IEA Technology Roadmap

The global iron and steel sector

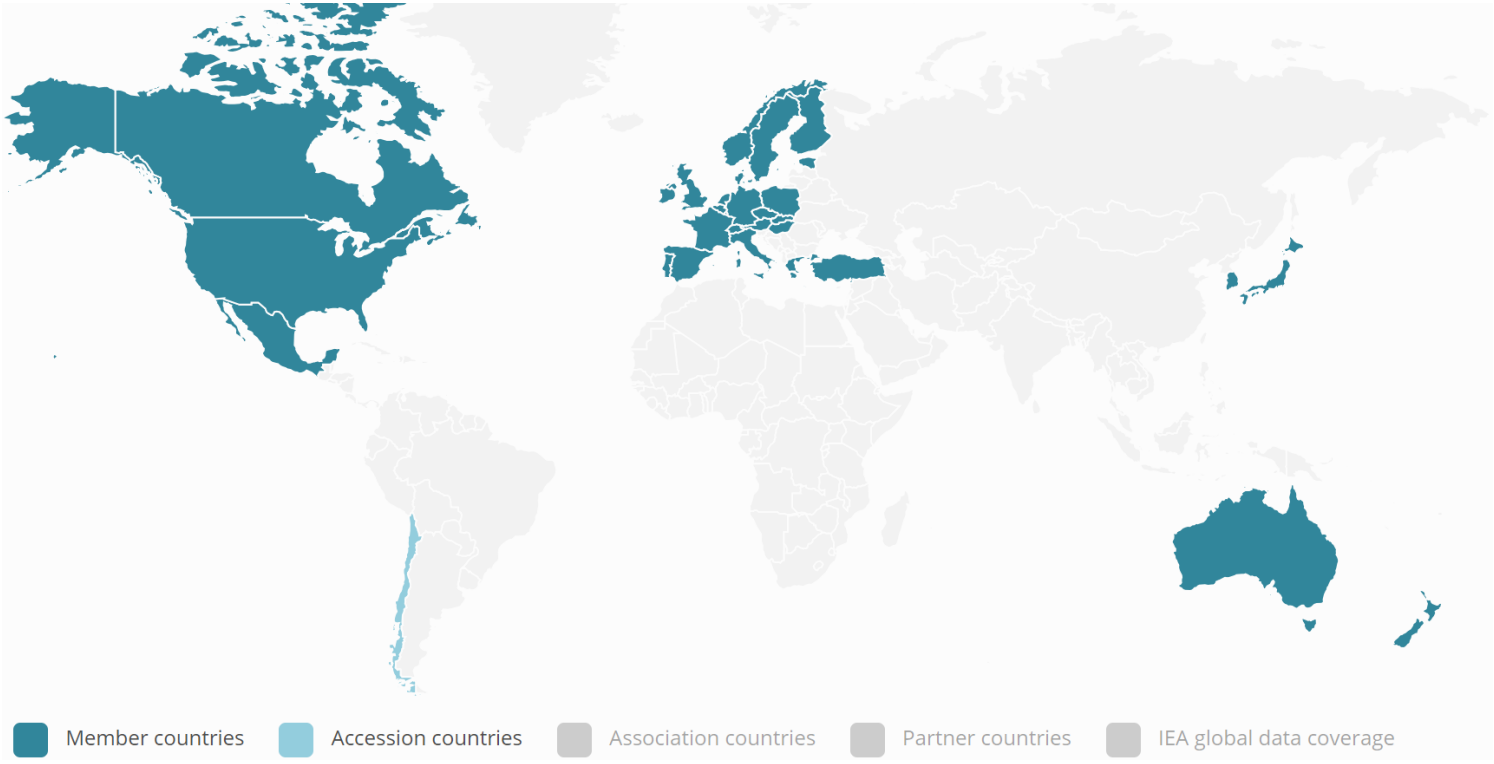
International Energy Agency, 29th March 2019, Paris

