REFLEX
Analysis of the European Energy System

THE FUTURE ENERGY DEMAND DEVELOPMENTS AND DEMAND SIDE FLEXIBILITY IN A SECTOR COUPLED ENERGY SYSTEM

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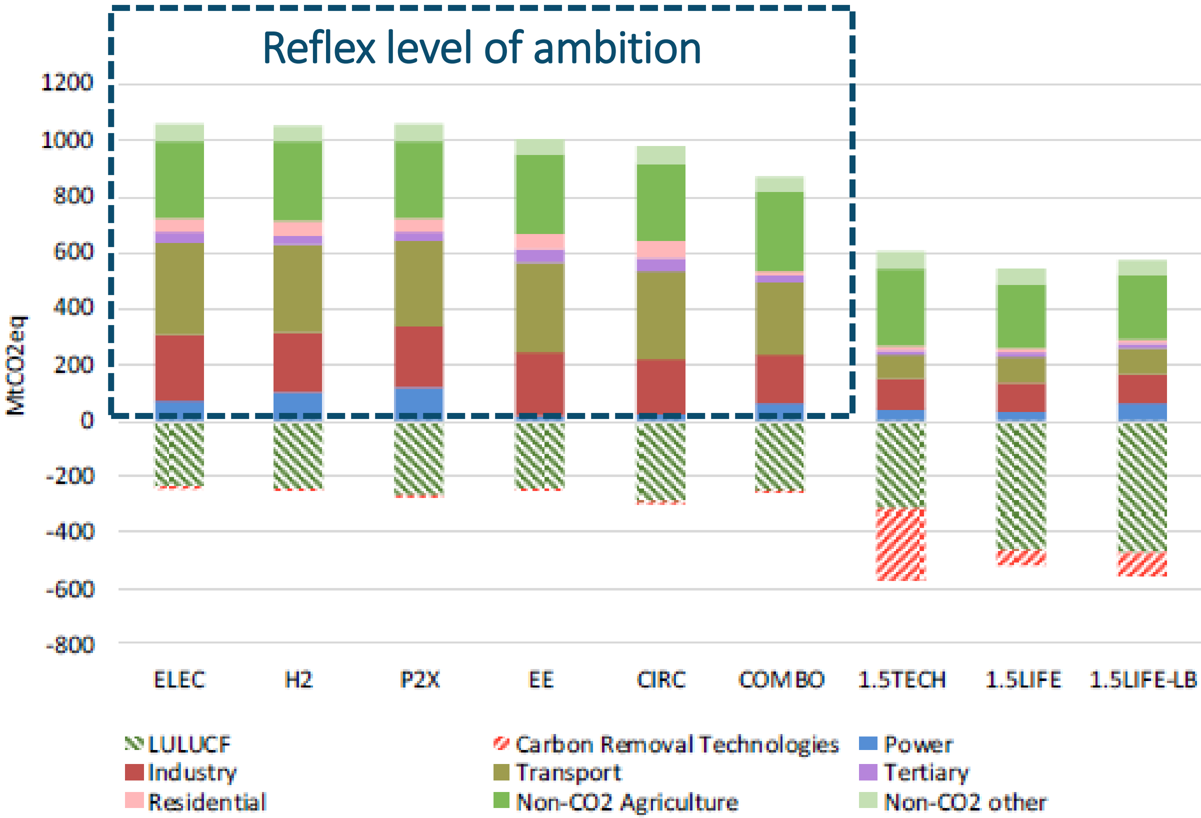
Final REFLEX Stakeholder Workshop
Brussels, 3rd April 2019

Agenda

Decarbonising final energy demand still needs substantial efforts

EU 2050 long-term strategy: 80% and 83% GHG reductions excl. LULUCF



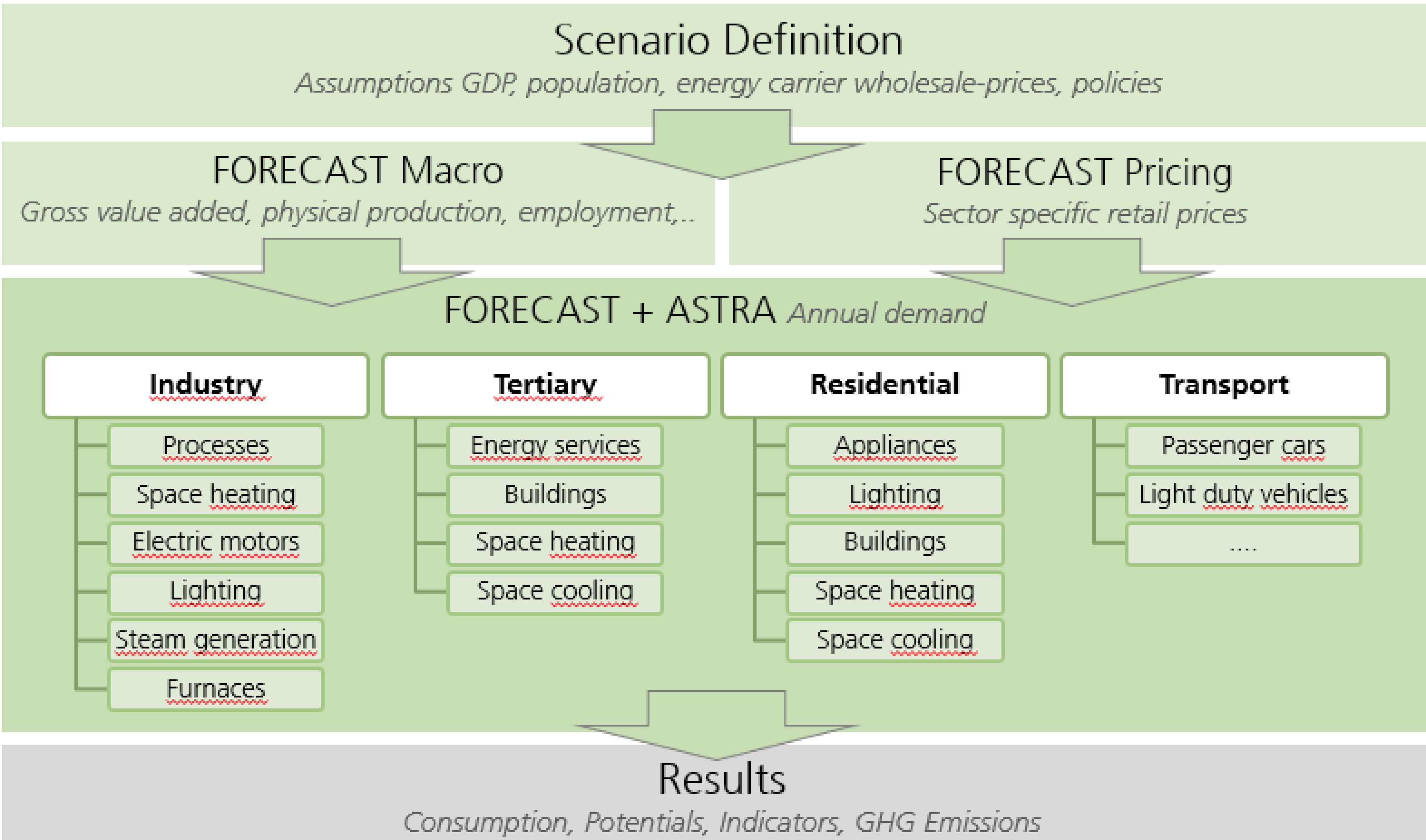
Source: Com(2018) 773

Challenges

- Thermal renovation
- Efficient new construction
- High-temperature heat
- Process emissions
- Feedstocks
- Alternative fuels
- Efficient transport modes

