International Energy Agency
1974•2014

Re-defining Climate Ambition to "Well-below 2°C"

Industry break-out session

Welcome!

Paris, 20 June 2016

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Industry break-out session goals

Part I: WHAT?

I.A) Identify main opportunities to:

- Reduce industrial CO2 emissions to a level compatible with 'well below' 2°C
- Facilitate systemic CO2 emissions reductions from industry

I.B) Discuss the relative CO2 impact of identified emission reduction opportunities

Part II: HOW?

II.A) Identify barriers and opportunities to accelerate the low-carbon industrial transition

II.B) Discuss effective policy mechanisms and stakeholders' actions to enable ambitious industrial carbon emissions reductions

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How can industrial energy use be further reduced and decarbonised?

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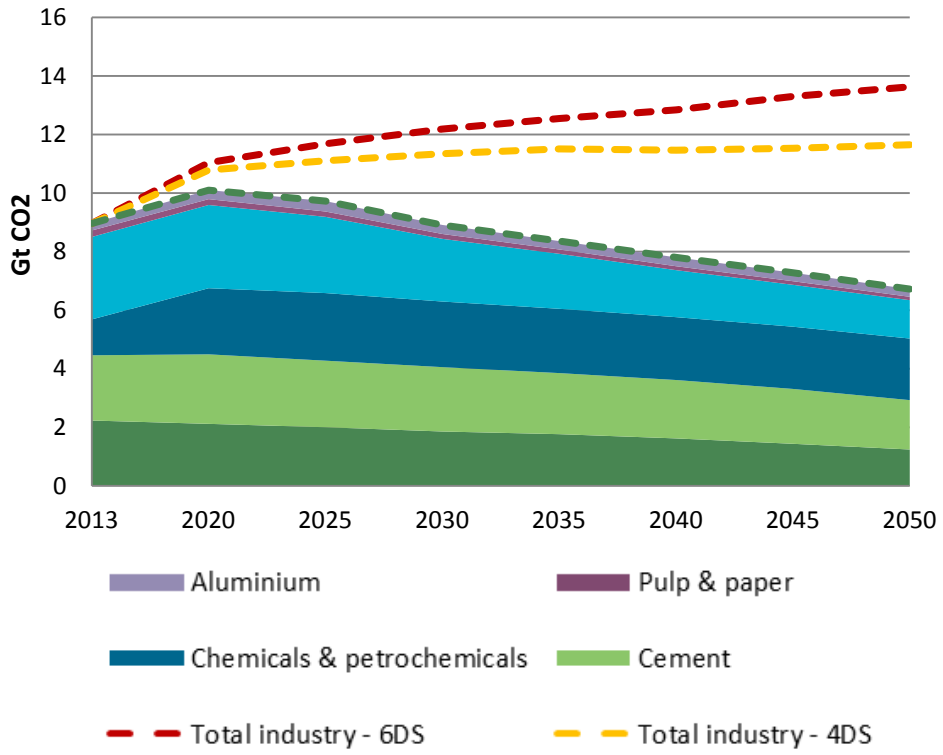
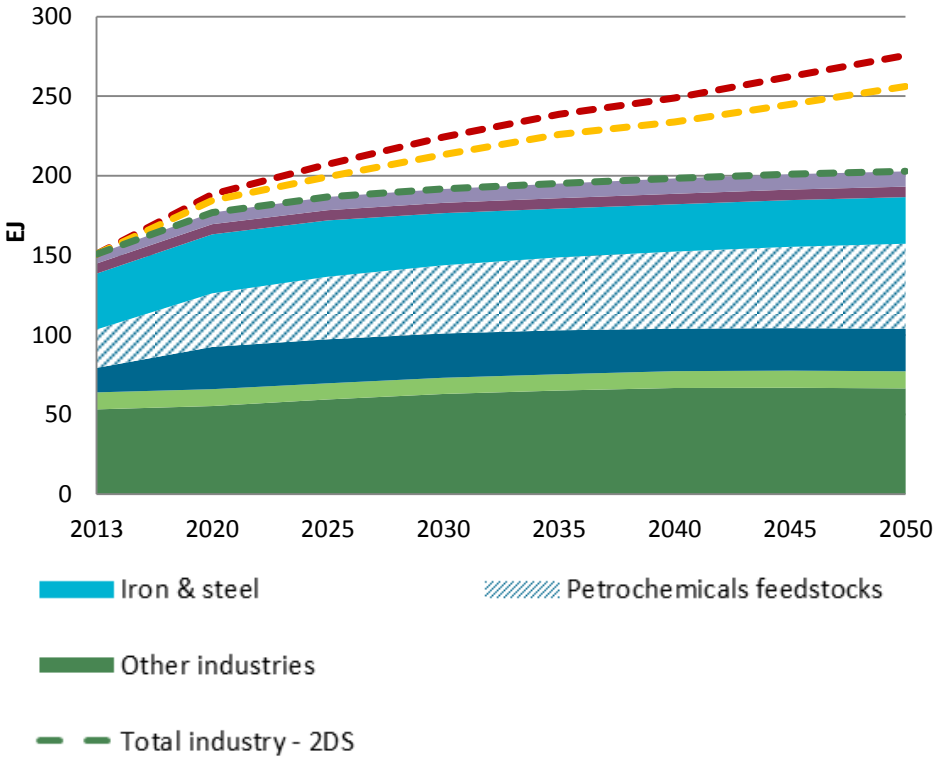
Global direct industrial CO2 emissions



