



# The role of Carbon Capture Utilization and Storage in the global energy transition: long-term optimization on the industry sector

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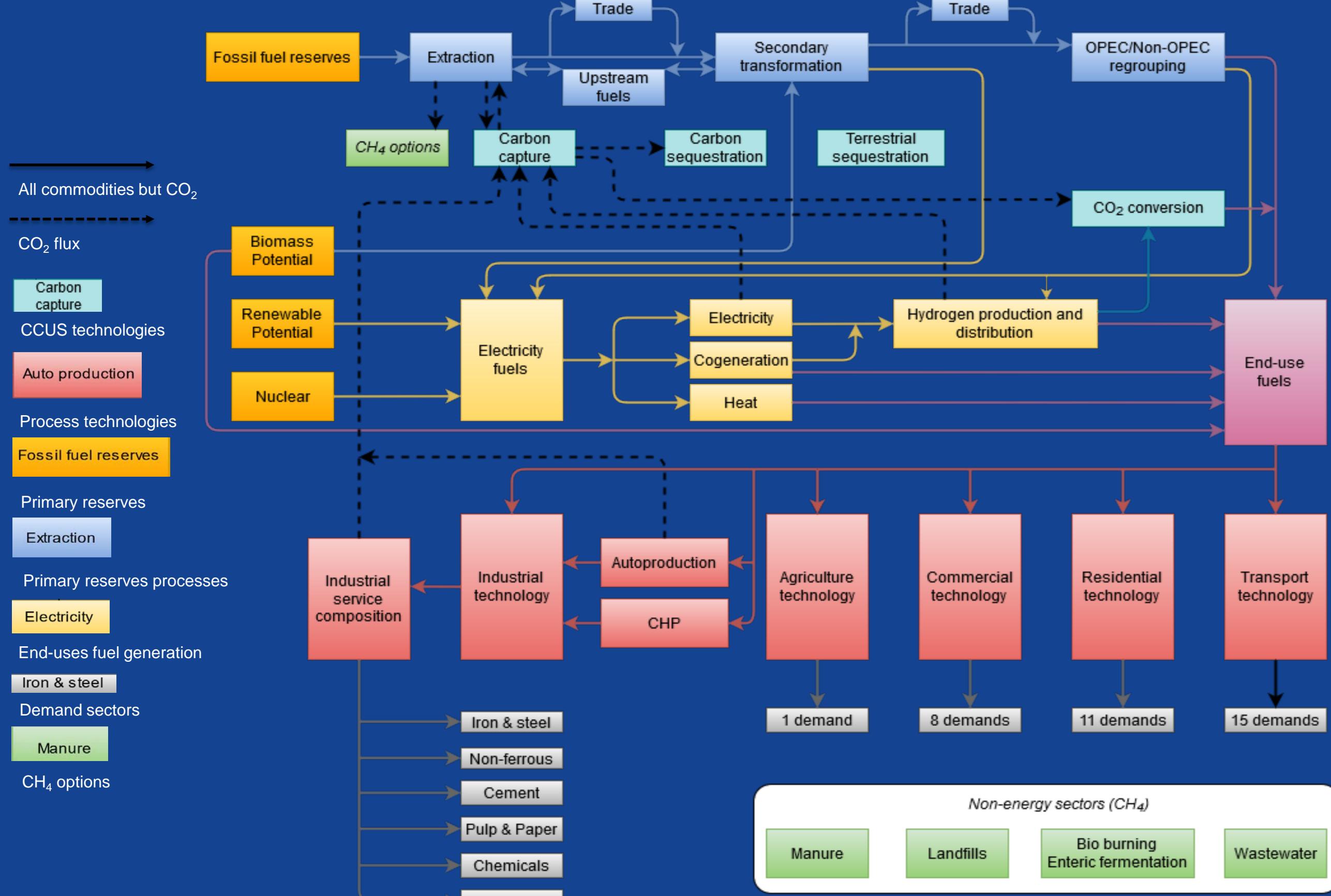
ParisTech's Chair Modeling for  
sustainable development

# THE ROLE OF CARBON CAPTURE UTILIZATION AND STORAGE IN THE GLOBAL ENERGY TRANSITION: LONG-TERM OPTIMIZATION ON THE INDUSTRY SECTOR

