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Expert Consultation on Scenarios for Decarbonising European Industries

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Modelling approach

Deep-dive into the levers and ambition levels

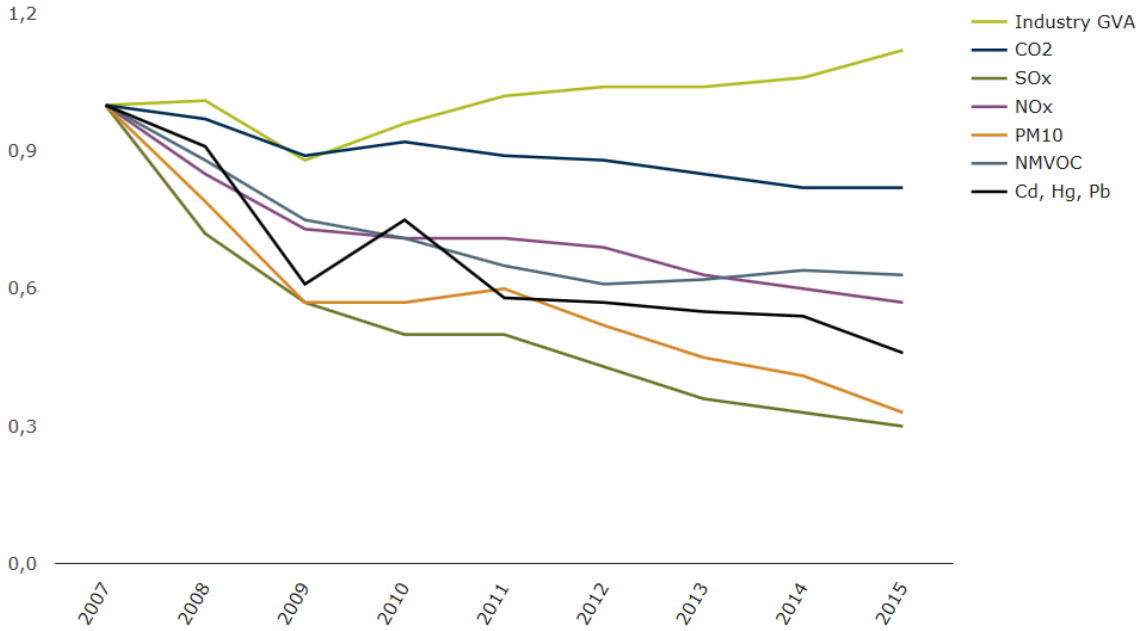
Discussion

Bibliography

Industry remains a significant source for energy consumption and GHG emissions mitigation in EU

Release of air pollutants for industry (2007=1)

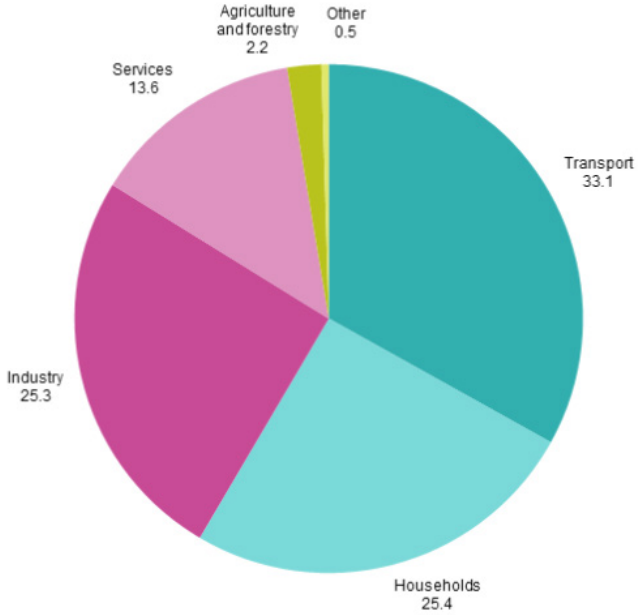
Industry remains a significant source of pollutant



Source: European Environment Agency (2018)

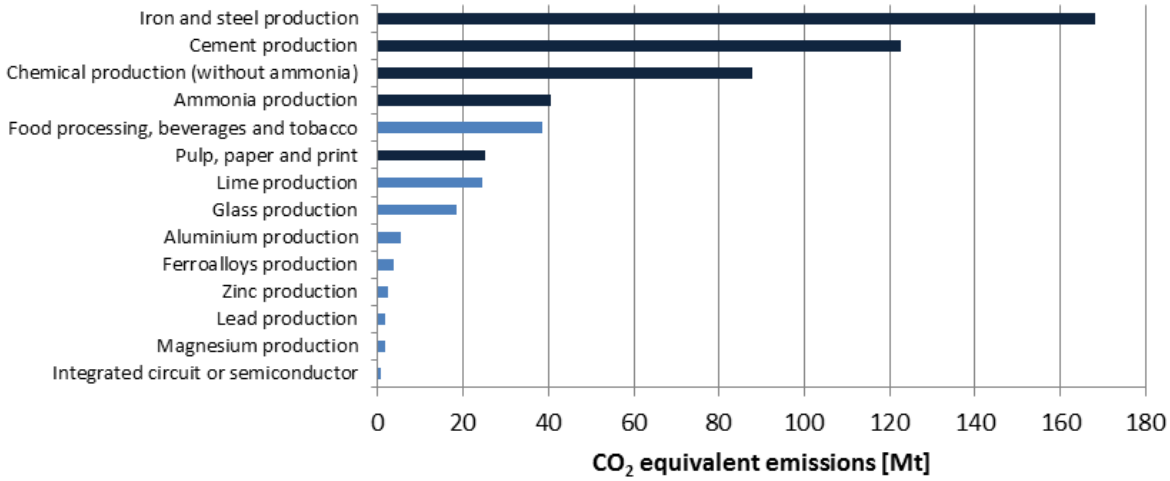
Final energy consumption

(EU-28, 2015, % of total)