Global industrial final energy demand



SOURCE: Energy Technology Perspectives 2016
NOTE: Energy use in blast furnaces and coke ovens is included in iron and steel.

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How can material demand levels be more sustainable ?

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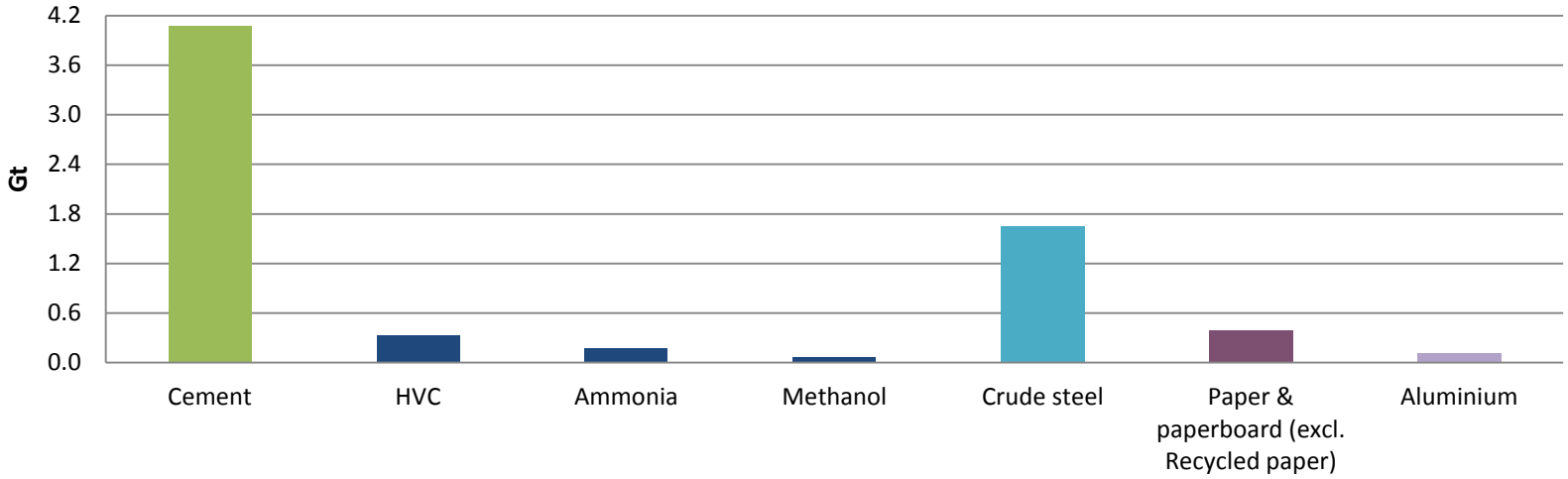
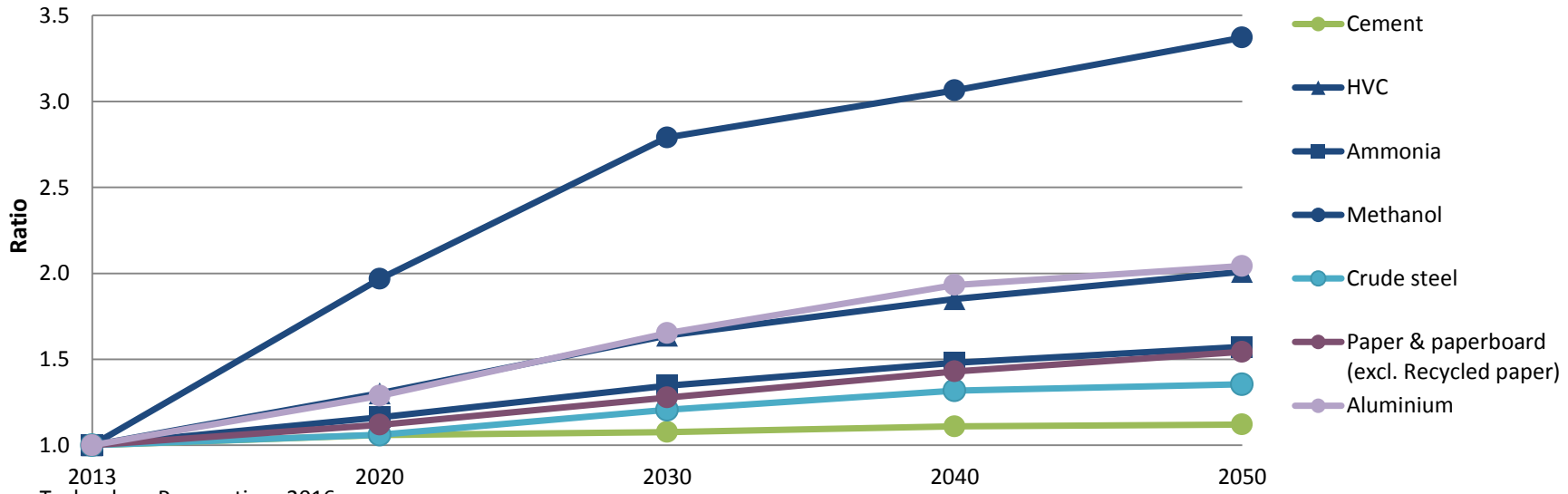
Global materials production (2013)