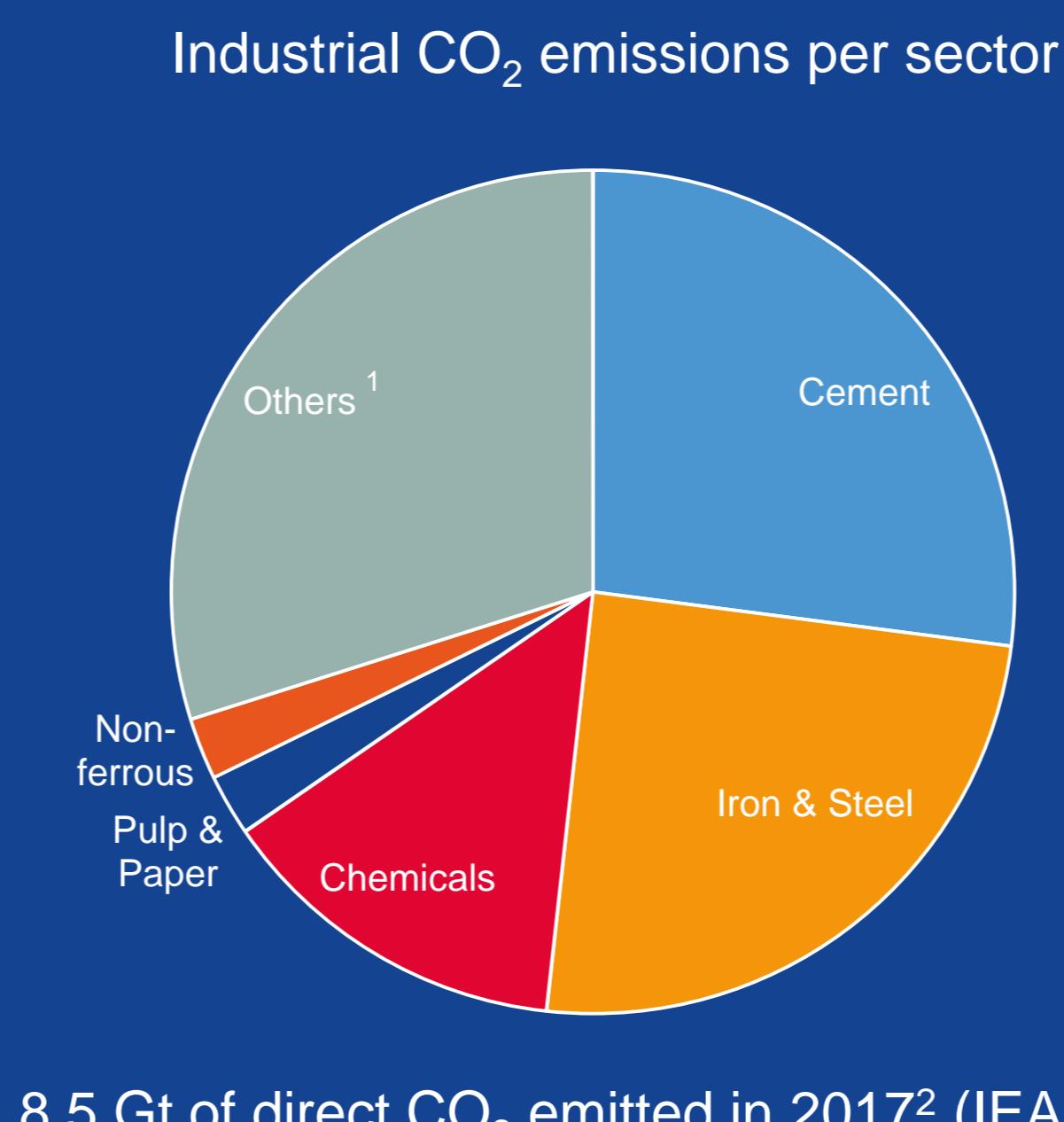
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MINES ParisTech, PSL Research University, Centre for Applied Mathematics

## TIAM-FR Model

- French version of the IEA-ETP TIMES Integrated Assessment Model
- Bottom-up linear programming model optimizing costs over decades
- Geographically integrated into 15 regions
- Commodities, processes and demand depicted in a Reference Energy System below



## CCUS technologies for industry



8.5 Gt of direct CO<sub>2</sub> emitted in 2017<sup>2</sup> (IEA)

### Key facts about industry

- 23% of global direct CO<sub>2</sub> emissions
- 30% of global GHG emissions (direct and indirect)
- 37% of global final energy use
- High dependence on fossil fuels
- Energy intensive 'hard-to-abate' sector
- CCS can achieve industry decarbonization alongside with green hydrogen, blue hydrogen, and energy efficiency
- CCU can reduce both fossil-based fuels and fossil feedstocks