IEA

Introduction

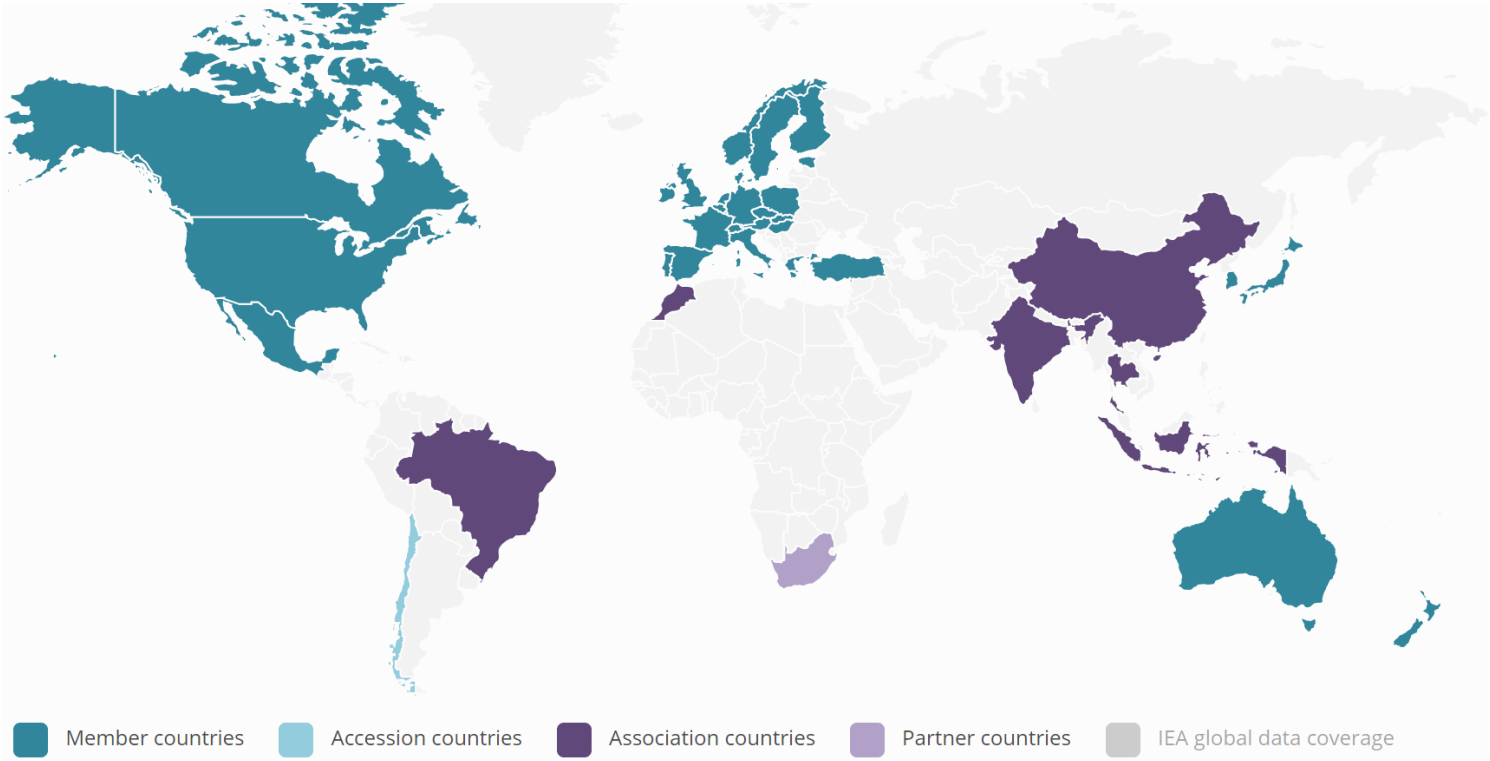
Background and broader context

The IEA Global Family



The IEA works around the world to support accelerated clean energy transitions with unparalleled data, rigorous analysis and real-world solutions.

The IEA Global Family



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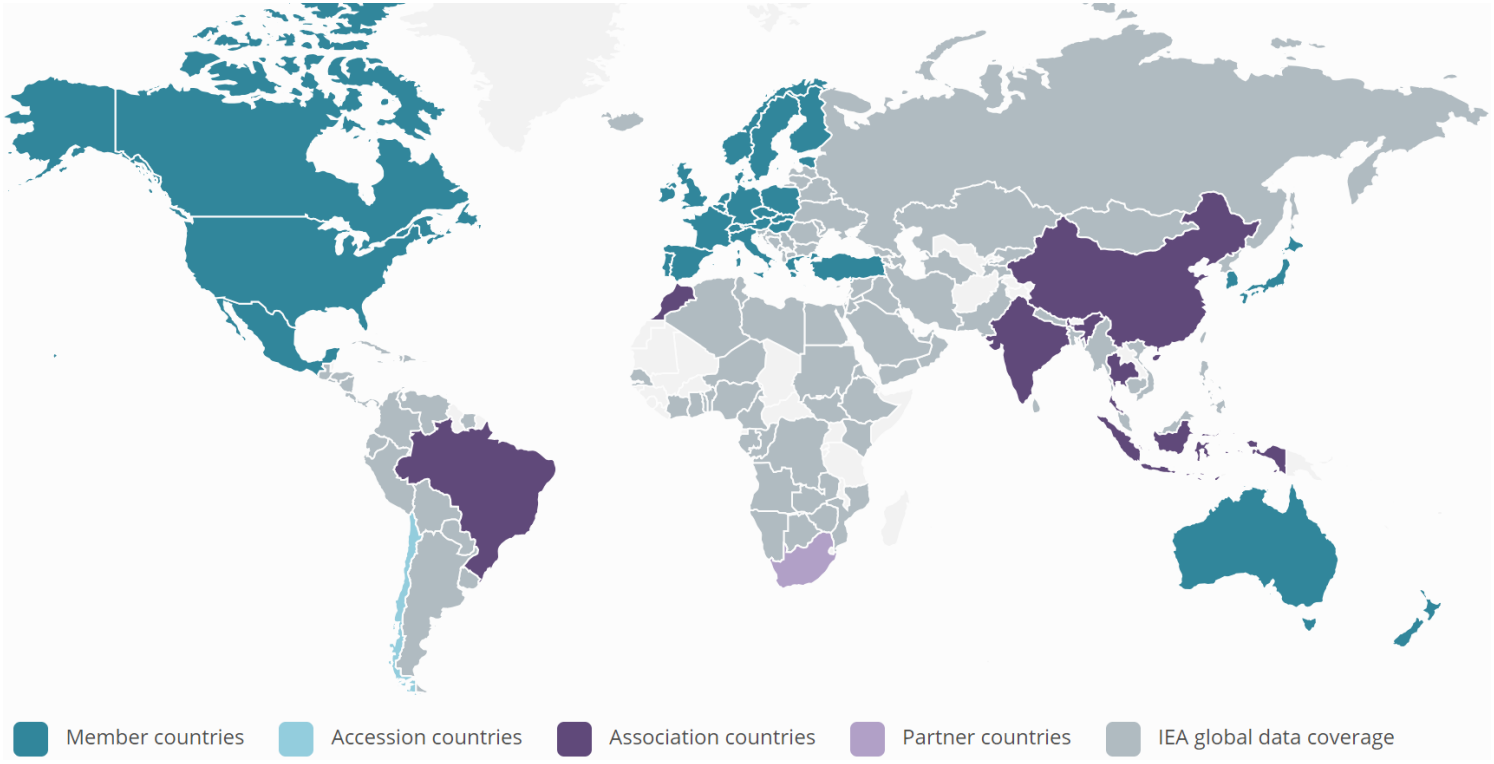