Global materials production growth - 2DS



SOURCE: Energy Technology Perspectives 2016

NOTE: HVC = high value chemicals that include ethylene, propylene, and aromatics.

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Which are the levers to reduce CO2 emissions in industry?

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CROSS-CUTTING CO2 EMISSIONS REDUCTIONS AREAS:

ENERGY EFFICIENCY

- Push industrial energy performance to BAT levels
- Explore EE multiple benefits
- Make the most of site-level opportunities: maximise process integration and allocate greater attention to O&M

INCREASE THE USE OF LOW-CARBON ENERGY SOURCES

- Switch to low-carbon fuels and feedstocks (e.g. biomass)
- Explore opportunities to further utilise renewable electricity

LOW-CARBON INNOVATIVE PROCESSES: going beyond current technical limits

- Accelerate the demonstration of low-carbon innovative processes
  - Carbon capture integration
  - Alternative low-carbon process routes
- Rapidly advance the identification of suitable CO_2 storage capacities and cluster CO_2 sources to strategically design suitable CO_2 transportation infrastructure
- Accelerate R&D of early-stage breakthroughs for low-carbon process technologies

MATERIAL EFFICIENCY: bending the demand curves for primary materials whilst providing the same services

- Minimise yield losses and material intensities at different manufacturing stages
- Increase the utilisation of recycled materials and industrial by-products in manufacturing

ENHANCED PROCESS AUTOMATION: what can improved controls and techniques bring? (e.g. smart manufacturing)