Agenda

Methodology



Source: https://www.forecast-model.eu
http://www.astra-model.eu

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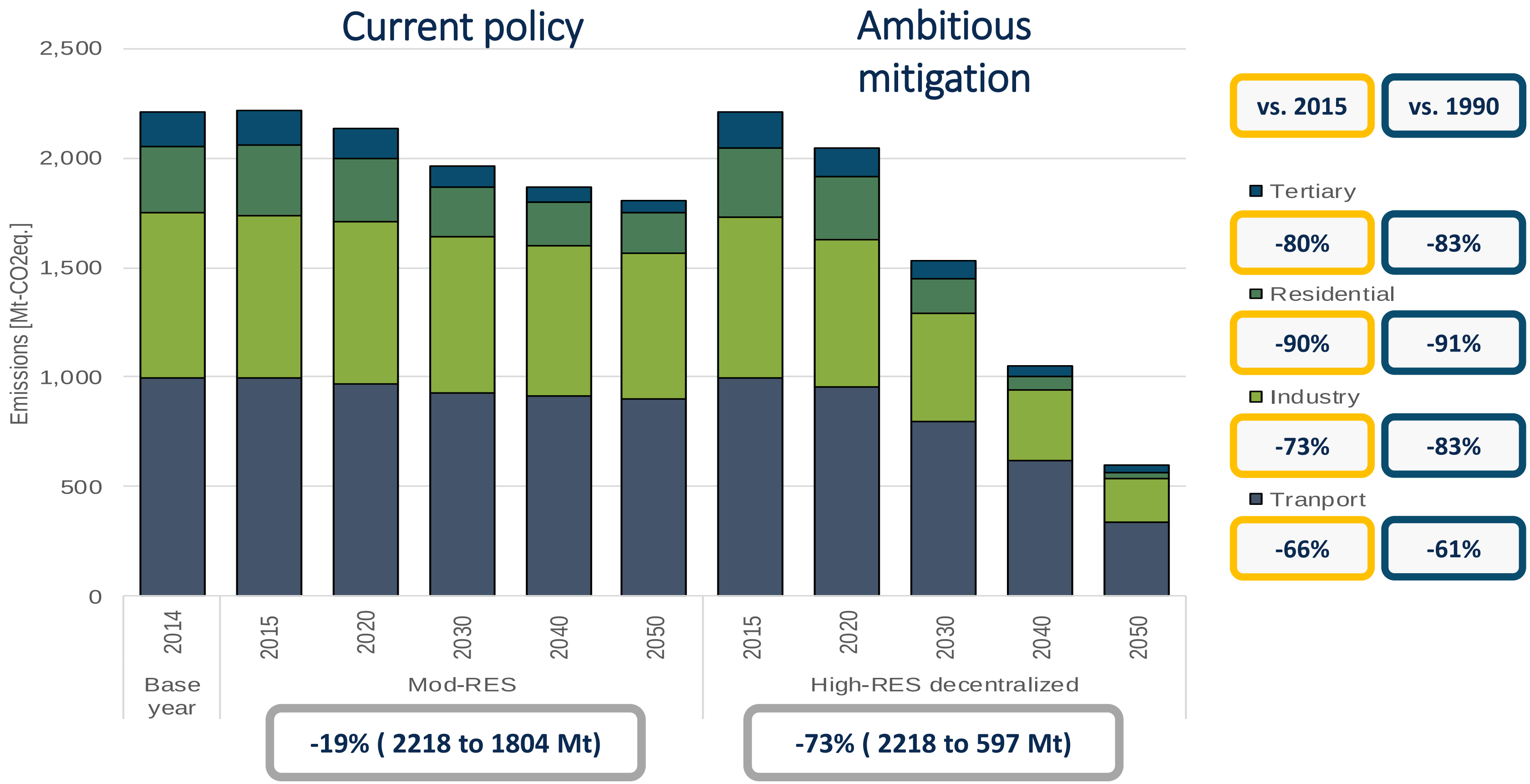
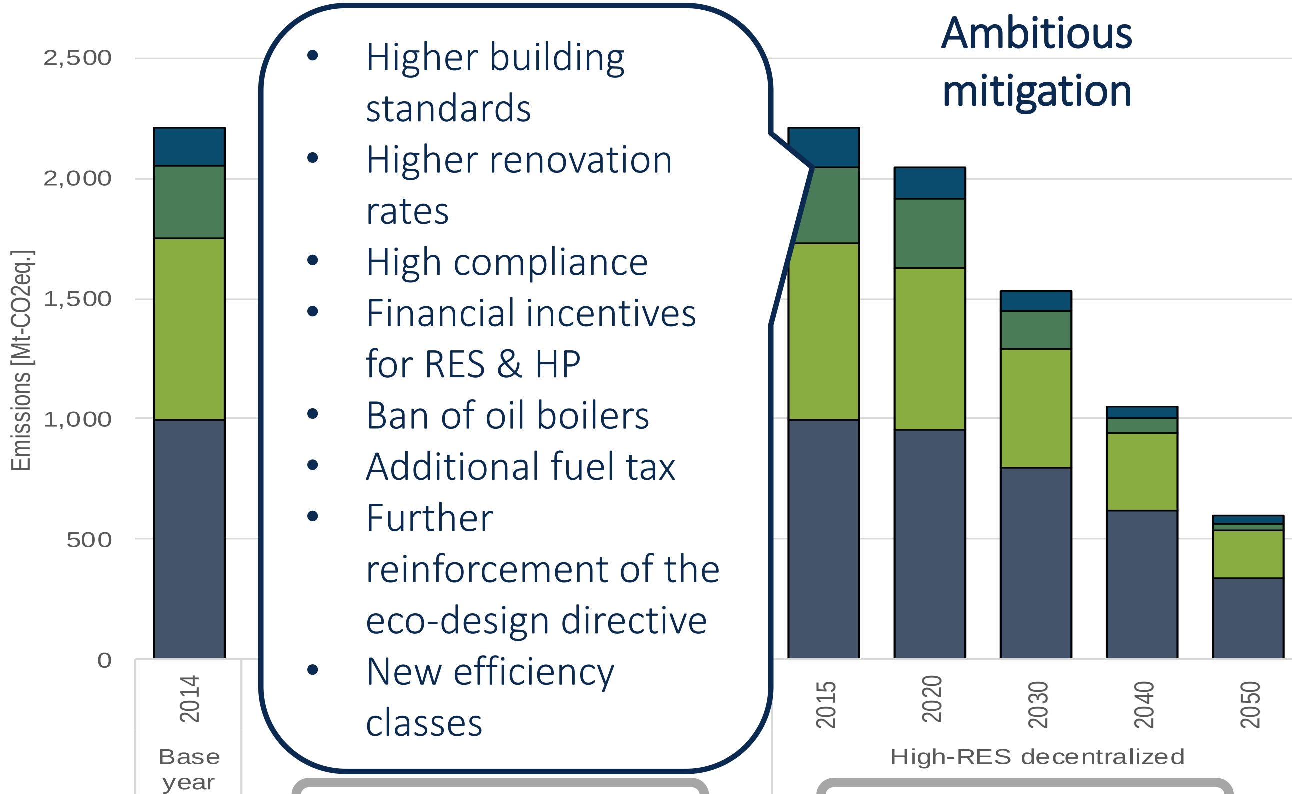
High level of ambition leads to significant decrease in CO_2 emissions [EU28]



Remaining emissions stem mainly from the use of **fuel oil** in the transport sector and the use of **natural gas** (mainly industry)

High level of ambition leads to significant decrease in CO_2 emissions [EU28]



	vs. 2015	vs. 1990
Tertiary	-80%	-83%
Residential	-90%	-91%
Industry	-73%	-83%
Tranport	-66%	-61%

-19% (2218 to 1804 Mt)

-73% (2218 to 597 Mt)

Remaining emissions stem mainly from the use of **fuel oil** in the transport sector and the use of **natural gas** (industry & transport)

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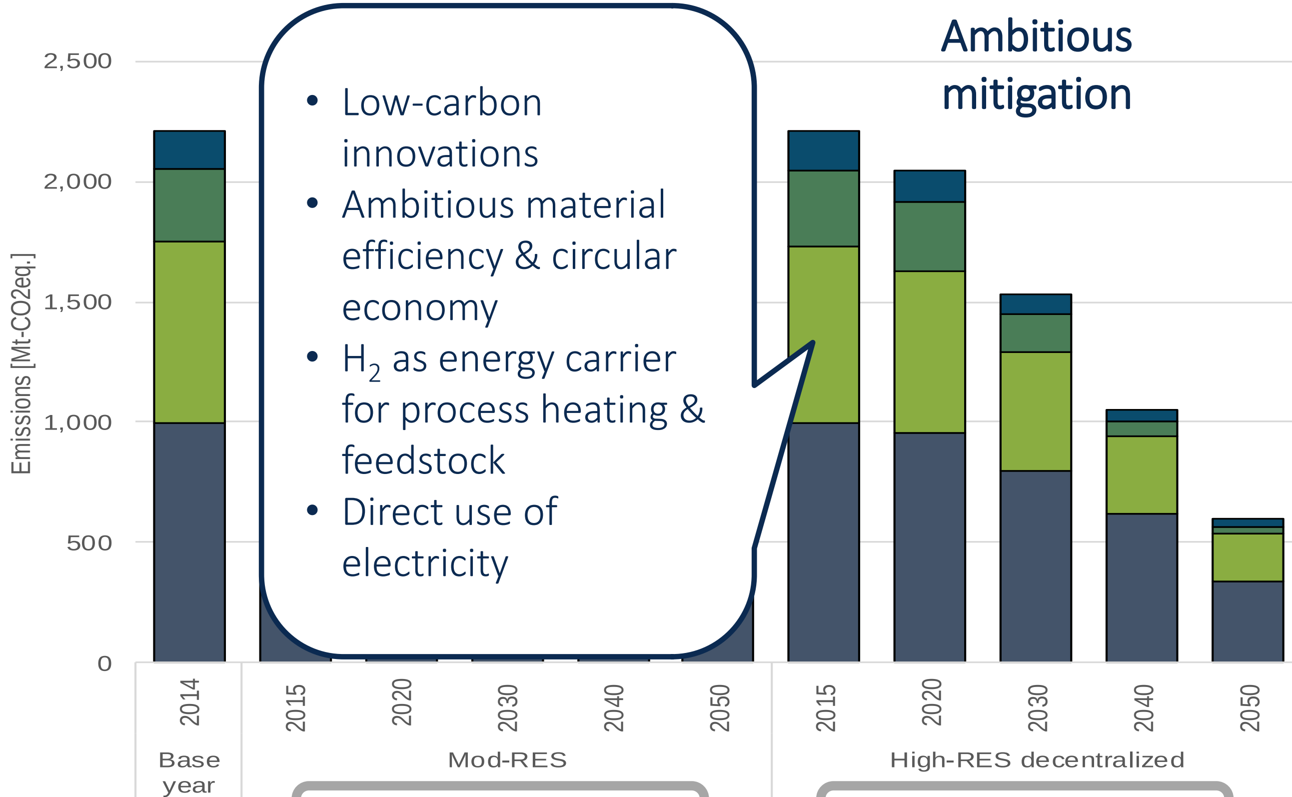