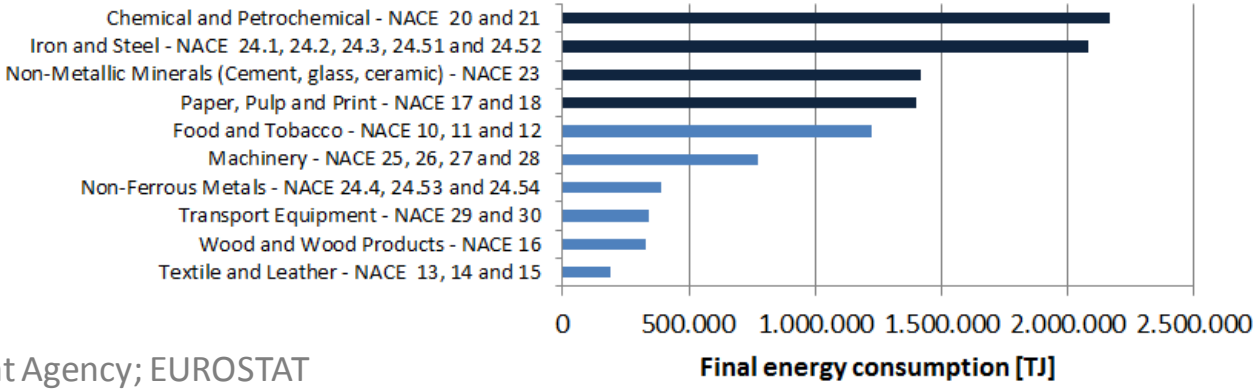
Source: Eurostat (nrg_100a, 2018)

Identification and selection of EU industries to be covered



CO_2 equivalent emissions
(Mt, 2015)

Final energy consumption
(TJ, 2015)



Sources: European Environment Agency; EUROSTAT

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Key questions and scope (across all sectors)

Basic **questions** to be resolved:

- What are possible decarbonisation scenarios?
- What are the contributions from various emitting sectors? What are the key levers?

Stakeholders (and **engagement**)

- EU Calc partners and network
- Selected experts (from research, industry and public bodies)
- Call for evidence (public)

Scope of solutions space and constraints

- Focus on yearly energy balances
- EU integrated level and MS granularity

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2050 Trajectories

Deep-dive into the levers and ambition levels

Example: Iron and Steel

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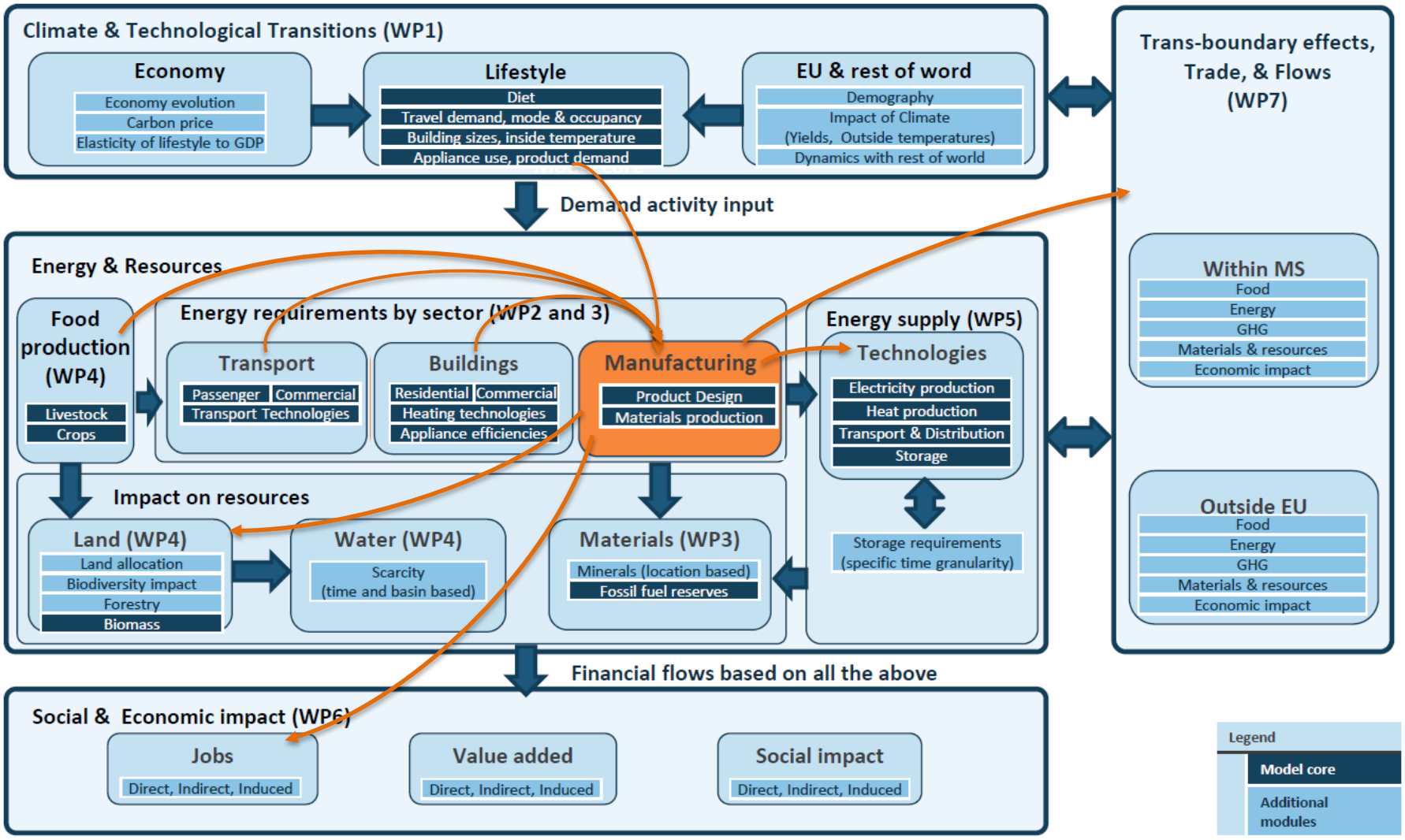
Global structure of the model