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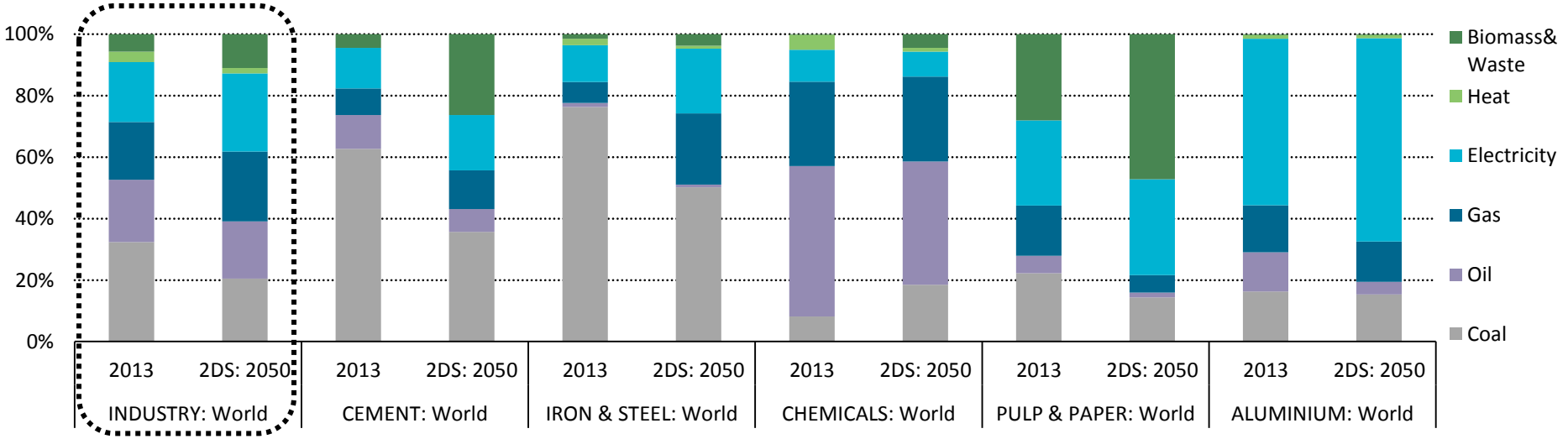
Which options are there to push low-carbon fuel switching further?

- *Opportunities to switch to lower-carbon energy mixes vary across industrial sectors as a result of technological constraints and sector-specific dynamics.*
- *Overall the greatest shifts identified in the 2DS are a 12% decrease of coal use and electricity gaining a 6% share, closely followed by increasing shares of biomass and natural gas.*

Industrial final energy mix



NOTES: Final industrial energy use includes energy embedded in petrochemical feedstock and energy use in blast furnaces and coke ovens.
SOURCE: Energy Technology Perspectives 2016

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What can low-carbon innovation bring?

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LOW-CARBON INNOVATION	PROCESS	PRODUCT
CEMENT	- Post-combustion CO2 capture - Enriched oxygen kilns	- Low-carbon cements
IRON & STEEL	- Blast furnace with top gas recovery and carbon capture integration - Enhanced smelting reduction process with carbon capture integration	- High performance steels
CHEMICALS	- Methanol production from lignocellulose gasification - Ammonia production from renewable-based hydrogen - Integration of carbon capture in chemicals production	- Enhanced insulating materials - Lighter resistant materials
PULP & PAPER	- Black liquor gasification leading to diverse bio-refinery concepts	- Dissolving pulp applications in the textile industry
ALUMINIUM	- Inert anodes	- Alternative applications for aluminium

NOTES: The table includes some examples for energy-intensive industrial sectors and it is not intended to be exhaustive. Product and process innovation can be interrelated; for instance, product innovation may trigger the need of innovations in the production process.