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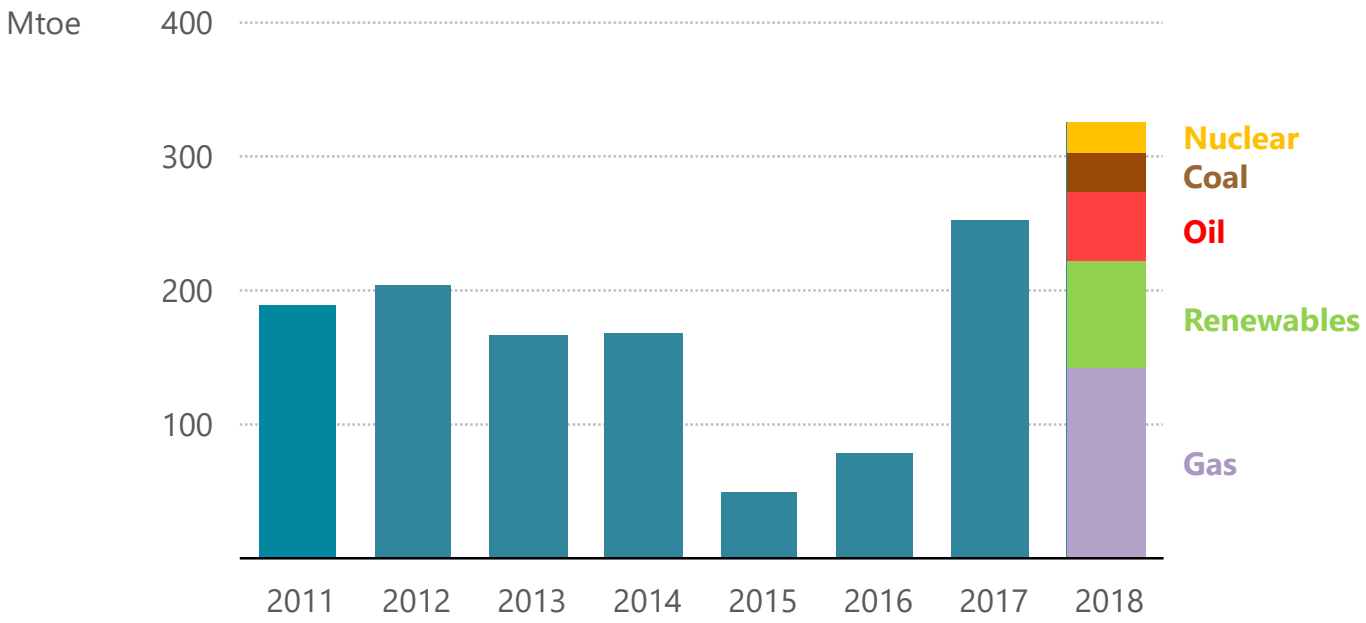
2018 – a remarkable year for energy

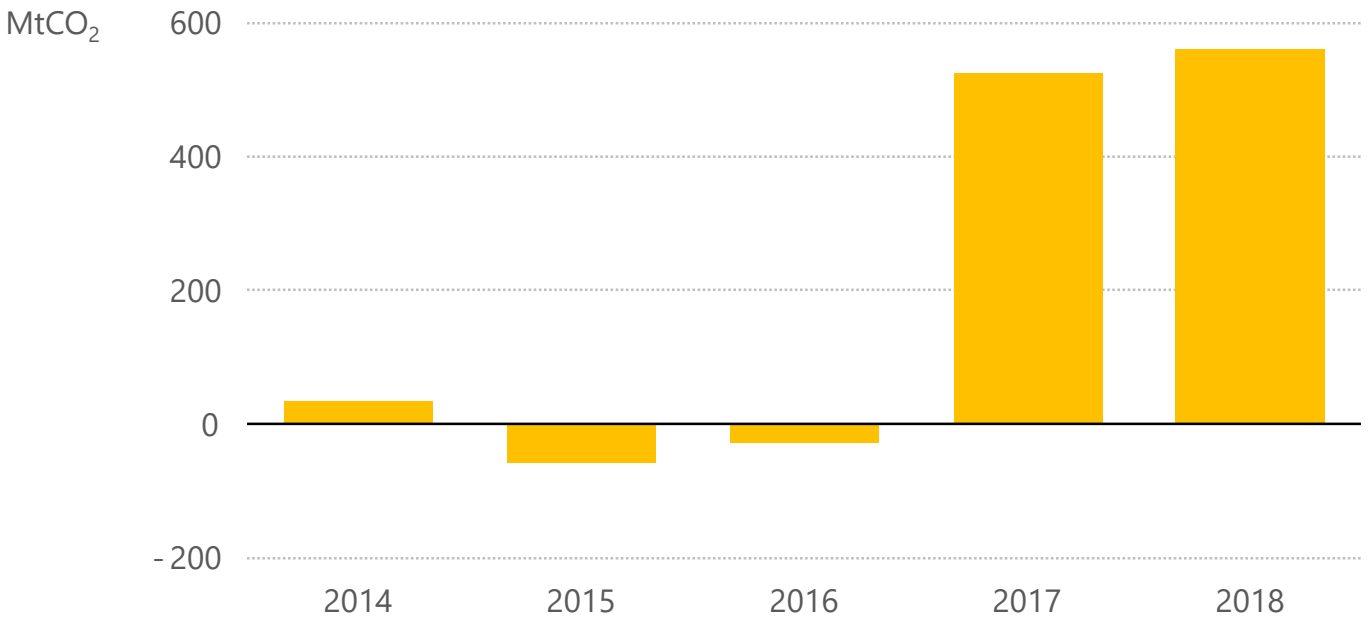
Annual change in global primary energy demand, 2011-18



Global energy demand last year grew by 2.3%, the fastest pace this decade, an exceptional performance driven by a robust global economy, weather conditions and moderate energy prices.