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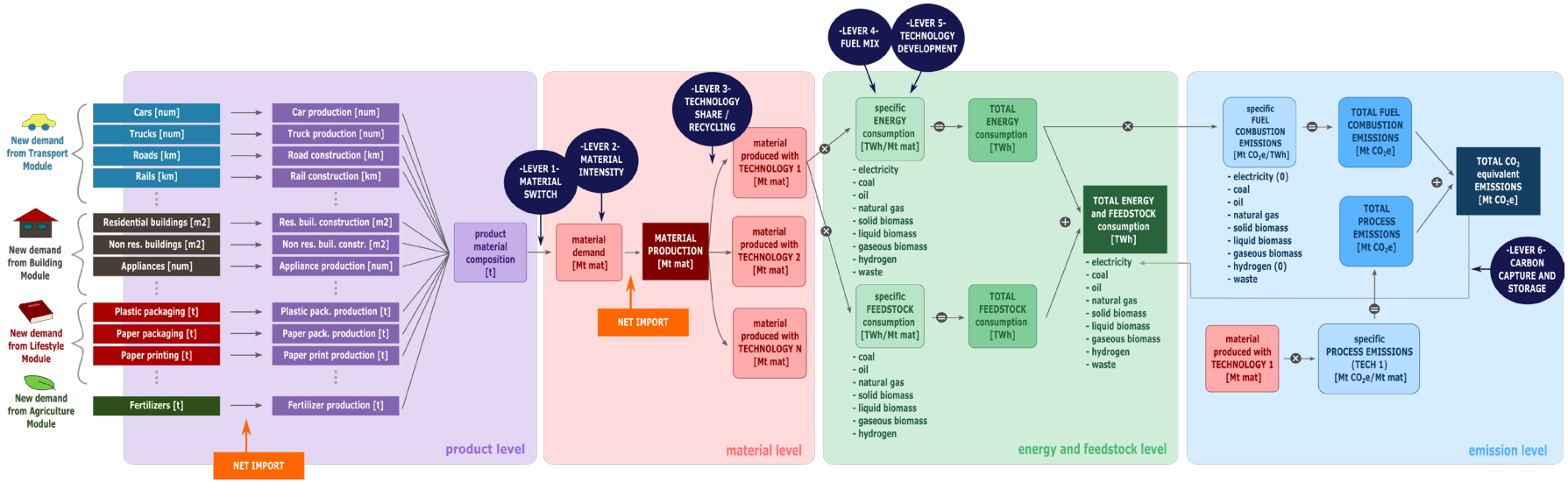
Industry workstream



activities [pass.km] → **products [cars]** → **materials [steel]** → **energy [kWh coal]** → **emissions [tCO_2]**

Industrial production is a function of choices performed in other sectors

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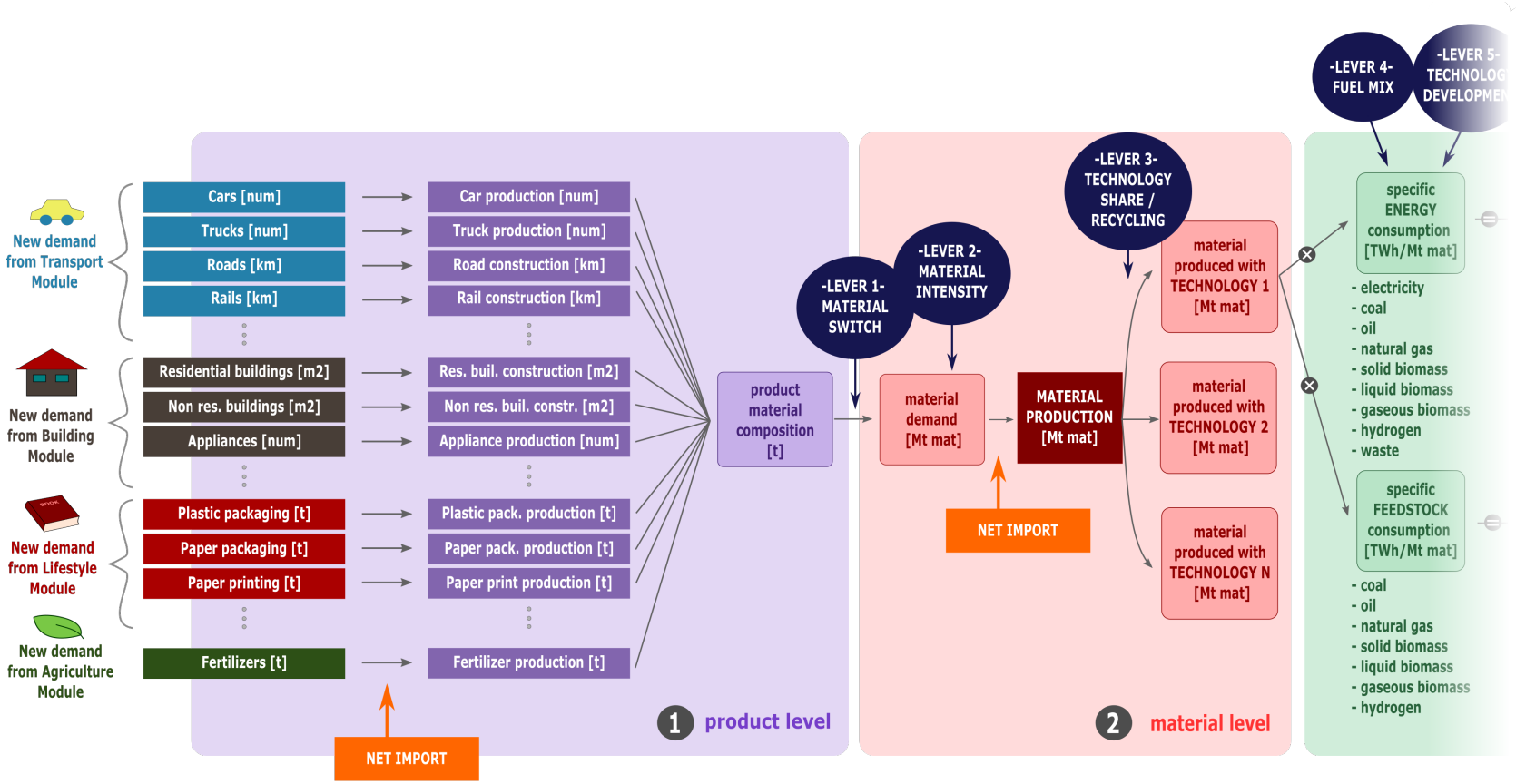
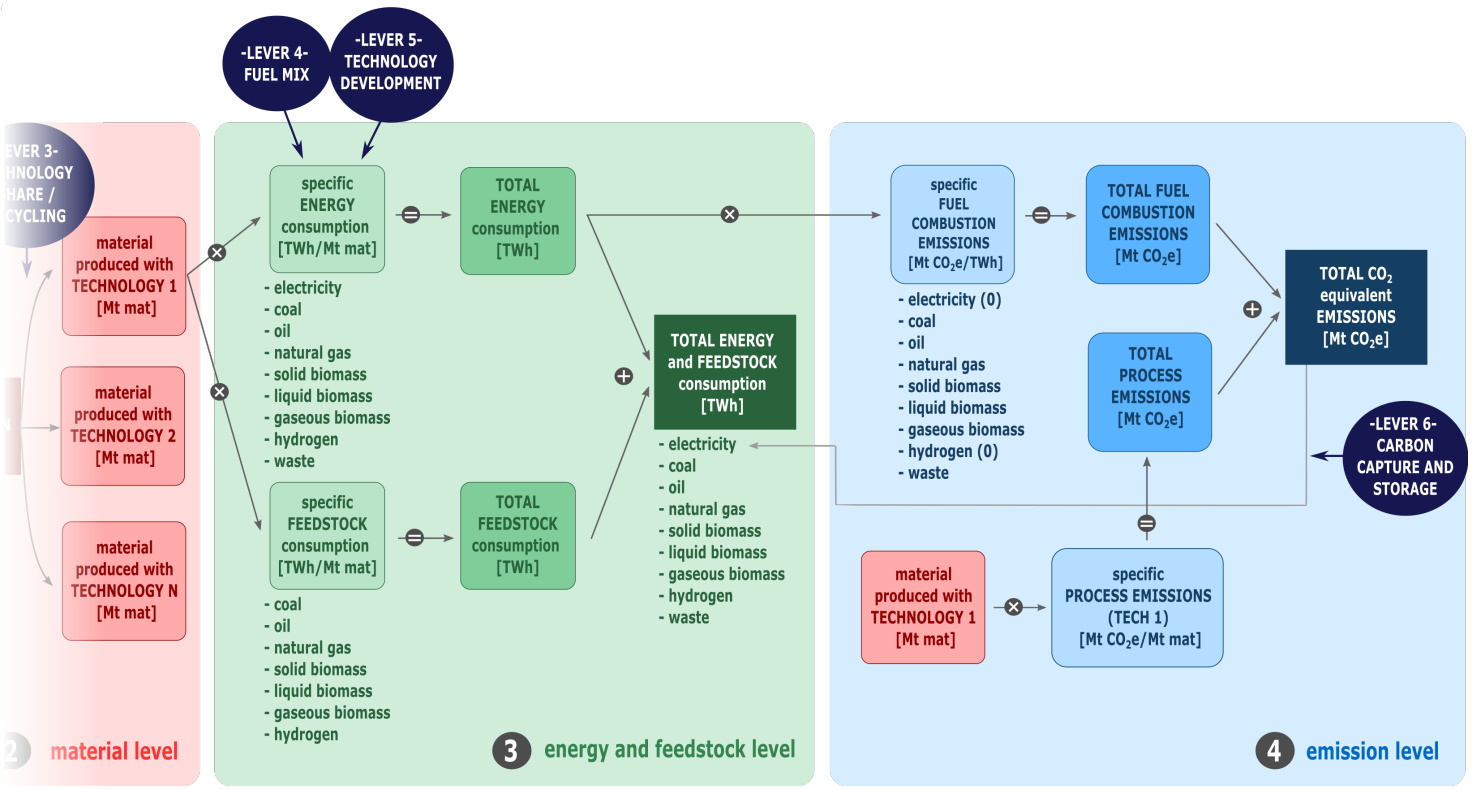
Industry workstream