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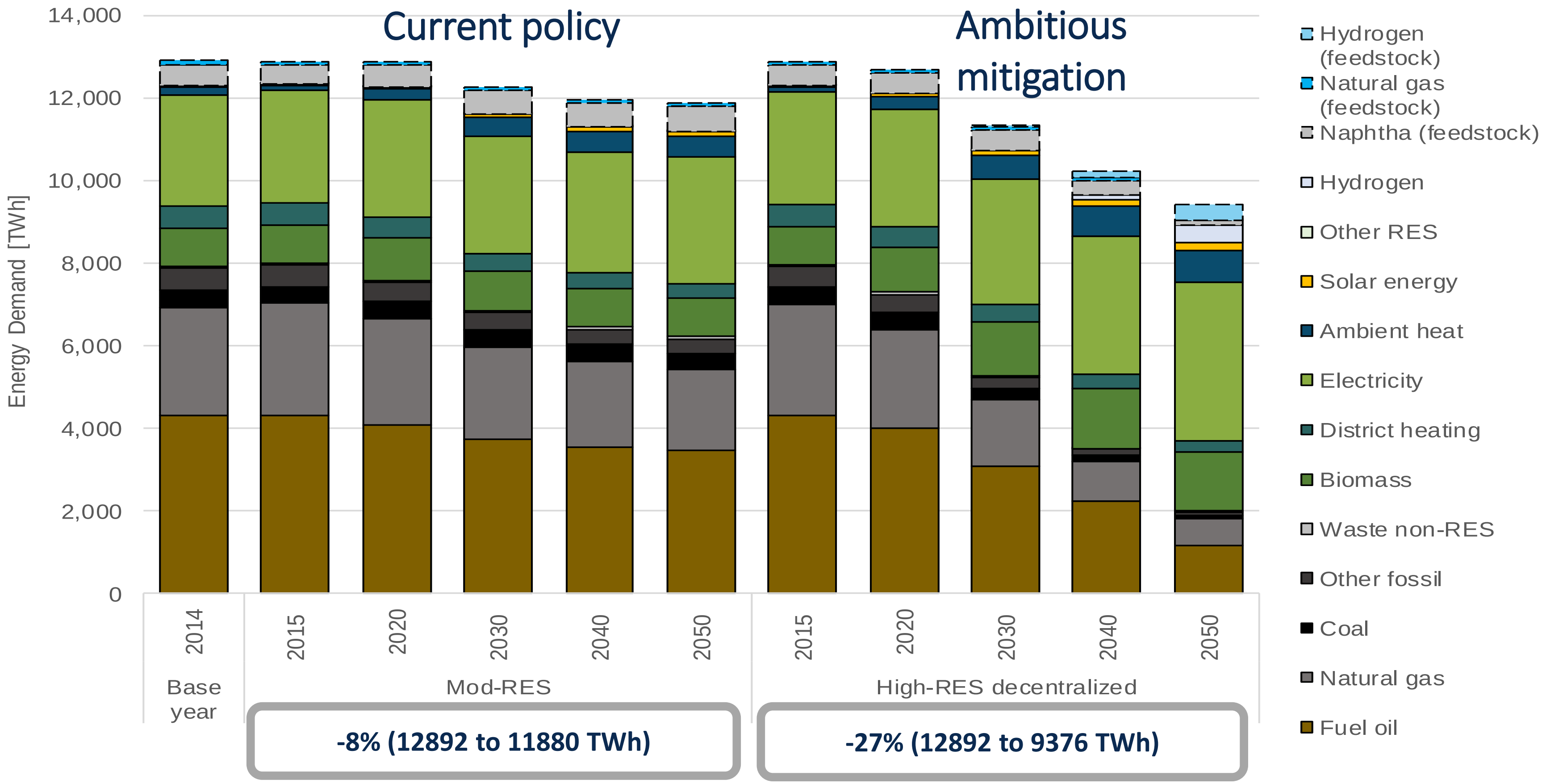
Electricity becomes dominant energy carrier in 2050 [EU28]



Increasing share of biomass mainly for **biofuels** - also increases in demand for SHW & SH

Large shares of fuel oil (1124 TWh from transport) & **natural gas** (622 TWh -> 308 TWh IND)

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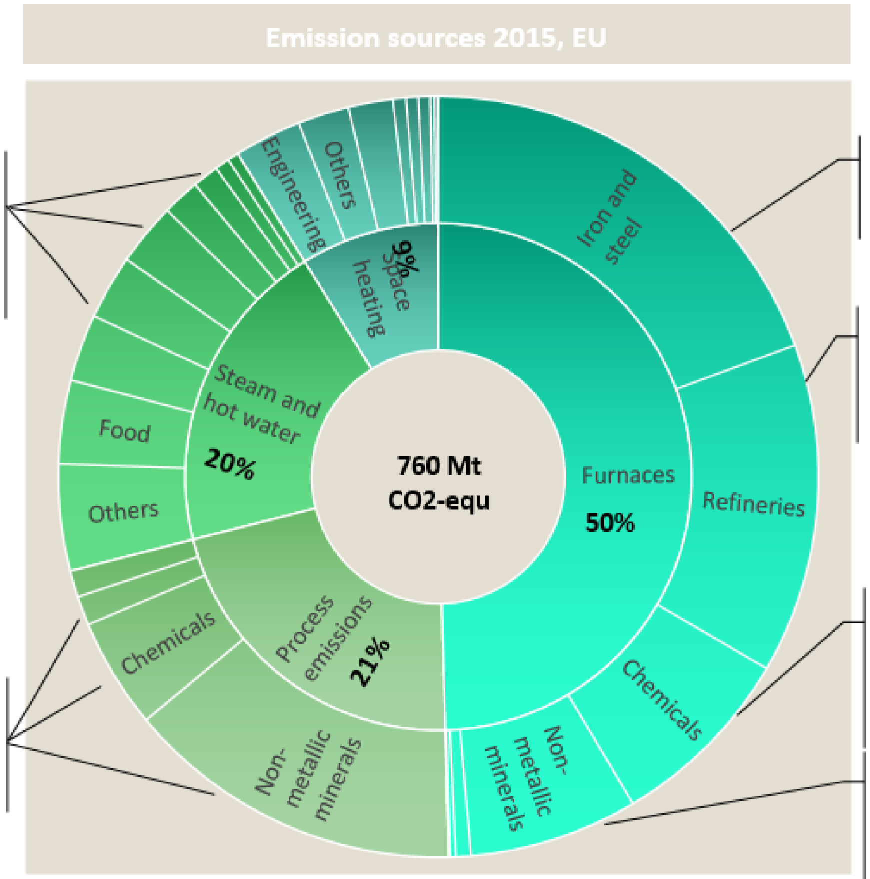
Today's available technologies are not sufficient for decarbonisation

Decarbonisation challenges

Strong reliance on natural gas, mostly high temperature

Process emissions chemically linked to production



Decarbonisation challenges

Coke technically required in blast

Strong reliance on refinery gas

Strong reliance on natural gas (also as feedstock)

High temperature limits use of renewables

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

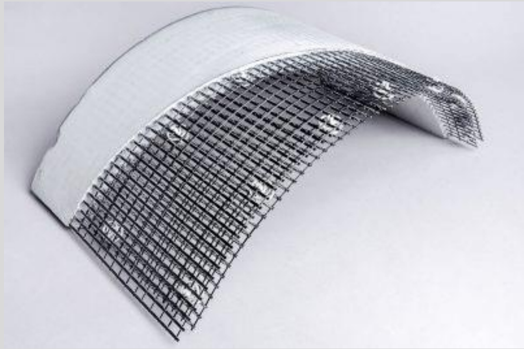
Scenario characterization by mitigation option

Clusters of mitigation options	Mod-RES	High-RES decentralized
Incremental efficiency improvement	Energy efficiency progress according to current policy framework and historical trends.	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	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)	-	-
Recycling and re-use	Slow increase in recycling rates based on historical trends.	Stronger switch to **secondary production**.
Material efficiency and substitution	Based on historic trends.	Decrease in clinker factor. Increase in **material efficiency & substitution**.

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

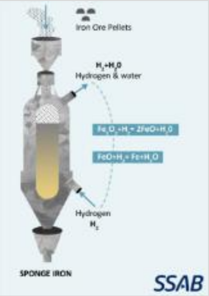
Break-through innovations with different levels of maturity are under development

Siderwinn (ArcelorMittal)

Fully electric steelmaking via electrolysis

Hybrit (SSAB)

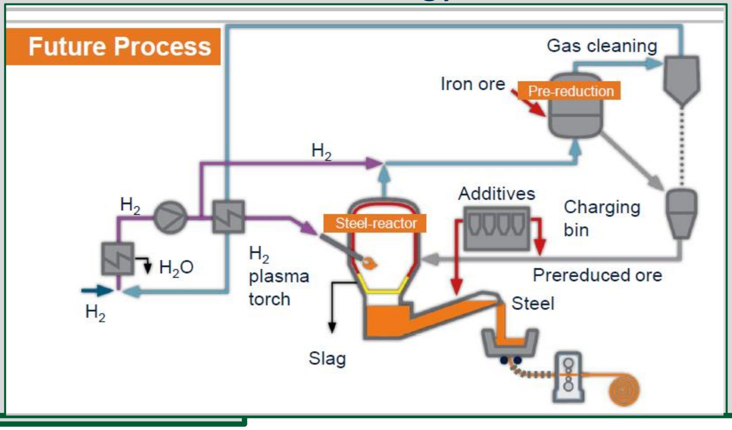
H_2 direct reduction of iron ore with EAF



https://www.greencarcongress
4/ssab.html

SuSteel (VoestAlpine)

H_2 based reduction of iron ore using plasma technology



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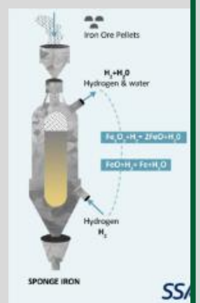

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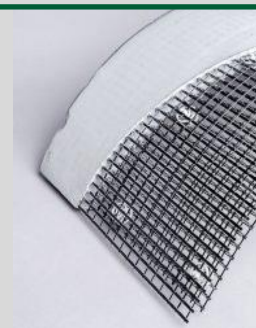
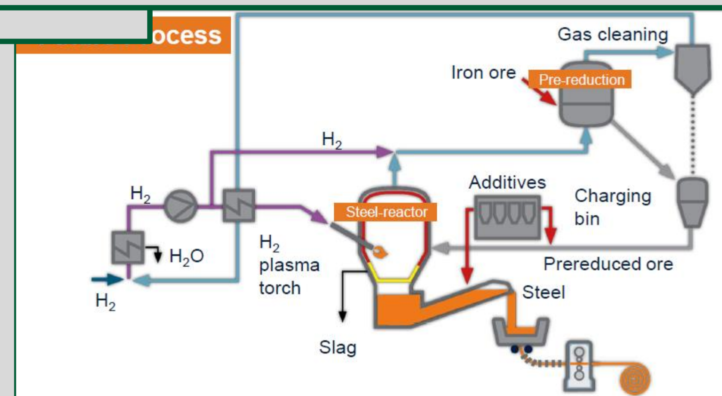
Grass paper (Creapaper)

Grass based fibres replacing wood fibres

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





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

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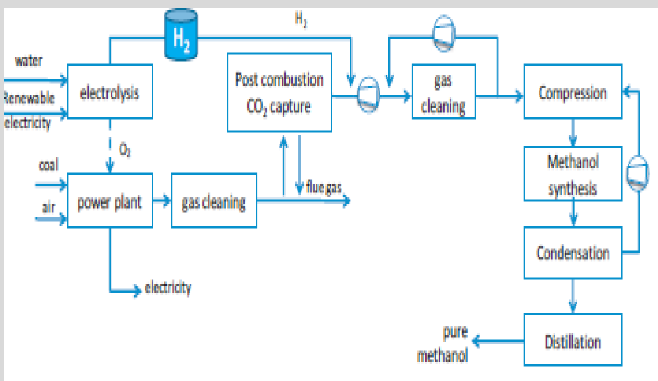
Fully electric steelmaking via electrolysis