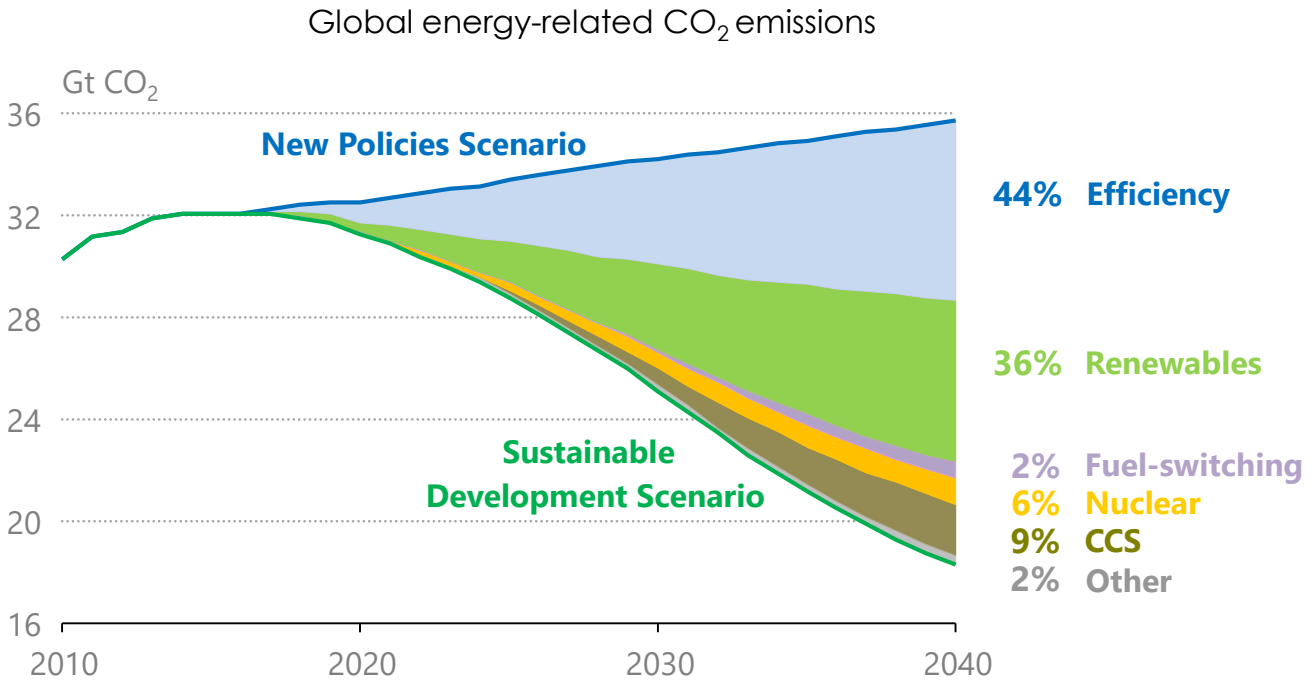
Energy-related CO_2 emissions hit a record high…

Annual change in global energy-related CO_2 emissions, 2014-2018



Higher demand for fossil fuels drove up global CO_2 emissions for a second year after a brief hiatus. Increases in efficiency, renewables, coal-to-gas switching and nuclear avoided 640 Mt of CO_2 emissions.

Where do we need to go?



A wide variety of technologies are necessary to meet sustainability goals, notably energy efficiency, renewables, CCUS and nuclear

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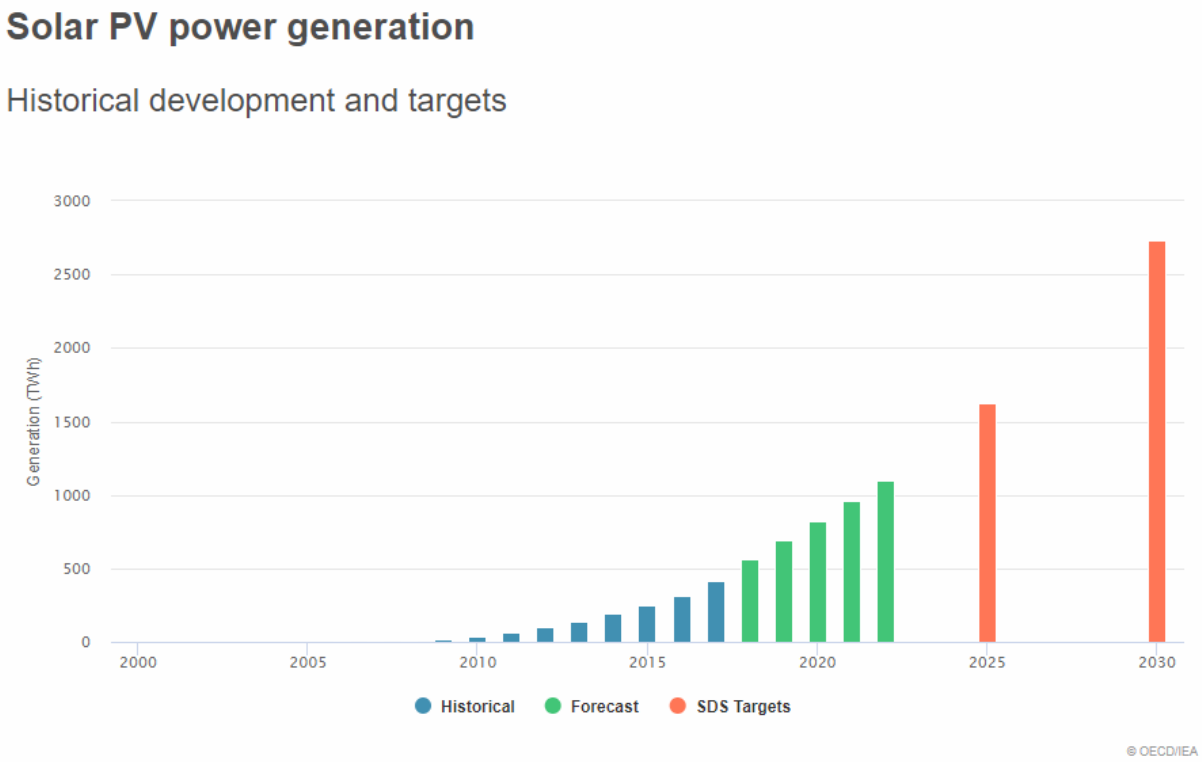
The global climate challenge: How are we doing?

Are clean energy technologies on track?

Some technologies have made tremendous progress in 2017 – particularly solar PV, LEDs and EVs – but most are not on track. Energy efficiency improvements have slowed and progress on key technologies like carbon capture and storage remains stalled.

The IEA tracks the progress of various technologies critical to a successful clean energy transition.

The global climate challenge: How are we doing?