Covers functional economy, product lifetime, imported products/materials, material substitution and intensity, technology share and development

Industry workstream



…Fuel mix and switches, recycled material ratios, Carbon Capture & Storage

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Scope of the analysis

NEW PRODUCT DEMAND

From Transport

- Int. combustion engine cars [num]
- Int. combustion engine trucks [num]
- Fuel cell cars [num]
- Fuel cell trucks [num]
- Electric cars EVs[num]
- Electric trucks [num]
- Ships [num]
- Trains [num]
- Planes [num]
- Trolley-cables [km]
- Roads [km]
- Rails [km]

From Agriculture

- N-fertilizers [t]

From Building

- Residential buildings [m2]
- Non-residential buildings [m2]
- Insulation residential buildings [m2]
- Insulation non-residential buildings [m2]
- Fridges [num]
- Washing machines [num]
- Dishwashers [num]
- District heating pipes [km]

From Lifestyle

- Plastic packaging [t]
- Paper packaging [t]
- Paper printing and graphic [t]
- Paper sanitary and household [t]

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Scope of the analysis

INDUSTRIES & TECHNOLOGIES

Steel [Mt]
- BF-BOF [%]
- Scrap-EAF [%]
- DRI-EAF [%]
- Hisarna [%]

Cement [Mt]
- Dry kilns [%]
- Wet kilns [%]
- Geopolymers [%]

Ammonia [Mt]

Other chemicals [Mt]

Paper and pulp [Mt]
- Wood pulp [%]
- Recycling [%]

Other industries [Mt]

ENERGY VECTORS

- Coal [TWh]
- Oil [TWh]
- Natural gas [TWh]
- Solid biomass [TWh]
- Liquid biomass [TWh]
- Gaseous biomass [TWh]
- Electricity [TWh]
- Hydrogen [TWh]
- Waste [TWh]

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6 levers to model the potential for decarbonising the industrial sector

#	Levers	Underlying levers (non-modelled, implicitly included)
1.	Material switch	Substitution of materials used in products (e.g. more aluminium and less steel in cars)
2.	Material intensity	Reduction of the material intensity (e.g. replacing common steel with high strength steel)
3.	Technology share/ recycling	Change of technology in the material production (e.g. switching from primary route to the recycling route or to innovative technologies)
4.	Fuel mix/ switch	Switch to green energy vectors in the material production (e.g. from fossil to biomass)
5.	Technology development	Increase of energy efficiency of each technology, new (breakthrough) technologies, R&D
6.	Carbon capture & storage	Use of CCS to capture carbon dioxide

Outputs

- Material production (per technology)
- Energy consumption (per vector)
- Emissions (per GHG type)
- Costs

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Modelling approach

- Calculation logic and scope of the model
- **2050 Trajectories**

Deep-dive into the levers and ambition levels

Discussion

2050 trajectories

2050 trajectories are defined in 3 steps:

- Historic calibration to 2015 (Gaps are plugged)
  - Product demand from other sectors; share of products manufactured in the EU
  - Material production from specific material consumption; share of materials manufactured in the EU from EUROSTAT
  - Energy vector for energy or feedstocks from EUROSTAT; split per origin (primary & secondary) and per technology from desk research
  - Specific process emissions from literature; GHG emissions from combustion and processes from EUROSTAT
- Definition of EU-wide ambition levels for 2050
  - General ambition levels defined in the project (BAU ←→ Transformational)
  - Levels are based on existing literature and expert inputs
- Choice of curve shape between present and 2050 (uptake, deployment)
  - Based on existing literature (technology roadmaps) and expert inputs

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4 ambition levels as boundaries to create scenarios

Level 1

- **Current development** scenario (coherent with historical trends)
- No additional effort
- „BAU scenario“

Level 2

- **Increased ambition** compared to BAU
- No breakthrough, but more extensive use of existing technologies

Level 3

- **Very Ambitious** but realistic. Significant effort requiring changes in the system, leveraging best practices available today
- Typically reaching -80 %

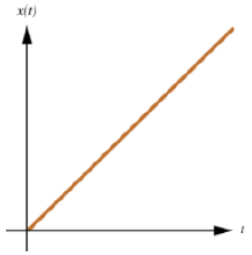
Level 4

Transformational breakthrough: Maximum potential based on transformational changes but reflecting technical or physical constraints

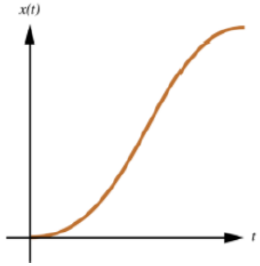
The levels are based on existing literature and expert inputs.