Hybrit (SSA…

H_2 direct reduction … with EAF

H_2 Methanol

RES H_2 from water electrolysis plus hydrogenation of CO_2 as carbon source



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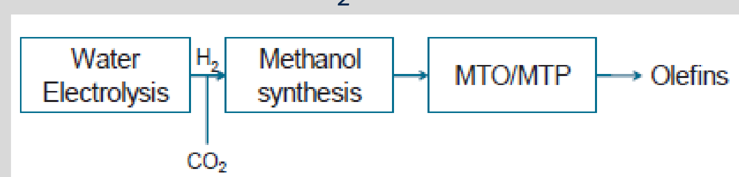
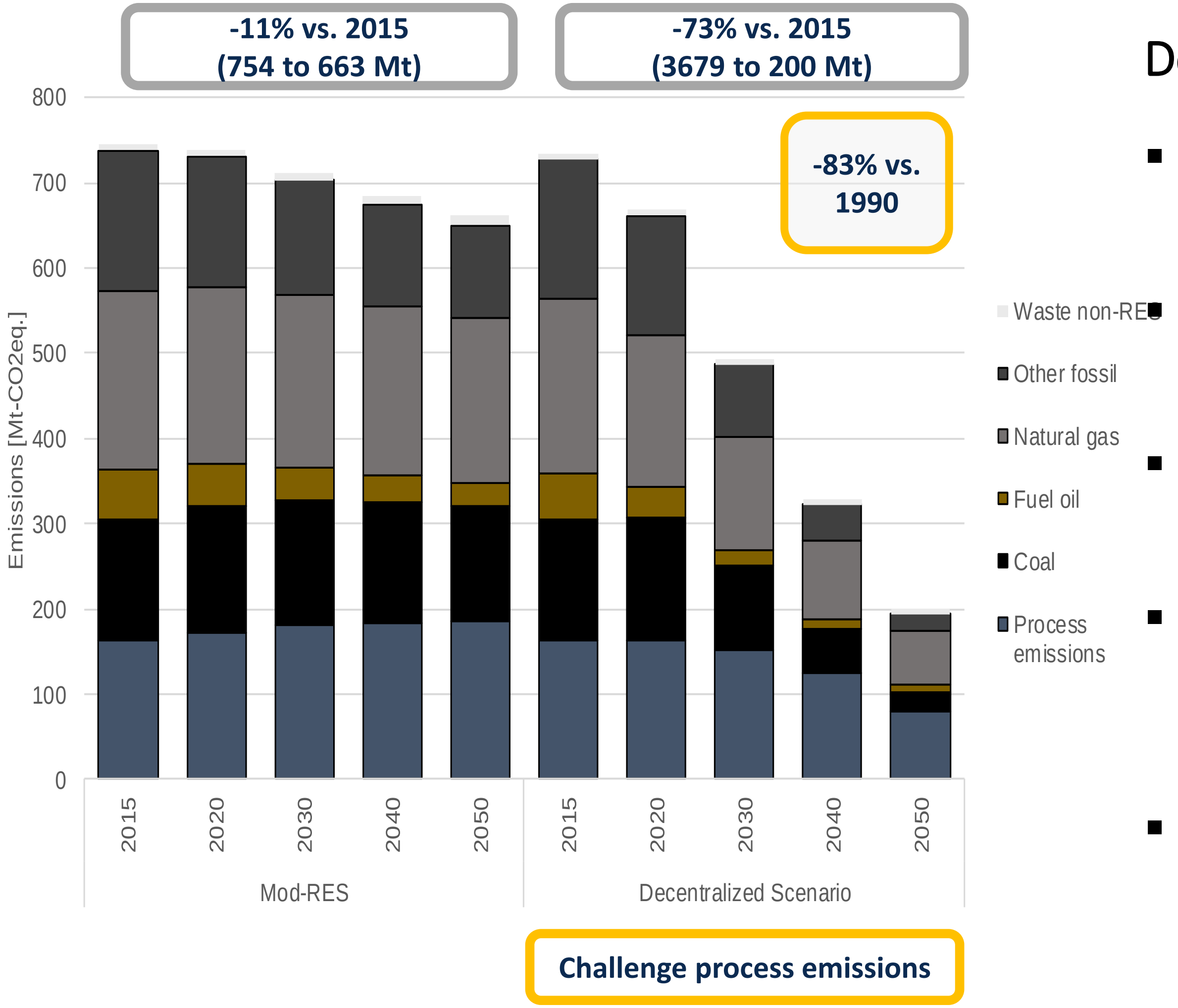
H_2 Methanol to Olefins

Ethylene and propylene production from RES H_2 methanol



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

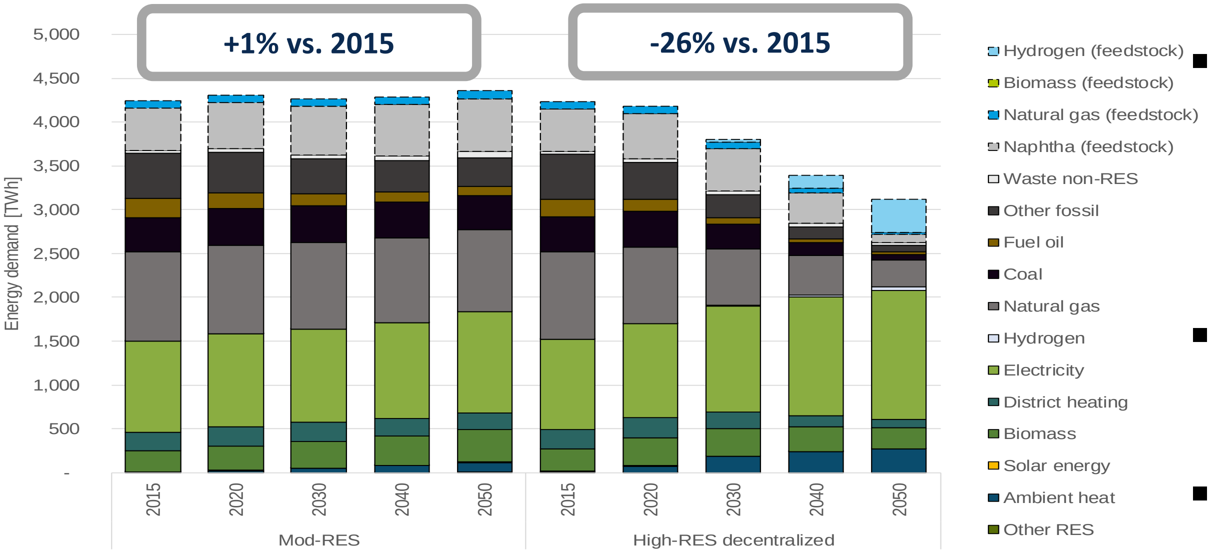
Very high level of ambition enables a high reduction in industrial CO_2 emissions for the EU28

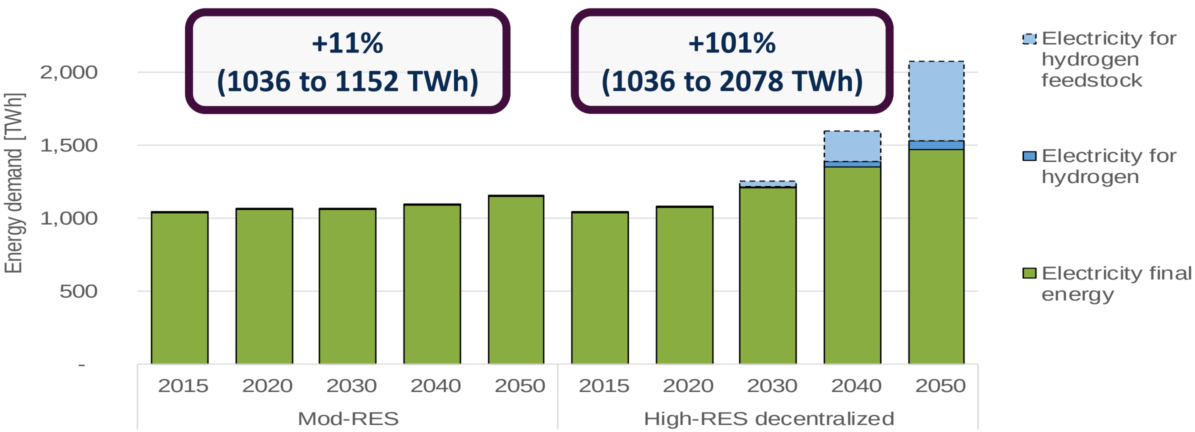


Decarbonising industry via

- Energy-efficient and low-carbon **production innovations**
- Direct **RES based electricity** for process heating
- **RES based hydrogen** as energy carrier and feedstock
- Comprehensive **circular economy & material efficiency** improvements
- Remaining emissions mainly from **natural gas & process-related** (e.g. glass, ceramics)

EU 28 industrial electricity demand increases due to use of H_2 based production processes & direct use of electricity for process heat