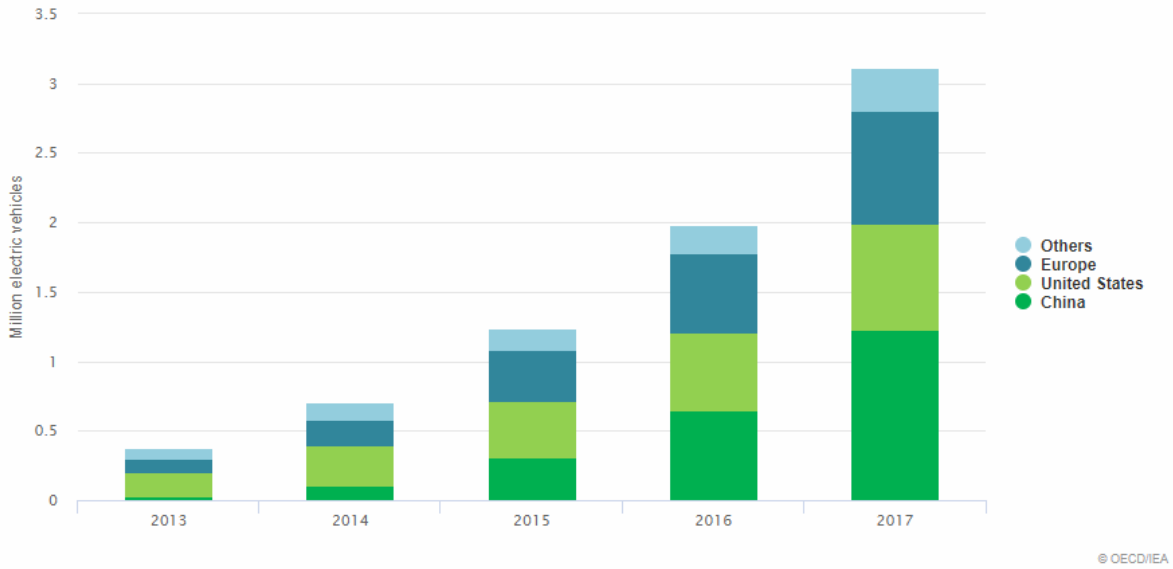


Some technologies are showing great promise and moving *fast*

The global climate challenge: How are we doing?

Evolution of the global electric car stock

The global stock of electric cars passed 3 million in 2017.



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Are clean energy technologies on track?

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Power

- Renewable power
  - Solar PV
  - Onshore wind
  - Offshore wind
  - Hydropower
  - Bioenergy
  - Geothermal
  - Concentrating solar power
- Ocean
- Nuclear power
- Natural gas-fired power
- Coal-fired power
- CCUS in power

Buildings

- Building envelopes
- Heating
- Cooling
- Lighting
- Appliances & equipment
- Data centres & networks

Transport

- Electric vehicles
- Fuel economy of cars & vans
- Trucks & buses
- Transport biofuels
- Aviation
- International shipping
- Rail

Industry

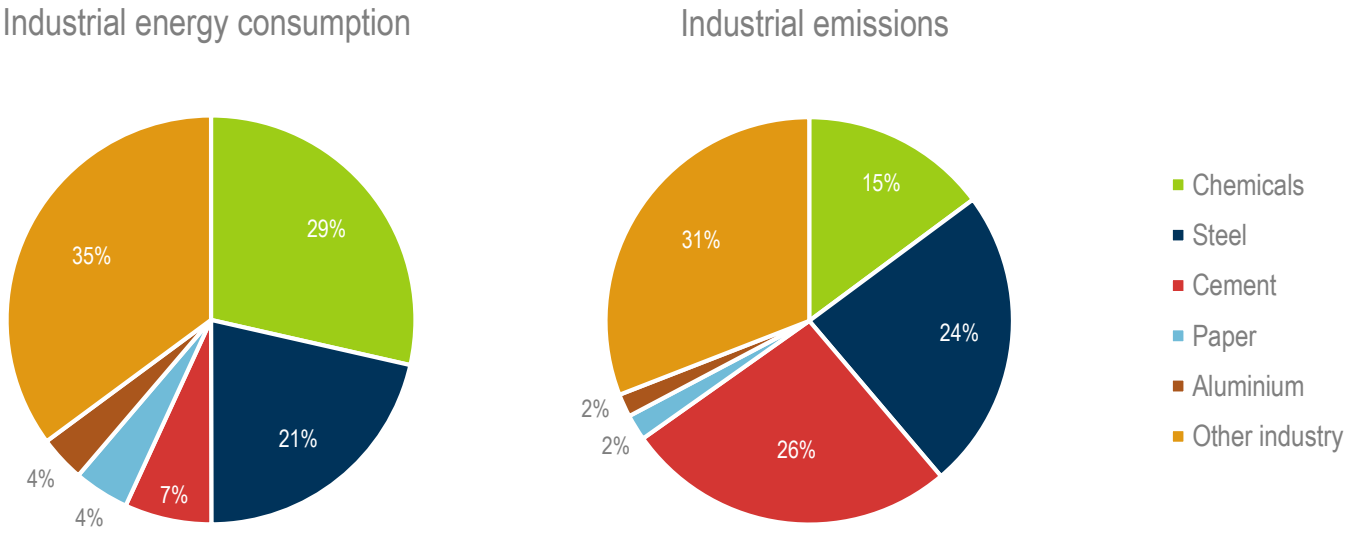
- Chemicals
- Iron & Steel
- Cement
- Pulp & paper
- Aluminium
- CCUS in industry & transformation

Energy integration

- Energy storage
- Smart grids
- Demand response
- Digitalization
- Hydrogen
- Renewable heat

The IEA tracks the progress of various technologies critical to a successful clean energy transition.