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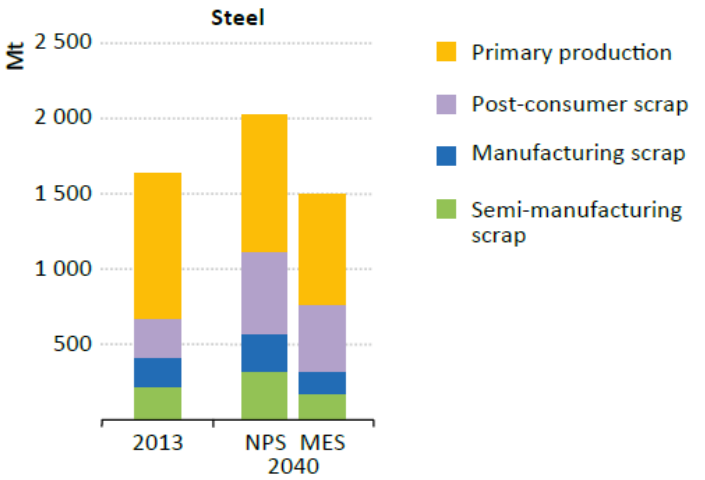
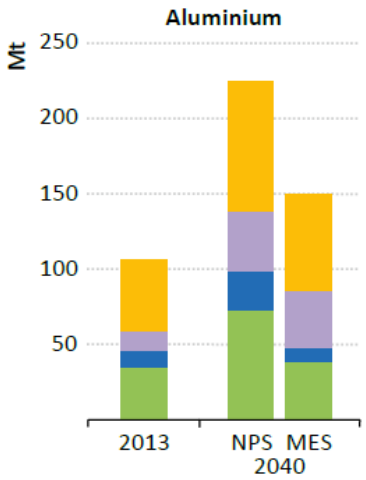
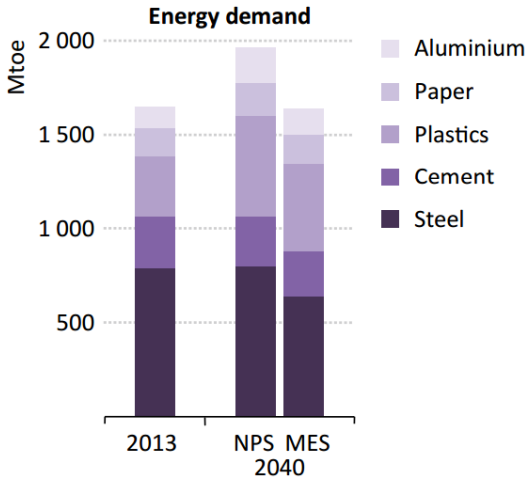
Understanding the impact of material efficiency strategies







- *Delivering the same final service with less overall material production can provide significant energy and CO2 benefits.*
- *Potential energy savings from material efficiency in energy-intensive industries was found to be about twice as large as the one for energy efficiency.*

SOURCE: World Energy Outlook 2015

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Which are the industry opportunities to reduce CO2 emissions at the system's level?

SYSTEMIC APPROACH: breaking the sectorial boundary

ACROSS INDUSTRIAL-SITES AND LOCAL ENERGY USERS: Clustered network approach

- Value and utilise industrial energy by-products (e.g. excess heat)

ACROSS SECTORS:

- Optimise the use of bio-based fuels and feedstocks across the energy system
- Value and utilise industrial material by-products (e.g. BF slag)
- Facilitate the low-carbon energy transition
  - Explore sustainable material developments (e.g. longer-lasting materials)
  - Enable further flexibility in the energy system
  - Explore possibilities to off-set system-level residual CO2 emissions (e.g. BECCS)

ALONG PRODUCT VALUE CHAINS

- Facilitate sustainable impacts up and down the supply chain
  - Consider the impact at the end-use when defining a low-carbon innovation
  - Optimise the re-use of industrial wastes along product supply chains
  - Enhance the recyclability of products
- Develop alternative sustainable product value chains

