuel burners	Cement: Low carbon cement (-50%) Cement: Less carbon cement (-30%) Cement: Low-carbon cement (-70%)
Fuel switch towards RES towards decarbonized electricity	Steam: Natural gas/biomass Clinker: Lignite -> waste/biomass	Steel: RES-H2 plasma Steel: RES DRI (Electrolysis) Glass: Electrification Ammonia: RES-H2 & CO_2 Methanol: RES-H2 & CO_2
Carbon capture and storage	Steel, clinker, lime, ammonia, ethylene, methanol	
Recycling and re-use/more-intense use	Paper, Aluminum, Copper: More re-use/recycling Glass: Closed-loop-recycling Steel: More EAF (scrap availability/higher quality), car sharing Cement: Recycling (to replace clinker) Re-use building materials (e.g. L-beams)	
Material efficiency	Construction: Less over-dimensioning Steel: High strength steel	
Material substitution	Vehicle construction: Carbon fibers, aluminum, magnesium replacing steel Construction: Wood, clay and straw replacing concrete and steel	

Recycling and secondary production assumptions

Share of basic good production		Mod-RES		High-RES	
	2015	2030	2050	2030	2050
Share electric steel	40%	42%	45%	51%	68%
Share secondary aluminium	50%	52%	54%	65%	70%
Share recycled paper fibres	58%	58%	60%	60%	62%
Clinker to cement ratio (for remaining market segment)	78%	74%	72%	70%	43%

Source: FORECAST

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