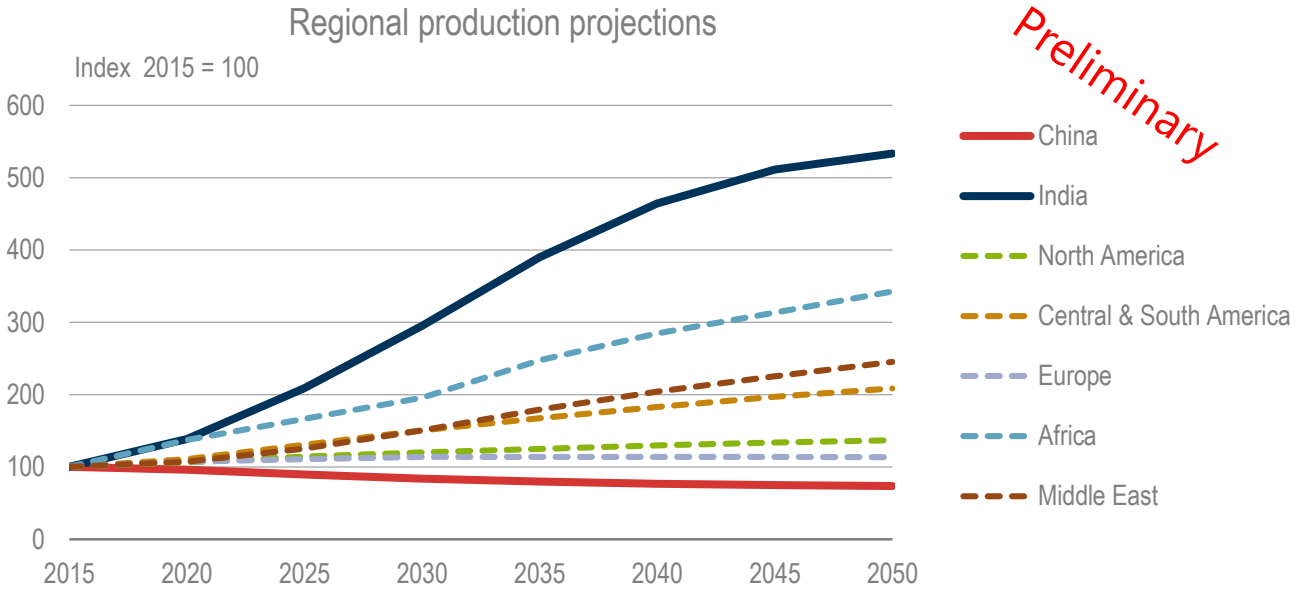
Why steel?



Note: Data are estimates for 2017; industrial emissions include process emissions

Steel production accounts for around a fifth of industrial energy consumption and about a quarter of direct industrial CO_2 emissions.

Regional contexts for “deep-dive” follow-ups



India’s crude steel production is projected to grow by more than 400% between 2015 and 2050, compared to global growth of 30% over the same period.

IEA Technology Roadmaps

Low-carbon pathways for key technologies

IEA Technology Roadmaps

- Since 2009, 22 Technology Roadmaps and How2Guides (33 publications)
- Re-endorsed at G7 Energy Ministerial Meetings in 2016 (Japan) and 2017 (Italy) *"(G7 Ministers) welcomed the progress report on the Second Phase of IEA's Technology Roadmaps, focused on viable and high impact technologies"*
- Close engagement with key industry stakeholders

How do we get there?

Context and Analysis

- What is the status of the technology today?
- What alternative technology options may be available in the long-run?
- What data are available, and what data are needed?

Implementable Pathway

- Assessment of technology performance and innovation challenges
- Consideration of barriers to market deployment and enabling factors
- Evaluation of cost-competitiveness across technology options and routes

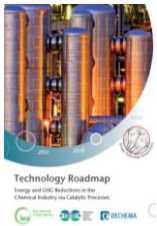
Prioritising Action

- How policies and regulation can support the clean energy transition?
- How to accelerate technology adoption with the private sector?
- How collaborative mechanisms can boost technology innovation?

Stakeholder Engagement

Industry-related IEA Technology Roadmaps

Global Chemicals



Global Cement update

Global Iron and Steel

2009 **2013** **2018** **2019**

Global Cement

Regional Cement (India)

Status review Cement (India)

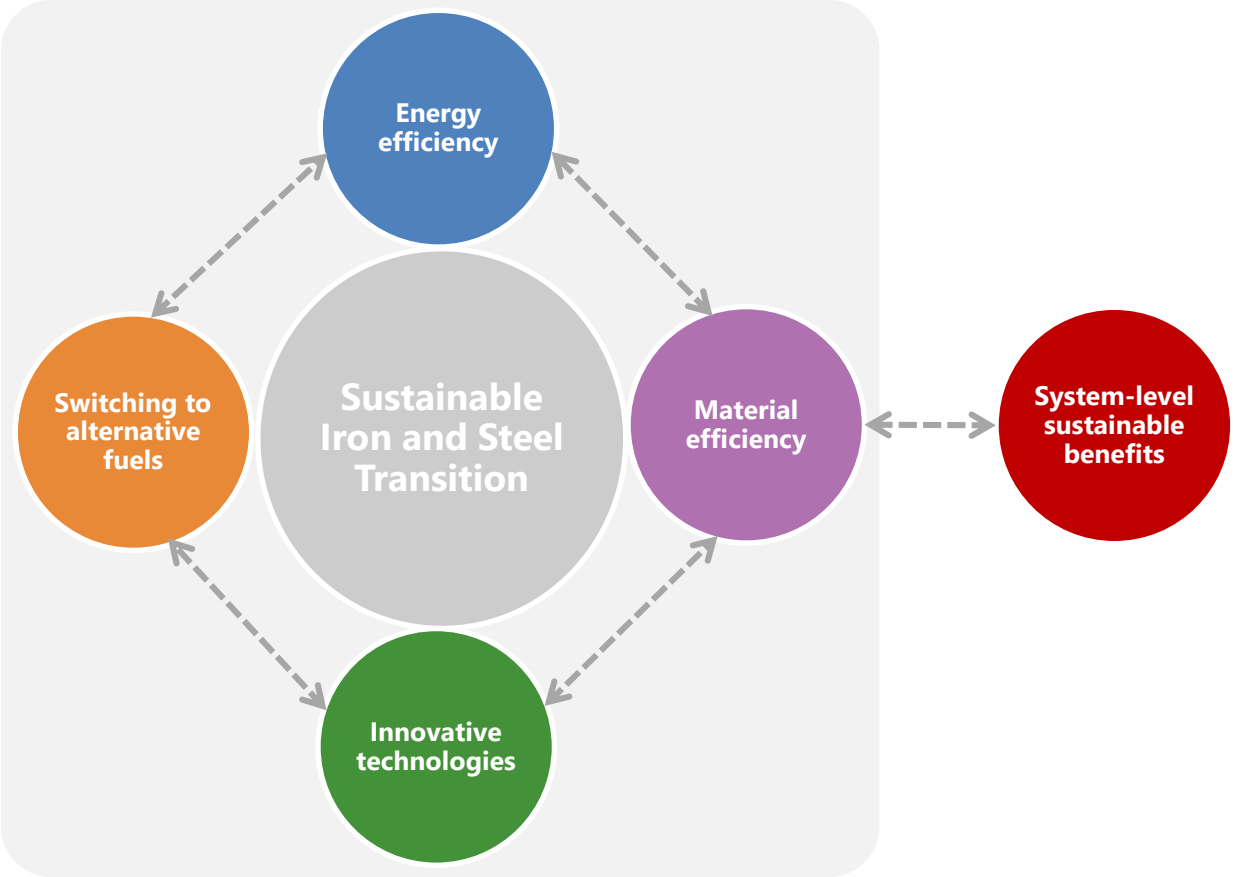
Iron and steel sector Technology Roadmap