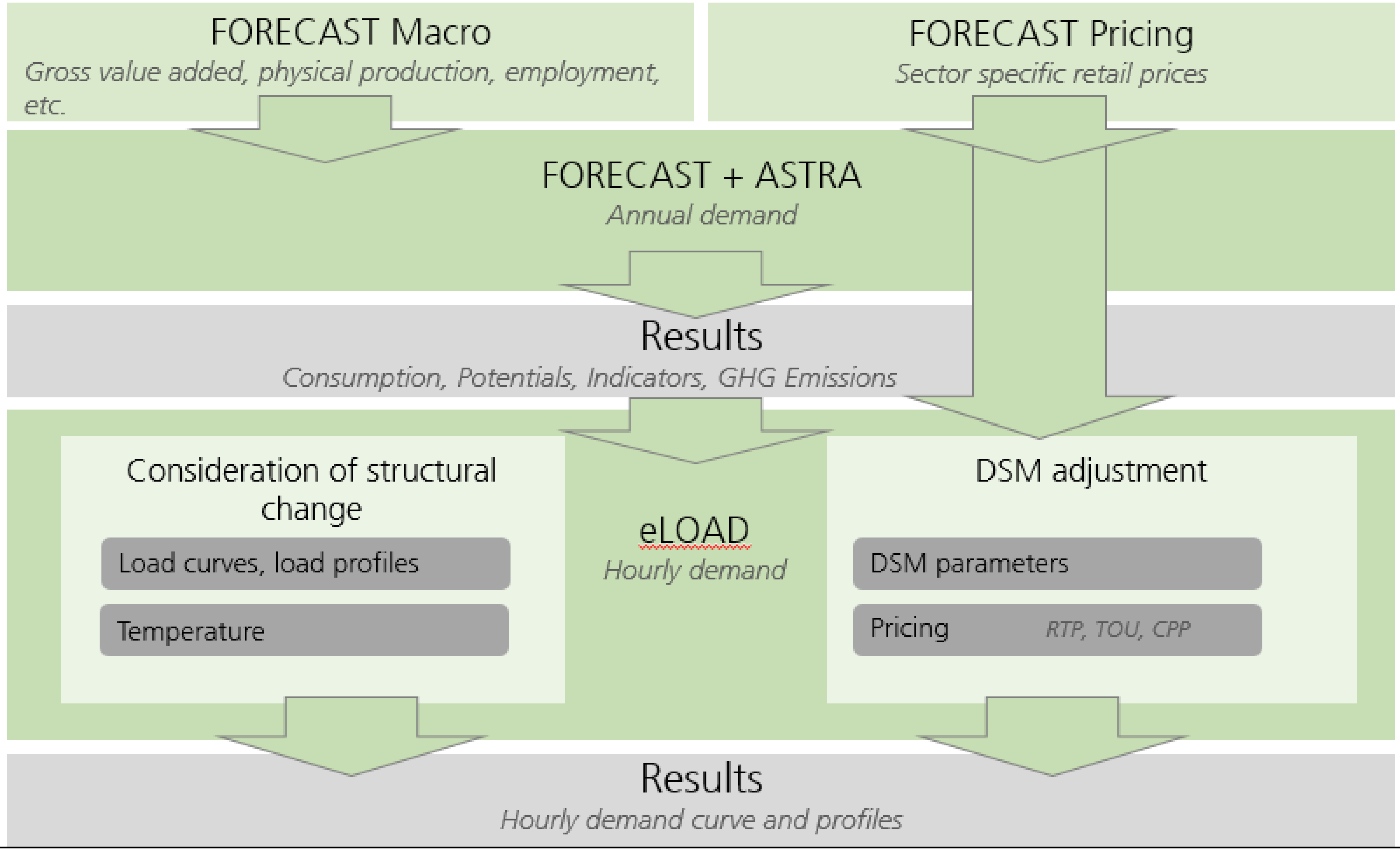
- New uses of **electricity for process heat** in all sectors (e.g. glass electric furnace, steel electrolysis)
- **Biomass** use remains on **current level**
- **RES Hydrogen** is used in the **steel industry** with H_2-DR replacing oxygen steel
- **Feedstocks** are dominated by **RES hydrogen** for the production of **ammonia, methanol & methanol-based ethylene** (384 TWh H_2 -> 549 TWh electricity)

Summary: Innovations facilitate decarbonisation of EU industry

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, – CO_2-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 ▪ CO_2 tax to provide incentives for companies outside the ETS ▪ Policies to boost material efficiency & circular economy as well as energy efficiency

Agenda

Methodology

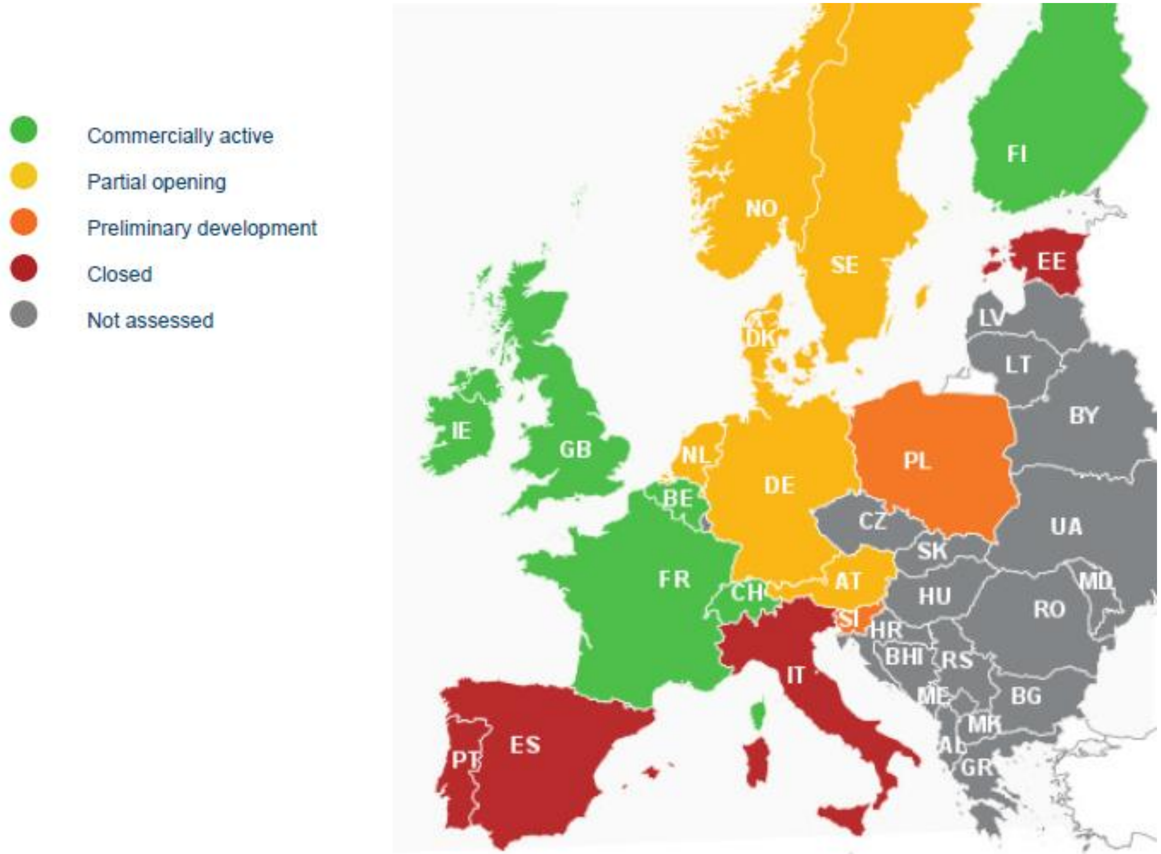


Source: https://www.forecast-model.eu

Regulatory framework conditions

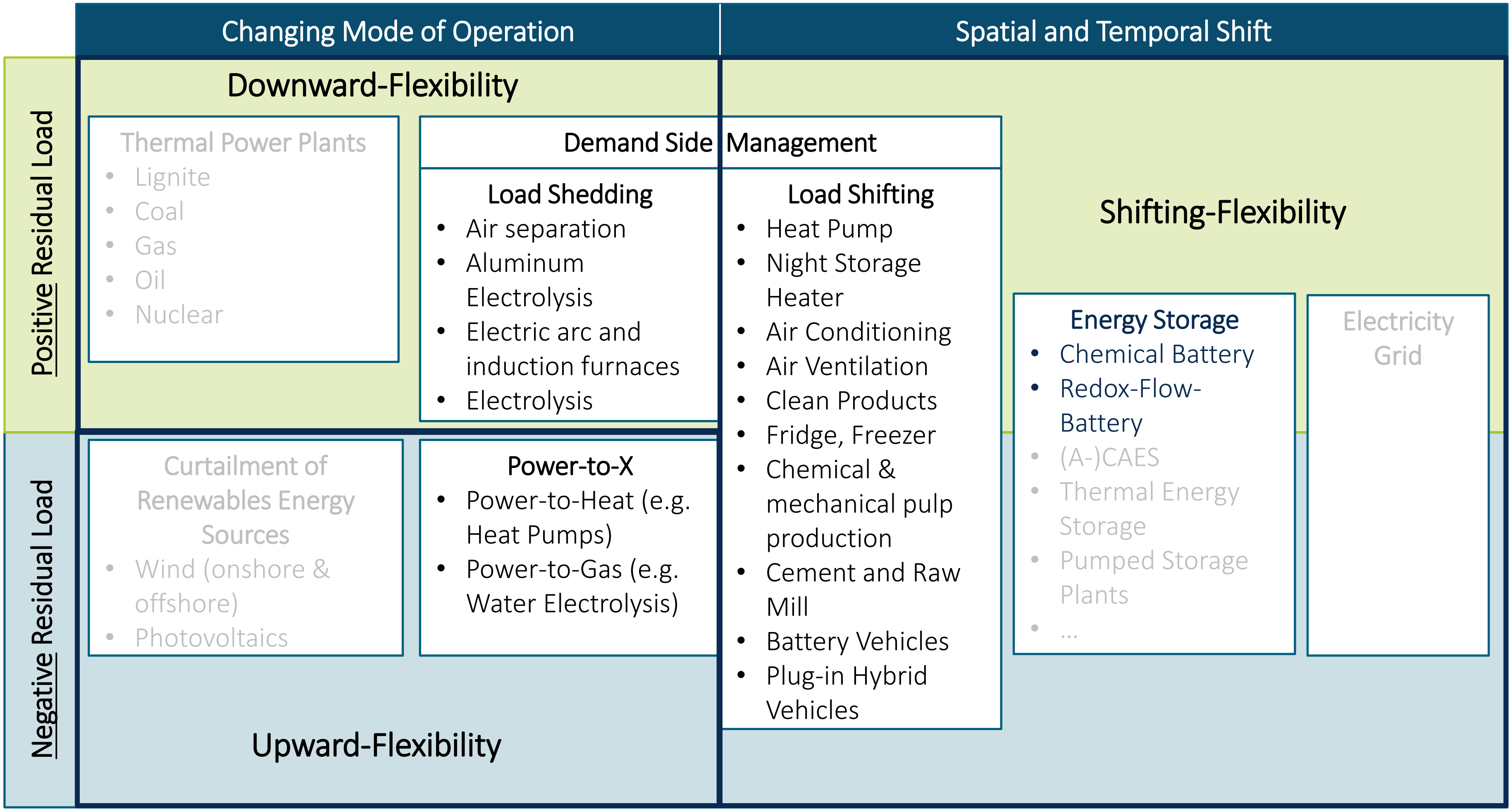
Demand side management is addressed in the Energy Efficiency Directive by:

- Encouraging demand side resources to participate in wholesale and retail markets
- The requirement to treat demand response providers, including aggregators, in a non-discriminatory manner
- Member States promoting access to and participation of demand response in balancing, reserve and other system services markets
- Requiring national energy regulatory authorities to define technical modalities



Map of explicit demand response development in Europe Source: SEDC 2017

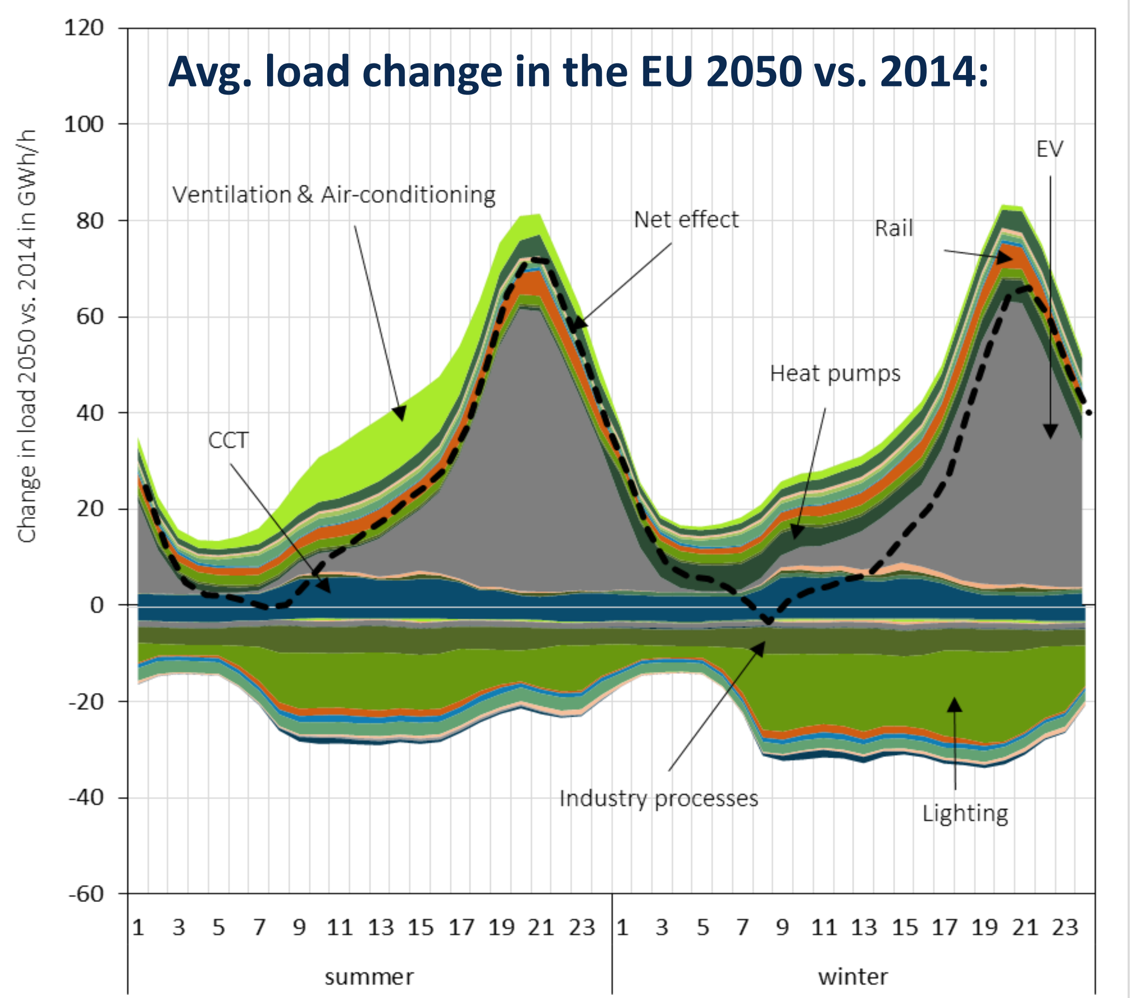
How can flexibility be provided? Classification of flexibility



Source: own illustration

Structural changes in system load

- Electrification of transport leads to **increasing peak loads** in the evening hours (if not managed)
- Increasing electricity demand for heating and cooling systems increases **temperature sensitivity** in particular in countries with cold and hot climate
- Results from the ModRES scenario 2014 vs. 2050

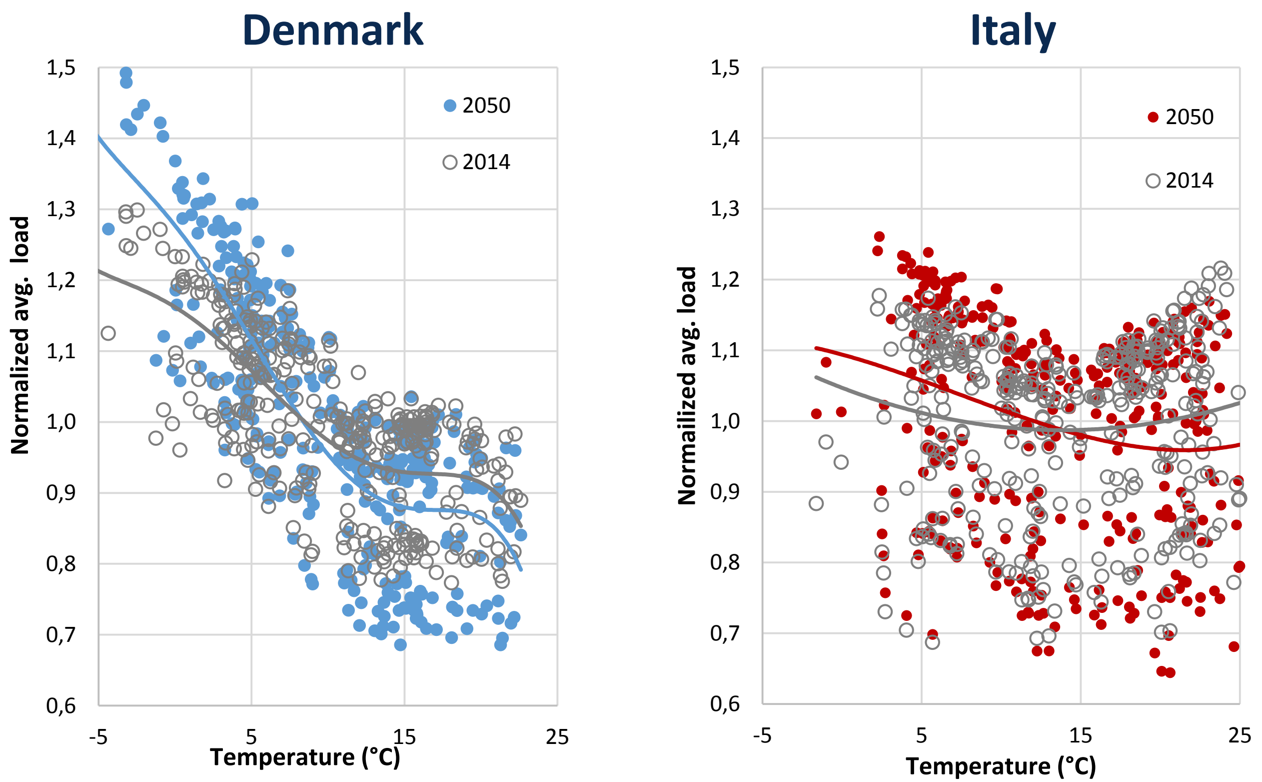


Heating & cooling processes most relevant demand-side flexibility in short- to medium-future

- Due to **high temporal availability** and **high installation rates**, heating & cooling processes show the most important demand-side flexibility potential in the near future (even considering relative low willingness to participate)
- Results from the ModRES Scenario

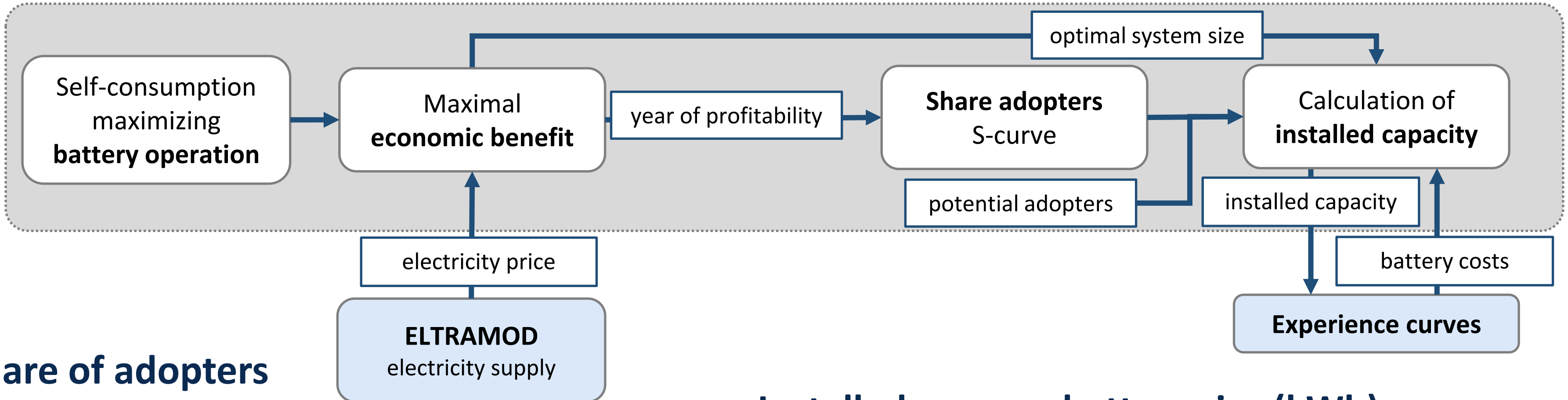
Sector	Process	2020	2030	2040	2050
HH	Ventilation & Air-conditioning	<1%	<1%	<1%	<1%
	Heat pumps	16%	36%	16%	21%
TE	Ventilation & Air-conditioning (*)	<1%	<1%	<1%	<1%
	Heat pumps	5%	4%	3%	2%
	Circulation pumps and heating auxiliaries	<1%	<1%	<1%	<1%
	Refrigeration	59%	27%	34%	34%
IND	Cement grinding	<1%	<1%	<1%	<1%
	Electric arc furnace	14%	24%	17%	4%
	Mechanical pulp	5%	4%	2%	2%
TRANS	e-Mobility	1%	4%	28%	38%
	∑	**100%**	**100%**	**100%**	**100%**