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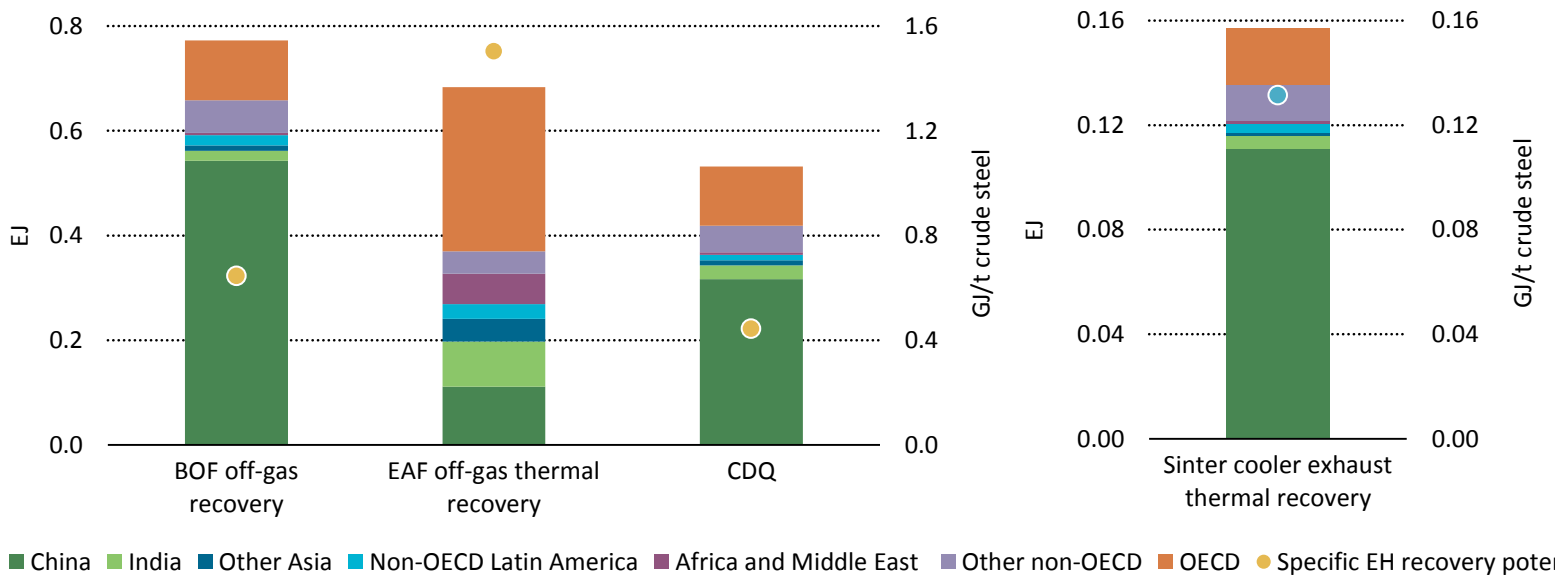
Which sustainable opportunities lie outside industrial sites?

- *Industrial excess heat can be a low-carbon energy source for compatible energy users under favorable local conditions*
- *For instance, 2 EJ or 1.3 GJ/t crude steel could be technically recovered globally in iron & steel*

Industrial excess heat technical potential in the Iron & Steel sector



NOTE: Only medium and high temperature industrial excess heat sources included.
SOURCE: Energy Technology Perspectives 2016

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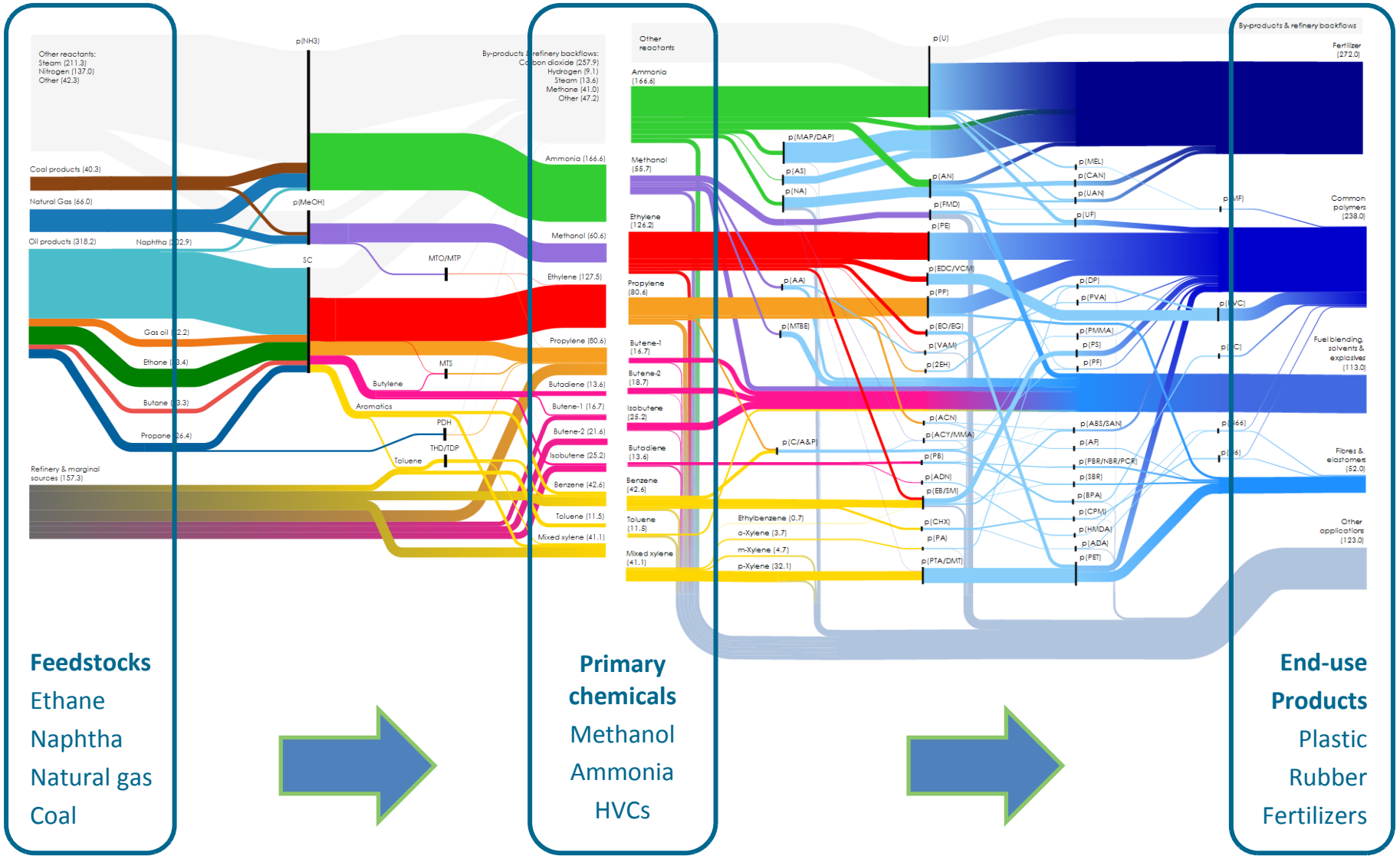
Understanding interactions of complex supply chains