Aims, scope and methodological overview

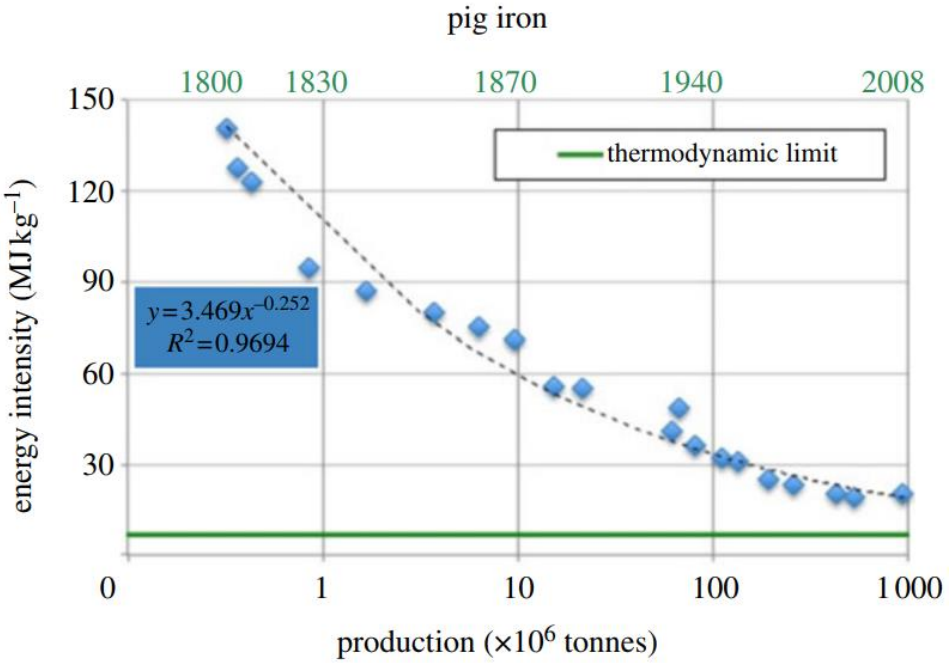
Enabling strategies for sustainable iron and steel production

Sustainable transition goals:

- Environmental sustainability
- Energy security
- Least-cost transition pathways
- Synergies between Iron and Steel and other sectors



Enabling strategies for sustainable iron and steel production



Energy efficiency

- Current average blast furnace → ~20 GJ/t crude steel
- Current state-of-the-art blast furnaces → 12 GJ/t crude steel
- Practical minimum energy needs → 10.4 GJ/t crude steel
- Thermodynamic minimum requirement → 9.8 GJ/t crude steel

Source: Gutowski et al. (2013), "*The Energy Required to Produce Materials: Constraints on energy-intensity improvements, parameters of demand*", *Phil. Trans. R. Soc. A, 371.*