Choices of curve shape between now and 2050

Different types of curves are used

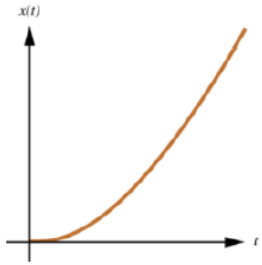


L-curve



S-curve

HS-curve



E-curve

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Example: Iron and Steel

Discussion

Iron and Steel Industry

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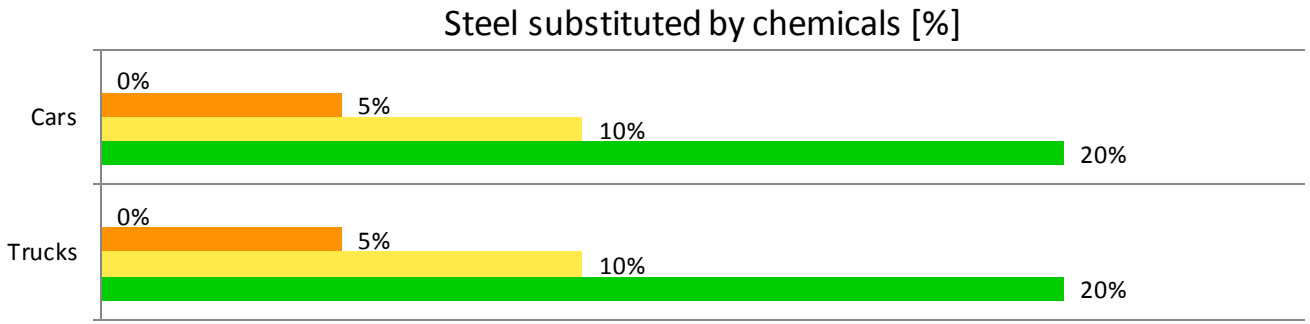
LEVERS (drivers for reducing GHG emissions in the industry sector)

1) Material switch [%]
2) Material intensity [%]
3) Technology share/recycling [%]
4) Fuel mix (energy vector mix) [%]
5) Technology development [%]
6) Carbon capture and storage [%]

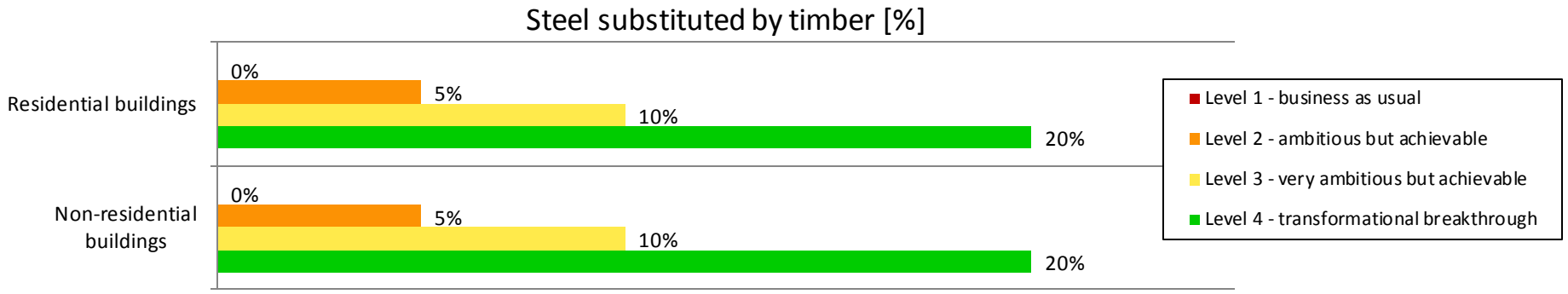
Lever 1 – Material Switch

In which percentage is the steel going to be replaced by other materials in products?