Feedstocks
Ethane
Naphtha
Natural gas
Coal

Primary chemicals
Methanol
Ammonia
HVCs

End-use Products
Plastic
Rubber
Fertilizers

SOURCE: *Levi, P. G. & Cullen, J. M. (2016); extract from draft journal submission*

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Industrial CO2 emissions reduction: YOUR VIEWS…

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a. **Have any relevant industrial CO2 emissions reduction areas been overlooked?**
b. **How would you rank the CO2 emissions reduction areas raised in terms of emissions mitigation impact?**
c. **What are the main low-carbon innovation streams being pursued to your knowledge? Any ongoing/planned demonstration projects to highlight?**
d. **Are material efficiency strategies discussed in your networks? Where do you see the greatest opportunities (in manufacturing or end-use)?**
e. Which breakthrough low-carbon industrial process technologies you would place emphasis on?
f. Is there any illustrative case study of an industrial process optimising the use of sustainable local energy sources, which you would like to highlight?
g. Is there any other relevant analysis/information you would like to share with the group?

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How to accelerate the low-carbon technology transition in industry?

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CHALLENGES

- Energy price volatility
- Regulatory uncertainty and political instability
- Commercially available technology energy performance limitations
- Risk of financing innovation
- International competitiveness
- Jobs security

OPPORTUNITIES

- Improve resilience to energy price volatility (e.g. reduce SEC, feedstock flexibility)
- Be part of the solution (e.g. sustainable material provider, flexibility enabler)
- Establish a competitive position as low-carbon technology/material provider
- Mitigate investment risks through private-public collaboration to boost innovation
- Market-pull for low-carbon products (e.g. public procurement)

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Low-carbon transition implementation

YOUR VIEWS…

a. **In your view what are the main barriers to accelerating the low-carbon transition in industry? Technological, regulatory, market-related?**
b. **Which policy instruments and stakeholders' actions can hasten and augment the CO2 mitigation potential of existing levers in the industrial sector?**
c. **Which mechanisms can accelerate the roll-out of demonstration projects for low-carbon innovative process technologies and production routes? How can these be supported from a private and public perspective?**
d. Which factors/conditions are limiting a more rapid reduction of industrial CO2 emissions in the short-term?
e. Are cross-cutting collaborative frameworks along product value chains being pursued in your respective sectors? How effective have these proven to be? How can these be supported from a private and public perspective?
f. Which strategies can help unveil local, sustainable and cost-effective opportunities?

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