### How CCUS technologies can help reduce industrial CO<sub>2</sub> emissions?

#### Main assumptions and scenarios

- IEA-ETP data (2010)
- Business As Usual
- 25 years technology life duration
- 2100 2°C/1.5°C climate targets
- 1706 GtCO<sub>2</sub> storage capacity
- With and without CCUS

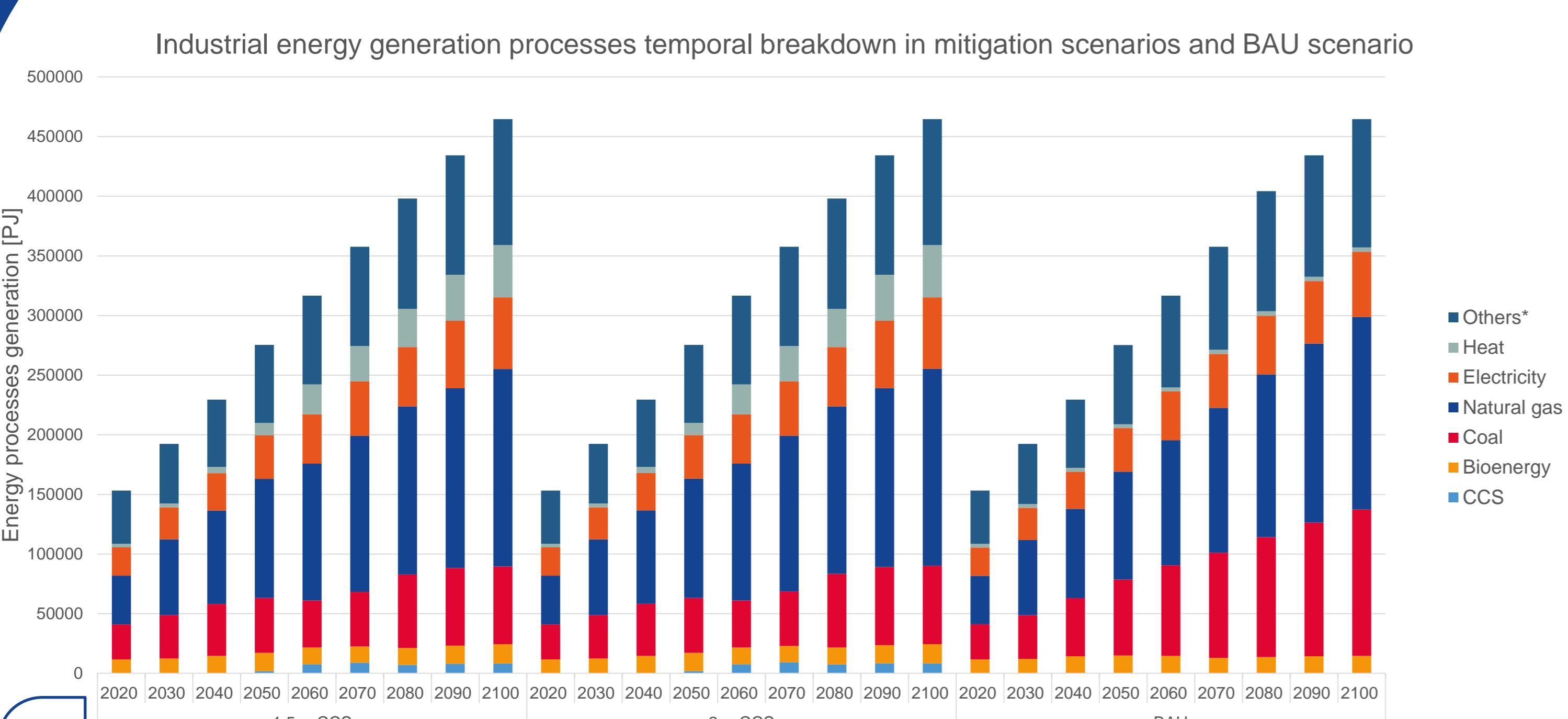
### 3 key sectors for CCUS options in TIAM-FR