TRANSPORT SECTOR



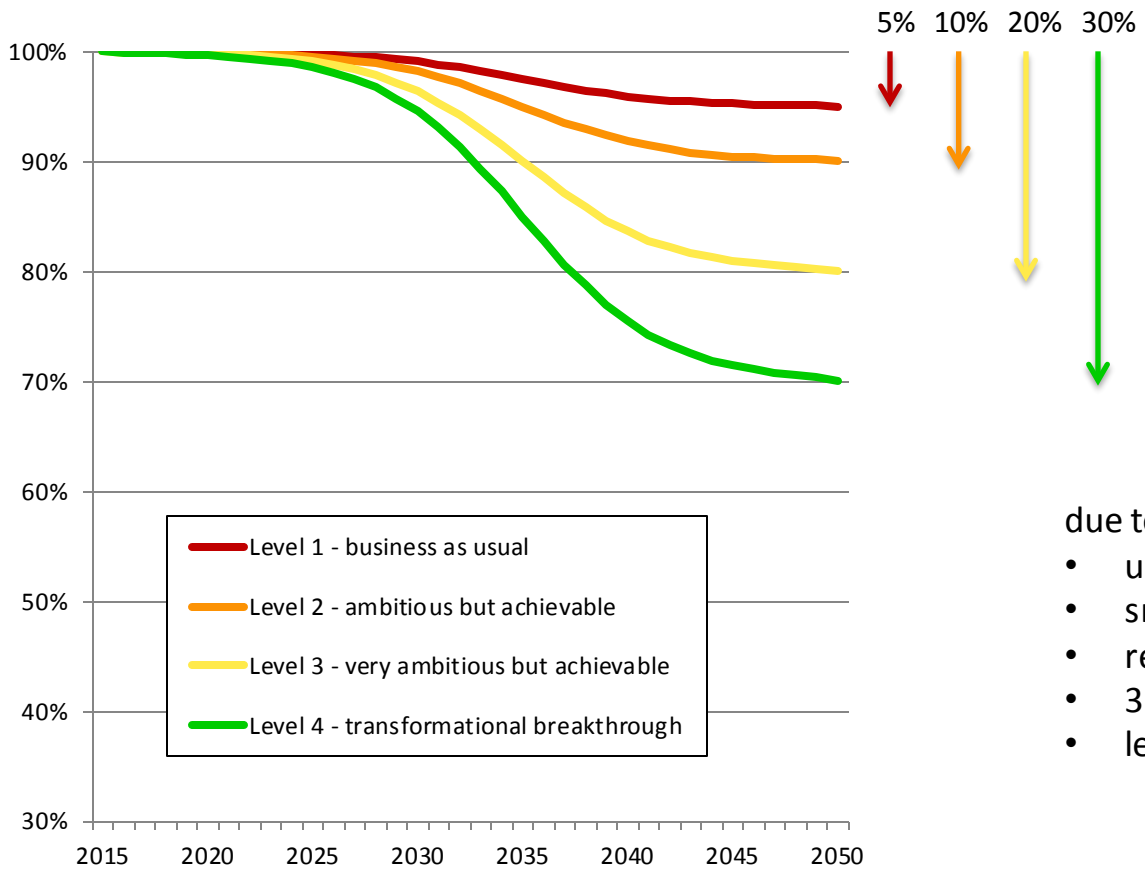
BUILDING SECTOR



Source:
Global Calculator

Lever 2 – Material Intensity

How much is the steel use going to decrease?



due to:

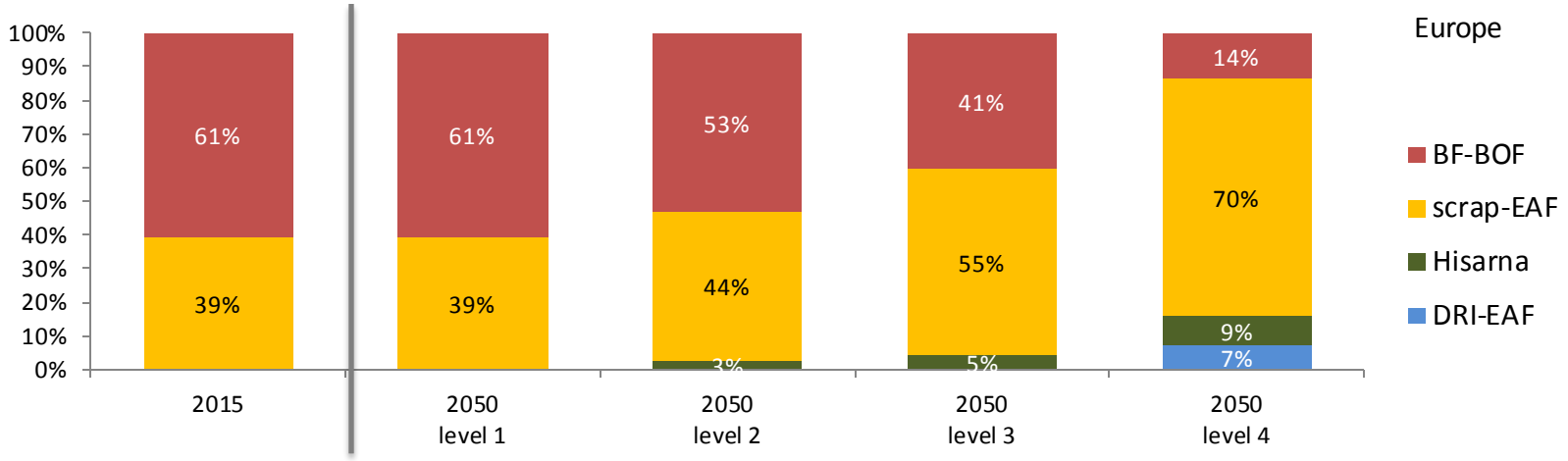
- use of high strength steel
- smart design
- reuse of components
- 3D printing
- less production waste

Sources:
Material economics (2018), The circular economy – A powerful force for climate mitigation
Global Calculator

Lever 3 – Technology Share/ Recycling

How much is the share of the recycling route going to increase?
Which new technologies are going to emerge?

- **BF-BOF** (primary route)
- **Scrap- EAF** (recycling route)
- **Hisarna** (ULCOS innovative technology to replace BF)
- **DRI-EAF** (not economically feasible due to higher cost of natural gas in Europe)
- **Electrolysis ULCOWIN** (electrochemical iron reduction without use of carbon)