Temperature sensitivity of system load increase

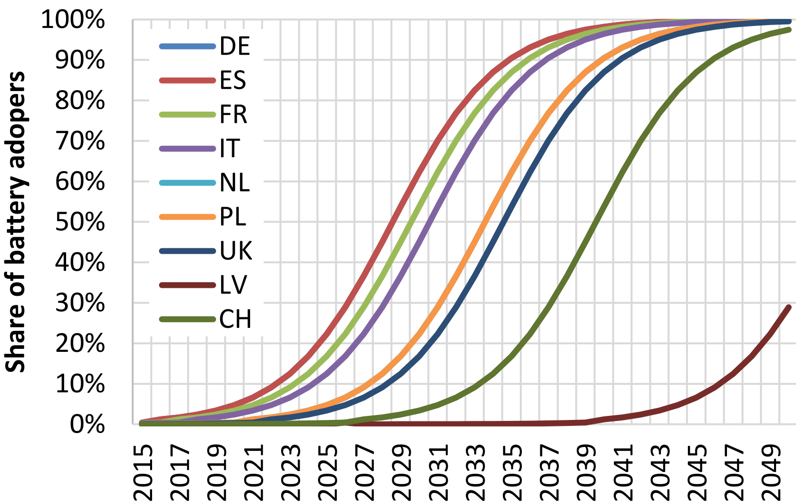


- Results from the HighRES centralized scenario (2014 vs. 2050)
- Temperature sensitivity increases for most countries due to electrification of heating

Due to technological learning and high electricity prices, solar storage systems are an option for households in most EU countries



Share of adopters in PV roof-top owners



Installed average battery size (kWh)

country	2015	2016	2017	2018	2019	2020	2030	2040	2050
CH	0	0	0	0	0	0	2.5	5	5
DE	0	0	0	2.5	2.5	5	5	5	5
ES	0	0	0	2.5	5	5	7.5	7.5	7.5
FR	0	0	0	0	2.5	5	7.5	7.5	7.5
IT	0	0	0	0	0	2.5	5	5	5
NL	0	0	0	0	0	0	5	5	5
PL	0	0	0	0	0	0	2.5	2.5	2.5
UK	0	0	0	0	0	0	5	5	5

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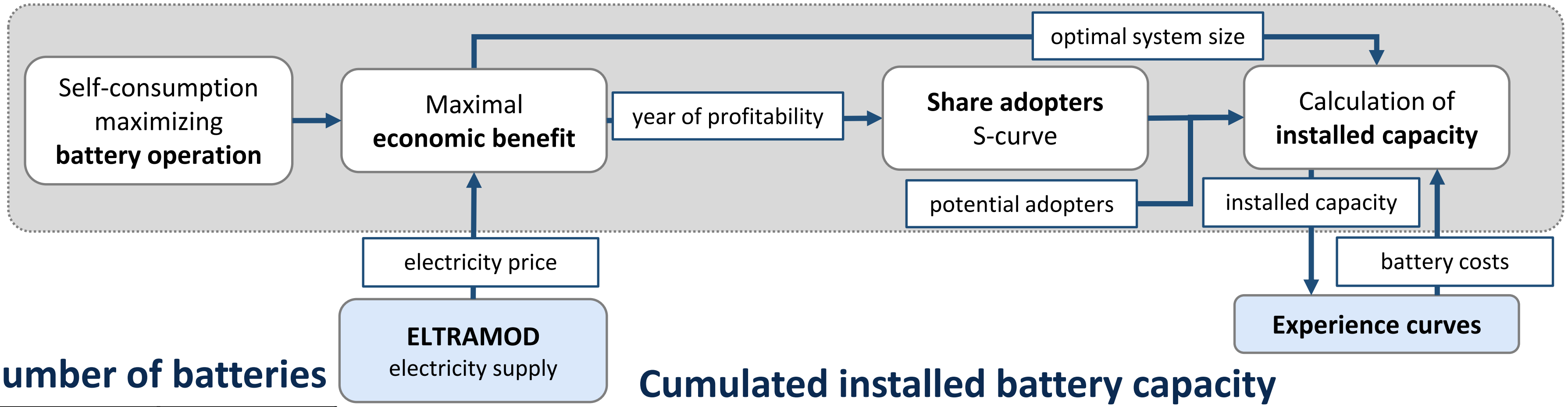


Number of batteries

country	2050
DE	12.8 Mio.
ES	9.1 Mio.
FR	13.5 Mio.
IT	12.5 Mio.
NL	1.1 Mio.
PL	4.1 Mio.
UK	9.2 Mio.
CH	2.2 Mio.
EU28+CH	**81.9 Mio.**

Cumulated installed battery capacity

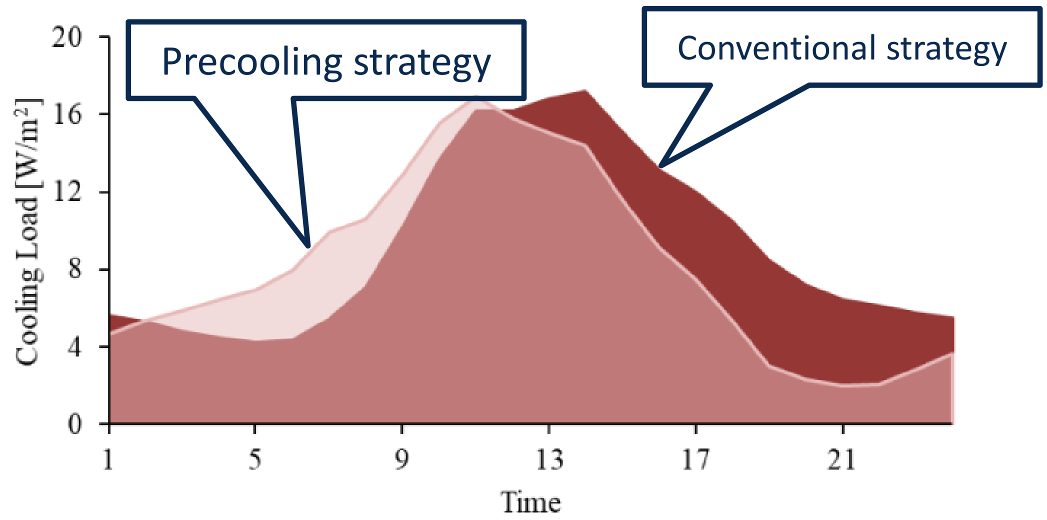
country	*Unit*	2020	2030	2040	2050
DE	*MWh*	2,404	39,003	54,865	63,861
ES	*MWh*	162	14,186	45,873	68,563
FR	*MWh*	1,264	36,108	73,182	100,286
IT	*MWh*	250	13,067	28,725	62,404
NL	*MWh*	0	2,000	6,392	5,329
PL	*MWh*	0	829	7,671	10,236
UK	*MWh*	0	6,053	36,033	45,942
CH	*MWh*	0	73	3,808	10,810
EU28+CH	***MWh***	**4,145**	**126,765**	**319,267**	**467,567**

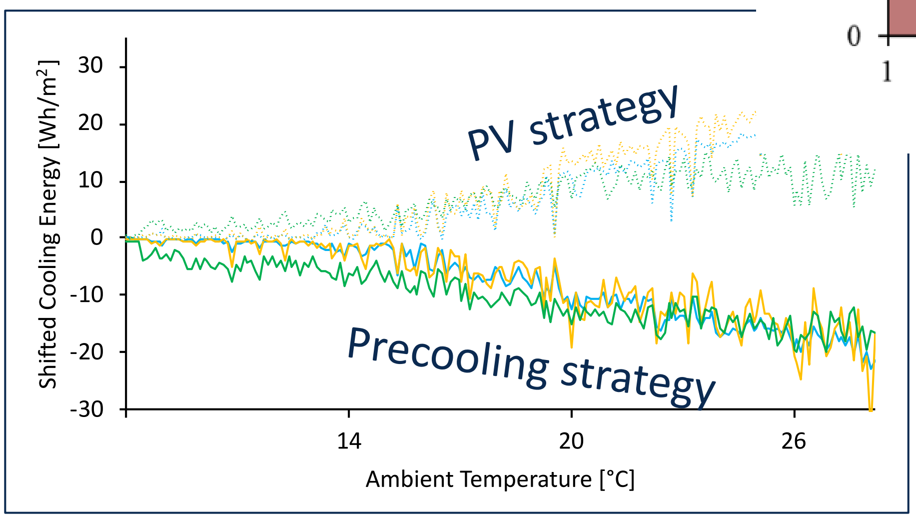
Air conditioning strategies offer additional shifting potentials in the buildings sector

Selected example for a building in southern Italy on a hot summer day

Shifting potential depends on

- Load shifting strategy
- Building structure
- Defined comfort levels
- The use of free cooling