Power generation	Industrial processes	Fuel generation
<ul style="list-style-type: none"> <li>Coal-fired + CCS</li> <li>CCGT + CCS</li> <li>Bioenergy + CCS</li> <li>Co-firing + CCS</li> </ul>	<ul style="list-style-type: none"> <li>Process heat + CCS</li> <li>Process steam + CCS</li> <li>Industrial heat + CCS</li> <li>Industrial electricity + CCS</li> <li>Co-generation + CCS</li> </ul>	<ul style="list-style-type: none"> <li>Diesel + CCS</li> <li>Heavy fuels + CCS</li> <li>Ethanol + CCS</li> <li>Hydrogen + CCS</li> <li>CCU for methanol</li> </ul>

<sup>1</sup>Including mainly food-processing, textile, mining, manufacturing and construction industries

<sup>2</sup>Including energy-related and process emissions

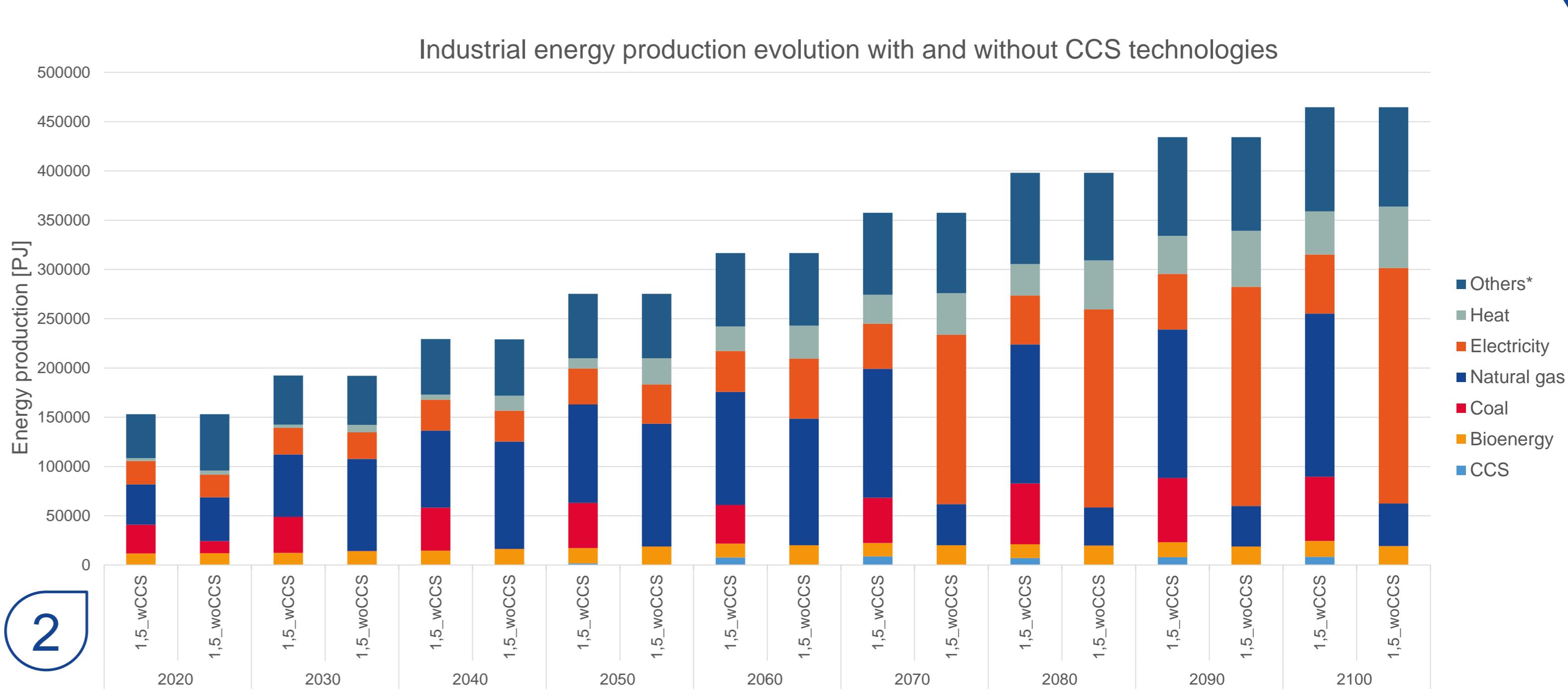
## Results for the industry sector by 2100



1

Scenario	Label	Industrial CCS investment [TW]	CO <sub>2</sub> stored from industrial processes [Gt]	Industrial discounted cost [B€]
Business as usual	BAU	0.2	1	10,300,000
1.5°C mitigation with CCS	1.5_wCCS	62	142	11,100,000
1.5°C mitigation without CCS	1.5_woCCS	0	0	12,300,000
2°C mitigation with CCS	2_wCCS	61	141	11,100,000