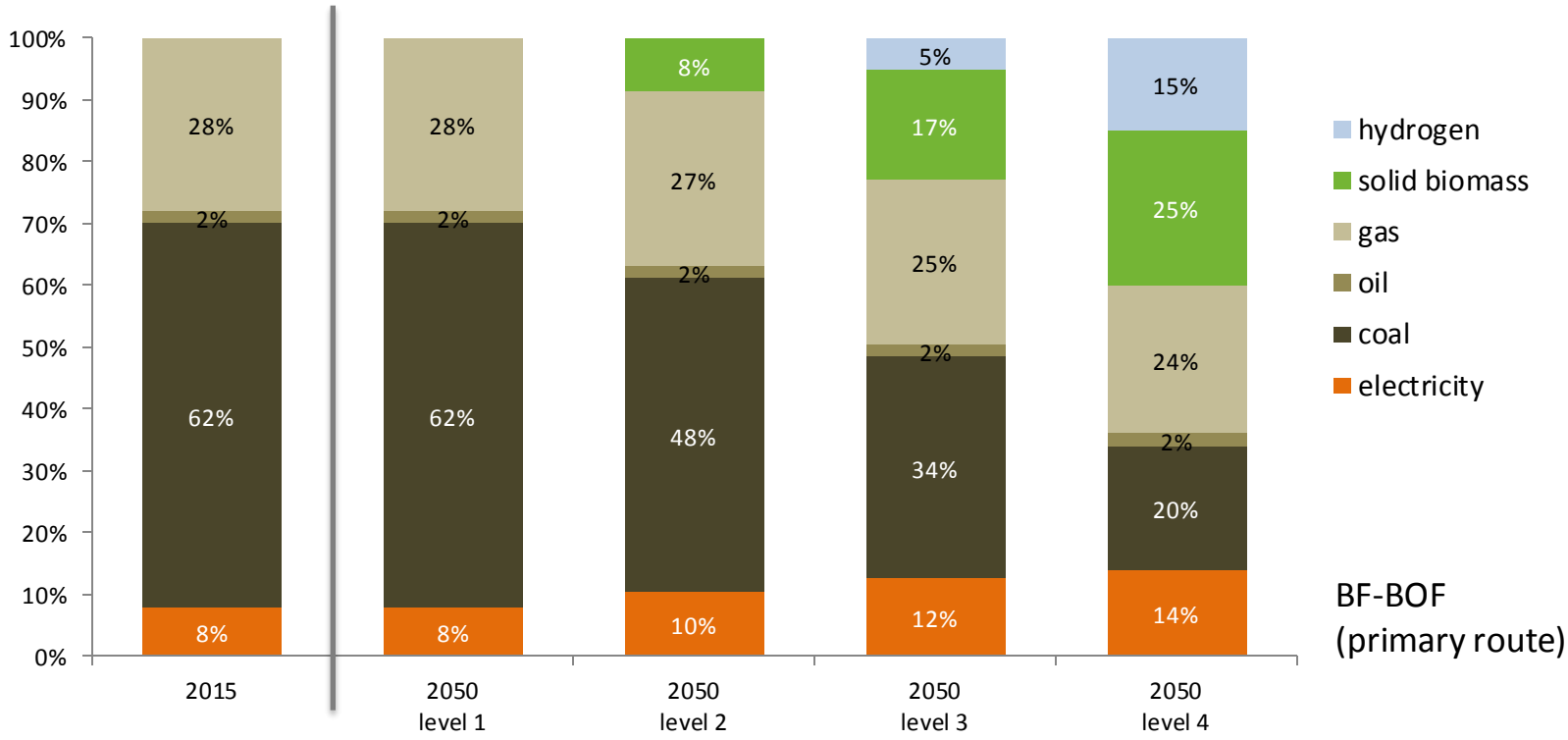


Sources:
Worldsteel association, World steel in figures 2016
BCG and VDEh (2013), Steel's contribution to a low-carbon Europe 2050
Tata Steel, Hisarna factsheet
Eurofer (2013), A steel roadmap for a low carbon Europe 2050

Lever 4 – Energy vector mix

Which energy vectors are going to replace fossil fuels?

- Switch to **biomass** (used to generate the reducing agent)
- Switch to **hydrogen** (used as a reducing agent replacing carbon)

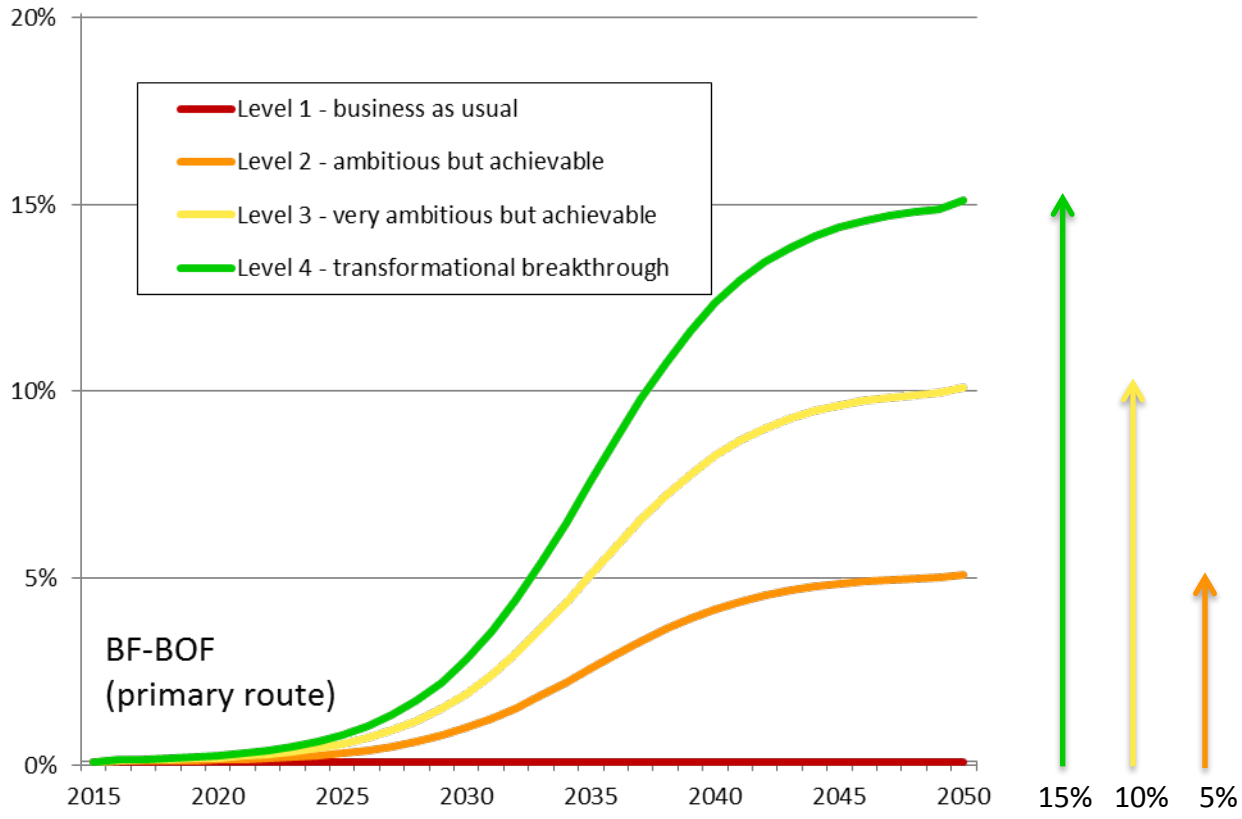


Sources:
BCG and Prognos (2018), Klimapfade für Deutschland
ICF (2015), Study on energy efficiency and energy saving potential in industry and on possible policy mechanisms
Worldsteel Association (2016), Addressing climate change through technology transfer and research
JRC (2013) Technology Map of the European Strategic Energy Technology Plan

Lever 5 – Technology development

How much is the energy efficiency going to increase?