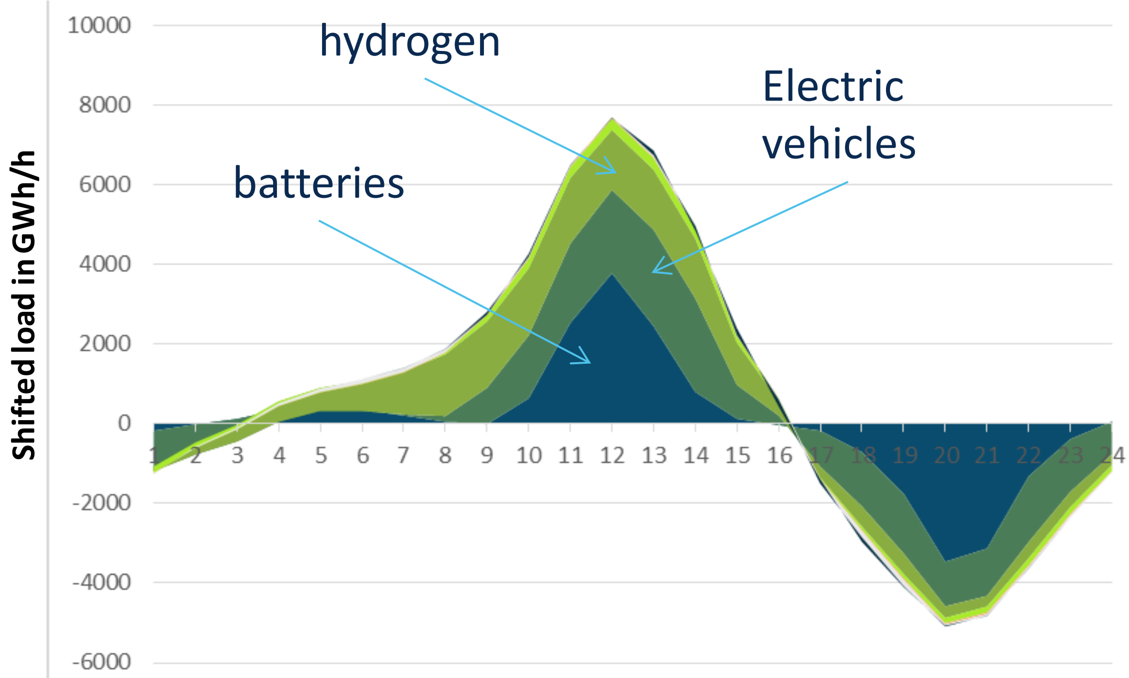




Combined impact on the residual load from different demand side management potentials in households

Possible flexibility provision:

- Batteries and their integration into load management offer large potential to shift excess renewable generation from peak hours into off-peak hours
- Depending on acceptance rates for the integration of electric vehicles into load management, considerable load can be distributed during within the day



Agenda

Conclusions

- **Decarbonization of the heat sector (process heating, steam & hot water, space heating):**
  - Industry

    80% decarbonization is possible – even without CCS, but requires:
    - process innovations, CO_2-free secondary energy carriers, innovations in material efficiency & circular economy
  - Buildings
    - Increase retrofit rate and retrofit depth: reduce heating demand, enable renewables
    - Efficient building technologies, appliances and controls (building automation)
    - Switching energy carrier to cover remaining demand with RES
  - Challenge to tap and supply renewable energy sources in urban areas
    - Energy sources: Ambient energy from lakes, rivers, ground(water), waste water, incineration, residual heat
    - Supply: Including local area networks using heat pumps, excess heat and regeneration of heat sources

Conclusions

- **Demand side flexibility**
  - In the building sector, untapped demand side management potentials are available but they need more favorable conditions across all EU countries
    - Regulatory: Allowance for bid aggregation, non-discriminatory market regulation, etc.
    - Market: Price signal in the tertiary sector to integrate e.g. heat pumps or air conditioning
    - Information: improved information on advantages and technical solutions to integrate flexibility on the demand side
- **Foster techno-economic progress (learning investments), not presented here:**
  - For heat pumps to reduce cost for
    - Equipment
    - Drilling
    - Planning and installation
  - For building insulation materials to reduce cost for
    - Insulation materials
    - Window glazing (incl. smart glazing)

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THANK YOU!

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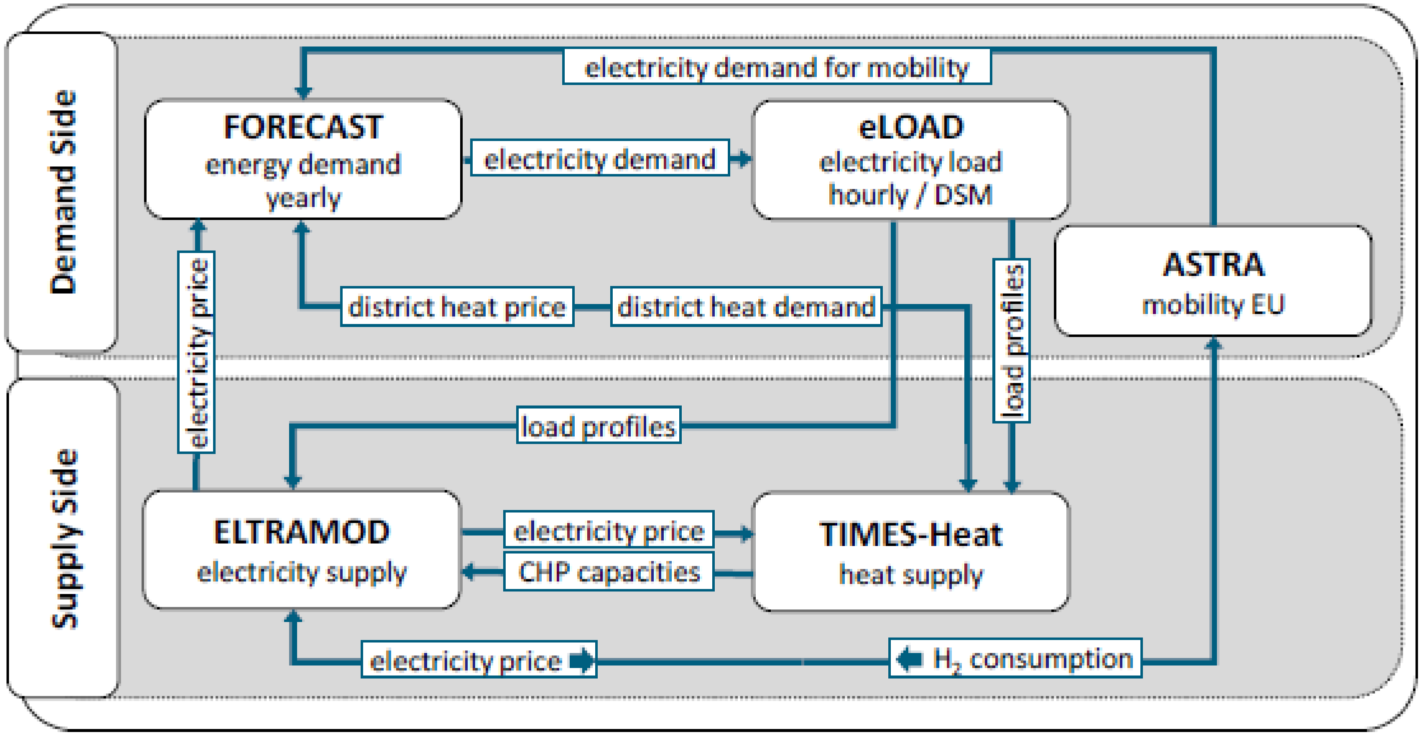
Backup

Overview model coupling on demand side



Sector perspectives

Industry sector

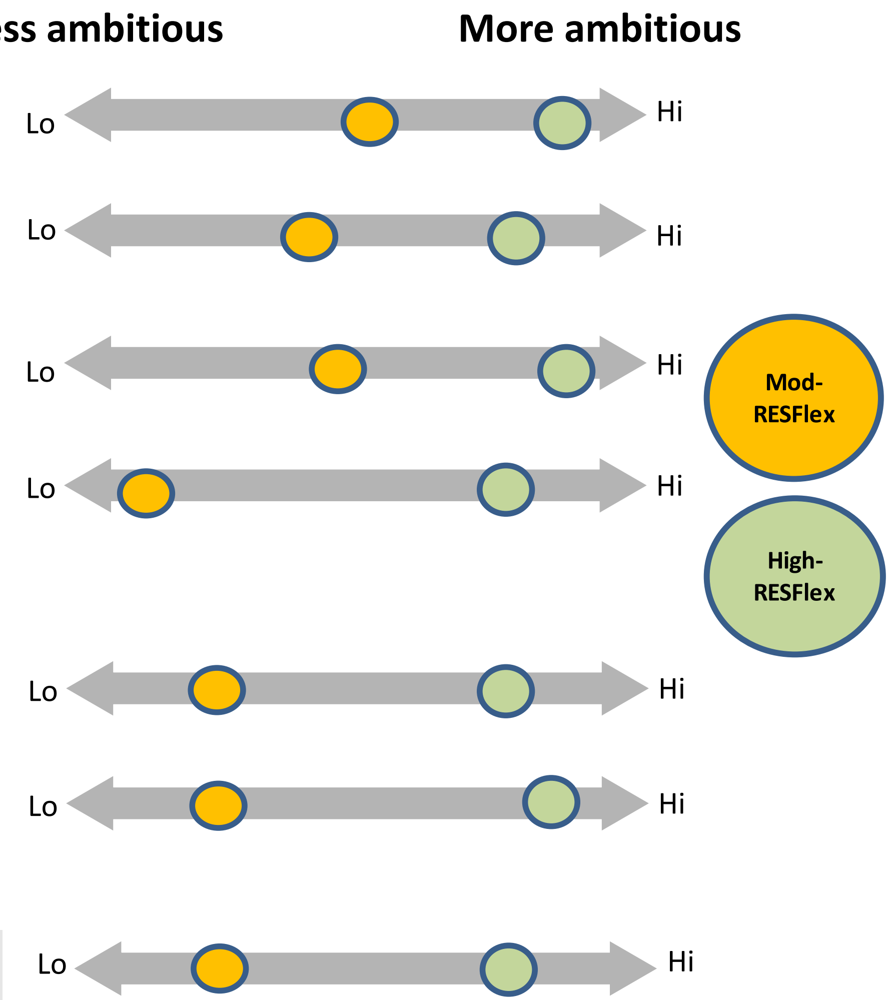
Energy efficiency	Diffusion of saving options (e.g. WHR, near net-shape casting)
Material efficiency	Trends to higher gross value added, trend to secondary production
Fuel switch to electricity	Fuel switch to electricity (preferred to biomass)
Innovative process technologies	New processes enter the market (e.g. DRI RES H_2, low carbon cement)

Transport sector

Transport policies	Efficiency, low-/zero-emission vehicles
Technologies	Share of electric vehicles charge control, ...

Building sector

Building standards and renewable energies	Efficiency, low-/zero-emission buildings



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