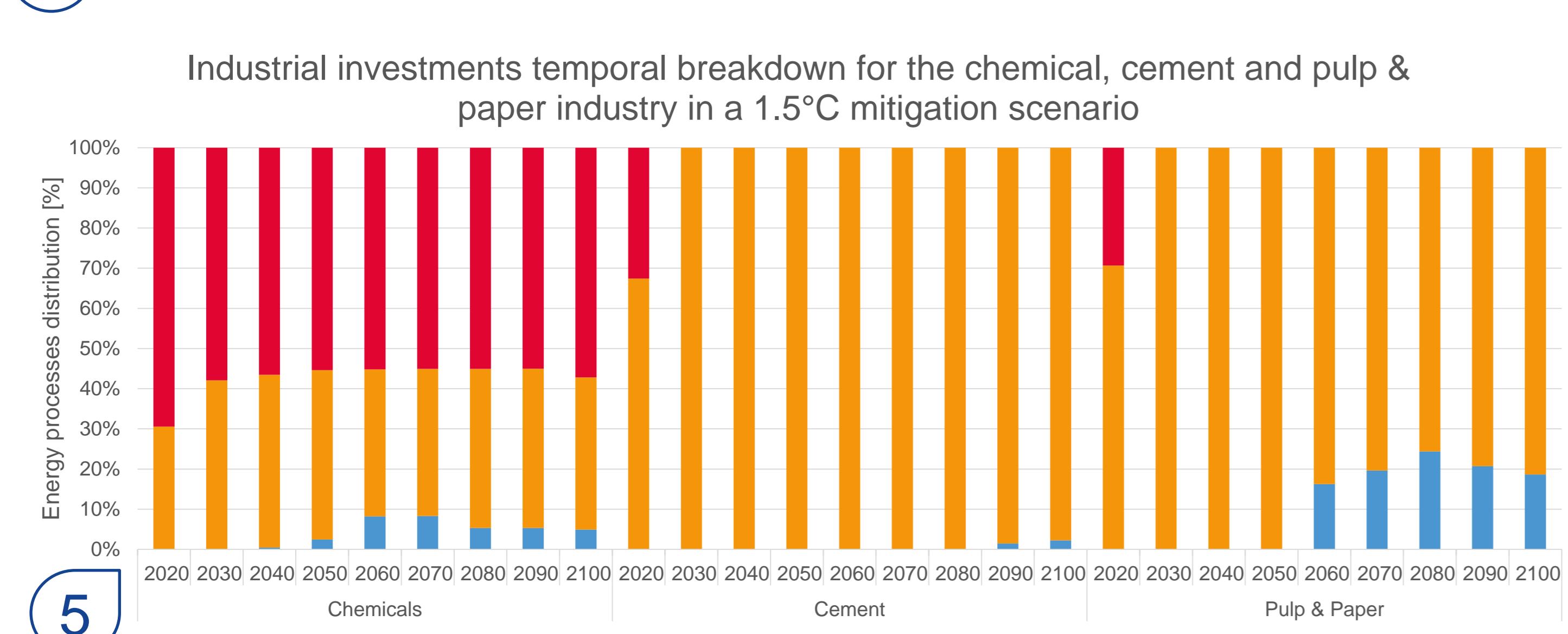
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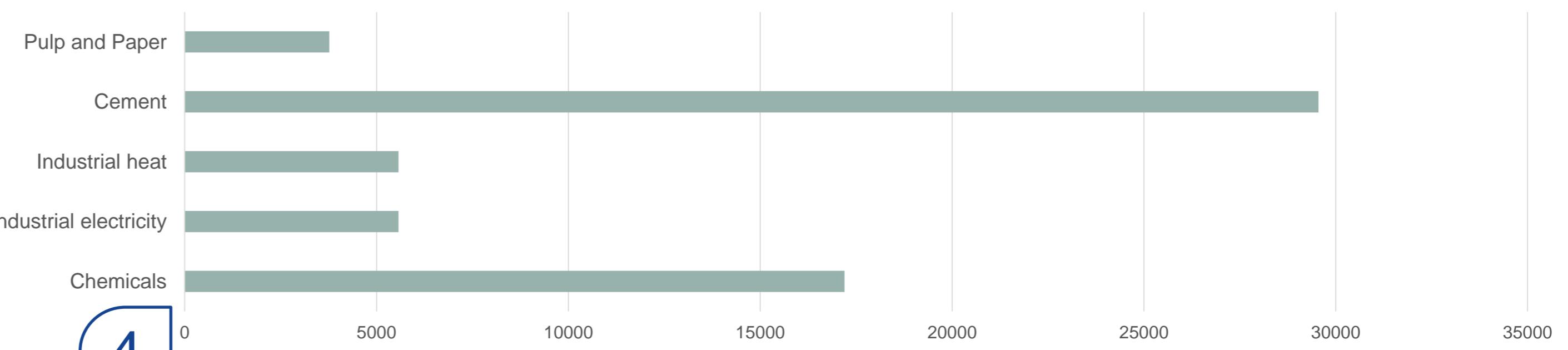
\*others includes NGL, LPG, heavy fuels, distillates, blast furnace gas, asphalt, naphtha, coke and geothermal energy