- The existing good reference steel plants are already close to the optimum, however not all European operators are at the level of the best performers



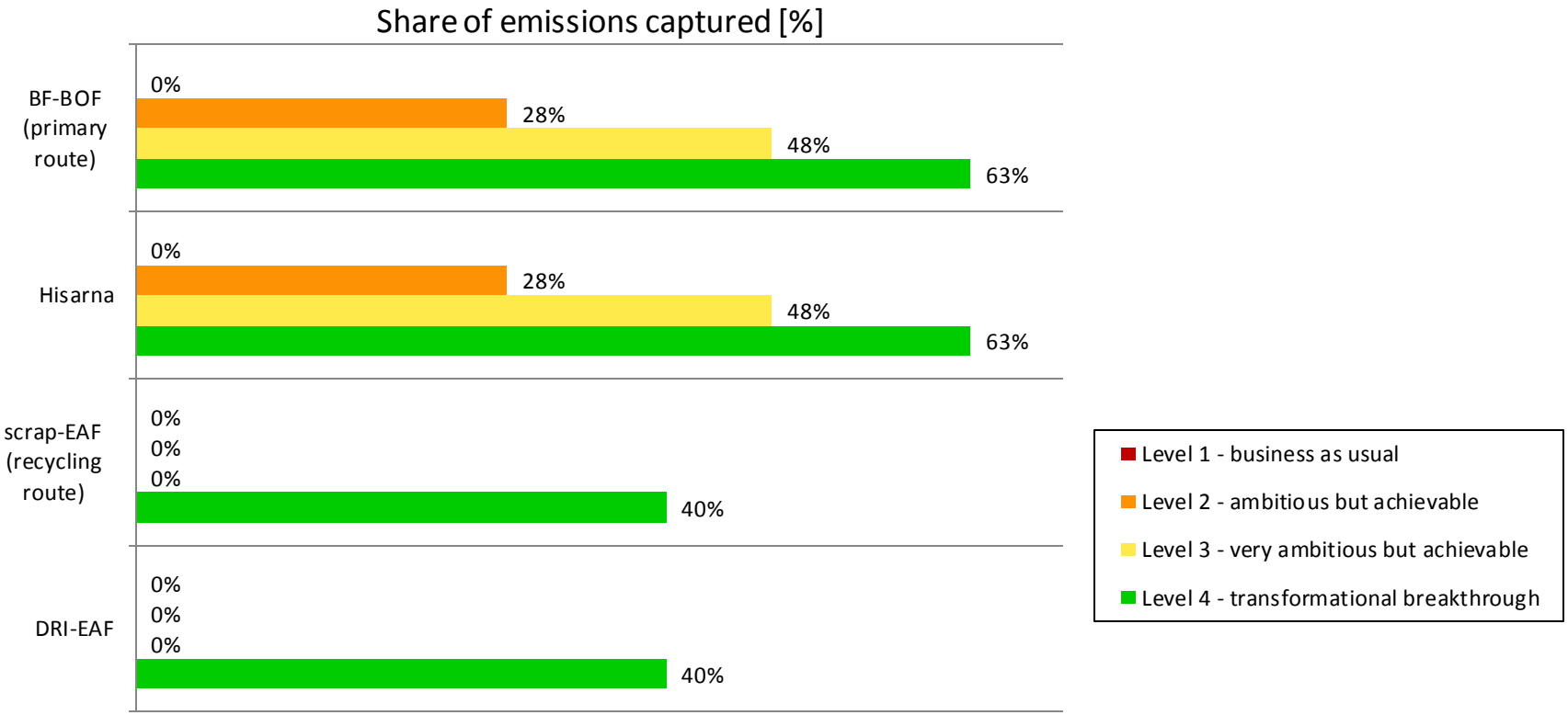
Energy efficiency measures

- Recovery of waste heat (including mean and low levels of temperatures)
- Recovery of process gases in excess (Top gas recycling BF)
- ICT integrated approach for plant energy management
- Reduction of internal waste

Sources:
ICF (2015), Study on energy efficiency and energy saving potential in industry and on possible policy mechanisms
JRC (2013) Technology Map of the European Strategic Energy Technology Plan

Lever 6 – Carbon Capture and Storage

Which role will CCS play in the steel industry by 2050?



Sources:
IEA (2016), 20 years of Carbon Capture and Storage
Eurofer Roadmap Steel
Global Calculator

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Discussion highlights

Key questions

- Do you think the scope of the model is complete? Would you like to add something that should be absolutely included?
- Do you think the levers are described correctly?
- Are any important levers missing?
- Are the levels of ambition mistaken? Indicate which one(s) and describe why.

Ongoing work

- Refinement of product demand evolution
- Covering raw material flows (for material production)
- Refinement of European specifics in industrial levers
- Refinement on MS level (granularity)

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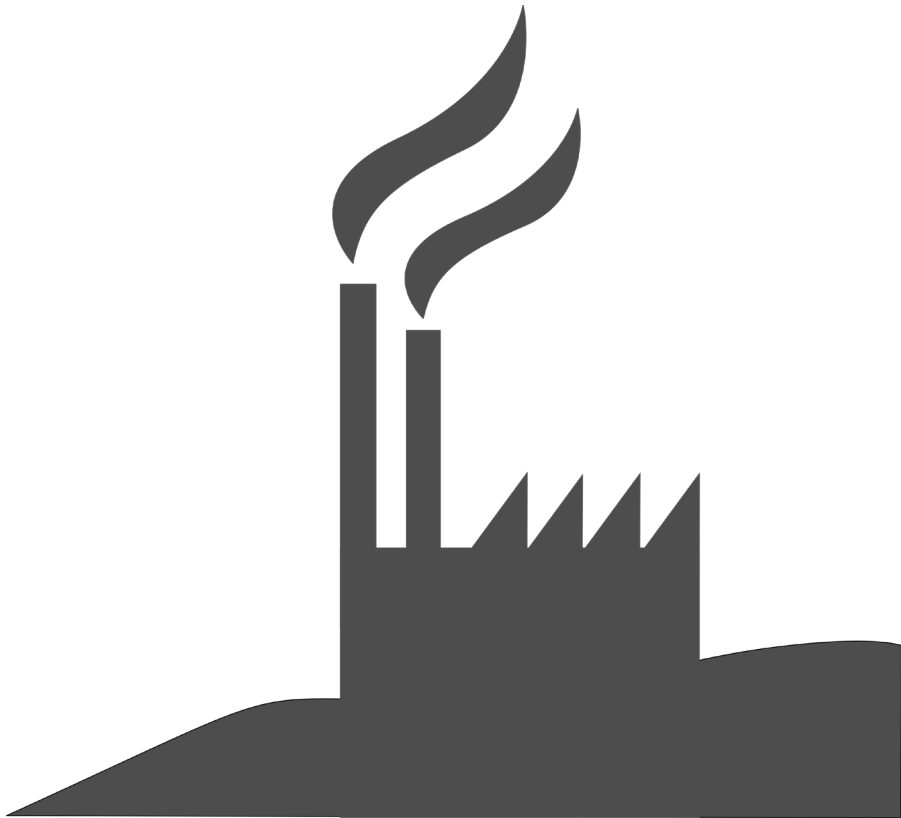
Thank you.



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