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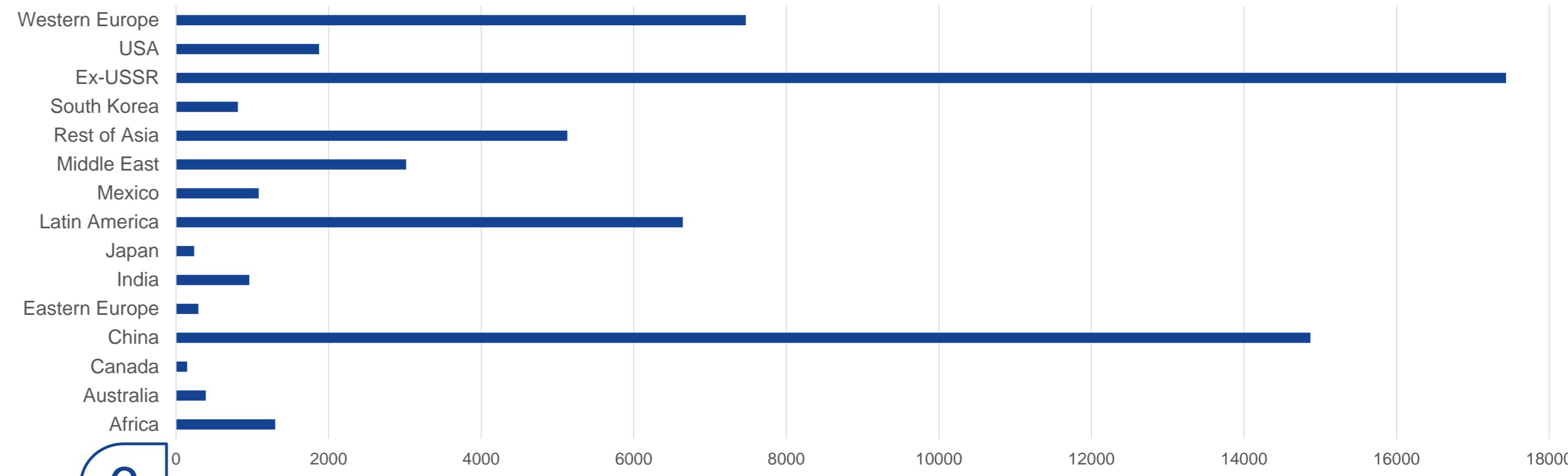
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### Cumulative CCS new capacities per sector in a 1.5°C mitigation scenario [GW]



4

### Cumulated CCS investments in industry by region in a 1.5°C mitigation scenario [GW]



6

## Key findings

- Minor disruptions in industrial processes between the BAU scenario and the mitigation scenarios, in where the use of coal is slightly replaced by heat importation.
- Not relying on CCUS technologies will require the electrification of industry. Thus, the carbon content of electricity is dramatically reduced as of 2070.
- Not relying on CCS will be more expensive.
- The model choices to invest in CCS mainly for the cement and chemical industries in the second half of the 21<sup>th</sup> century.
- New technologies with better energy efficiencies are preferred against CCS technologies to reduce industrial emissions. Hydrogen is not chosen as an option.
- China, ex-USSR, Latin America and Western Europe are the regions that invest the most in CCS technologies.

## Key issues and way further

- Cost actualization
- Other mitigation pathways consideration
- CCU implementation
- Comparison with MIT top-down model
- Sensitivity analysis
- Results feasibility assessment