Exploring alternative low-CO_2 steel technologies

Innovative technologies

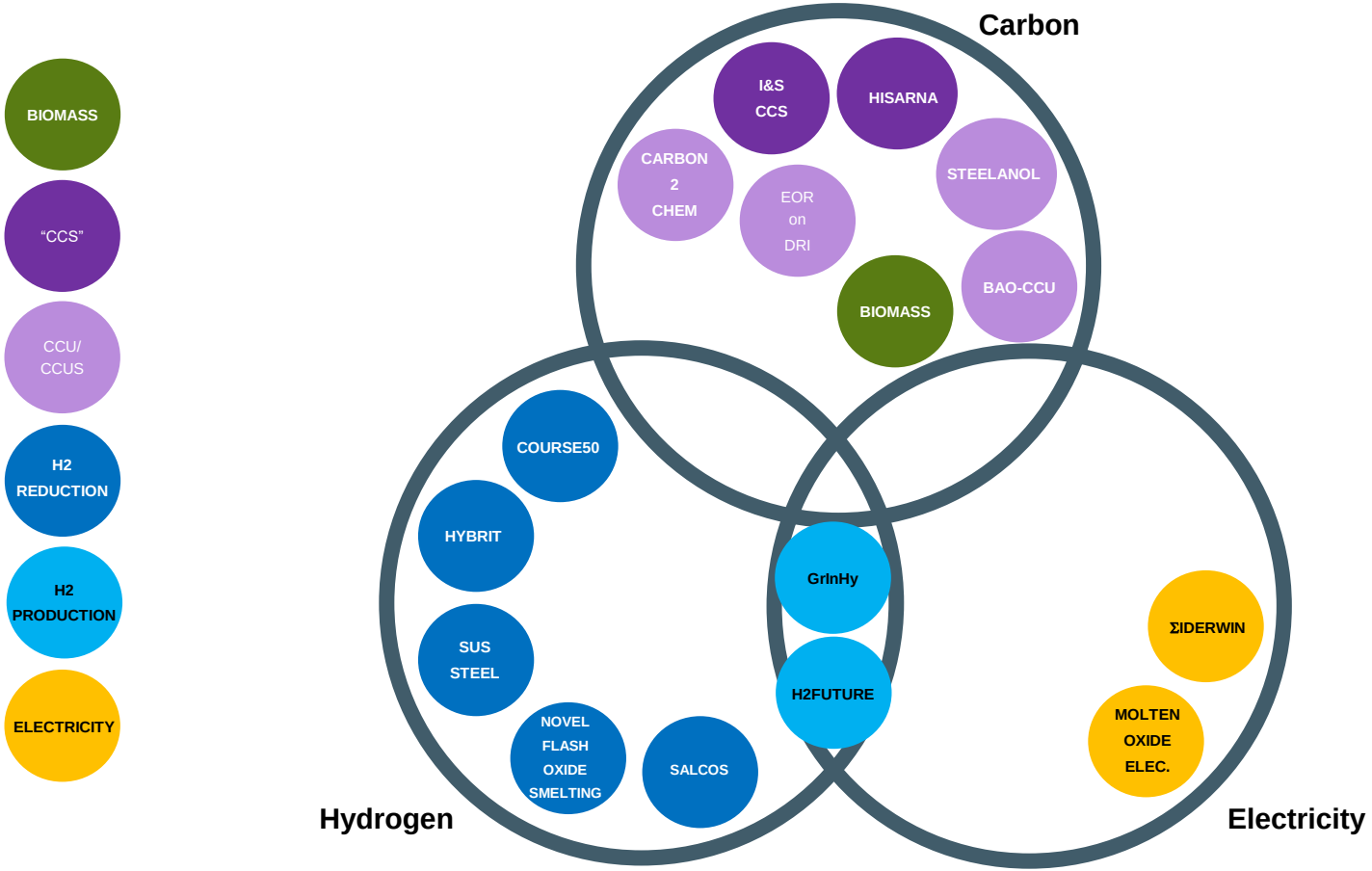
- **Upgraded smelting reduction**. Maximises the CO_2 content of the off-gases through pure oxygen operation, facilitating CO_2 capture. Pilot trials currently underway. Avoids the need for coke or sinter. [Large pilot demonstration TRL 6-7]
- **Oxy blast furnace and top gas recycle:** The CO_2 content of the top gas is raised by replacing the air in the blast furnace with oxygen and recycling the top gas. Lowers coke requirements. [Large pilot demonstration TRL 6]
- **Upgraded DRI process** (based on natural gas) that reuses off-gases from the shaft as a reducing agent after CO_2 capture. [Paper studies]
- **Coke oven gas (COG) reforming**: Increasing the hydrogen concentration of COG through reforming tar to reduce net energy consumption. Through integration with oxy blast furnaces, CO_2 capture can be added.
- **Hydrogen from renewable-electricity for DRI production** [Pre-feasibility]
- **Direct use of electricity to reduce iron ore** relying on renewable electricity. [Intermediate TRLs]

CO_2 MANAGEMENT

- **Hydrogen from renewable-electricity for DRI production** [Pre-feasibility]
- **Direct use of electricity to reduce iron ore** relying on renewable electricity. [Intermediate TRLs]

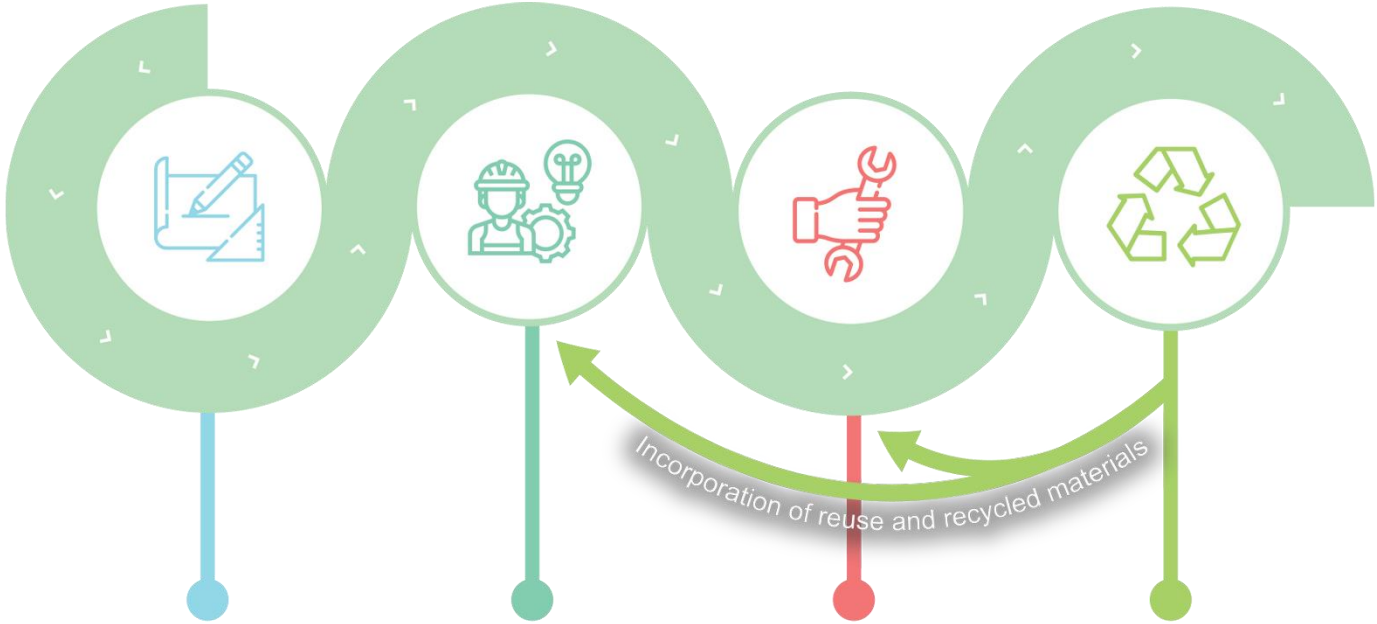
CO_2 AVOIDANCE

Exploring alternative low-CO_2 steel technologies



Slide content courtesy of the World Steel Association.

Material efficiency from cradle to grave



Material efficiency

DESIGN STAGE

- Lightweighting, reduced over-design and optimised design
- Design for use, long-life, and reuse

FABRICATION STAGE

- Reducing materials losses and over-use when manufacturing materials/ products and in construction

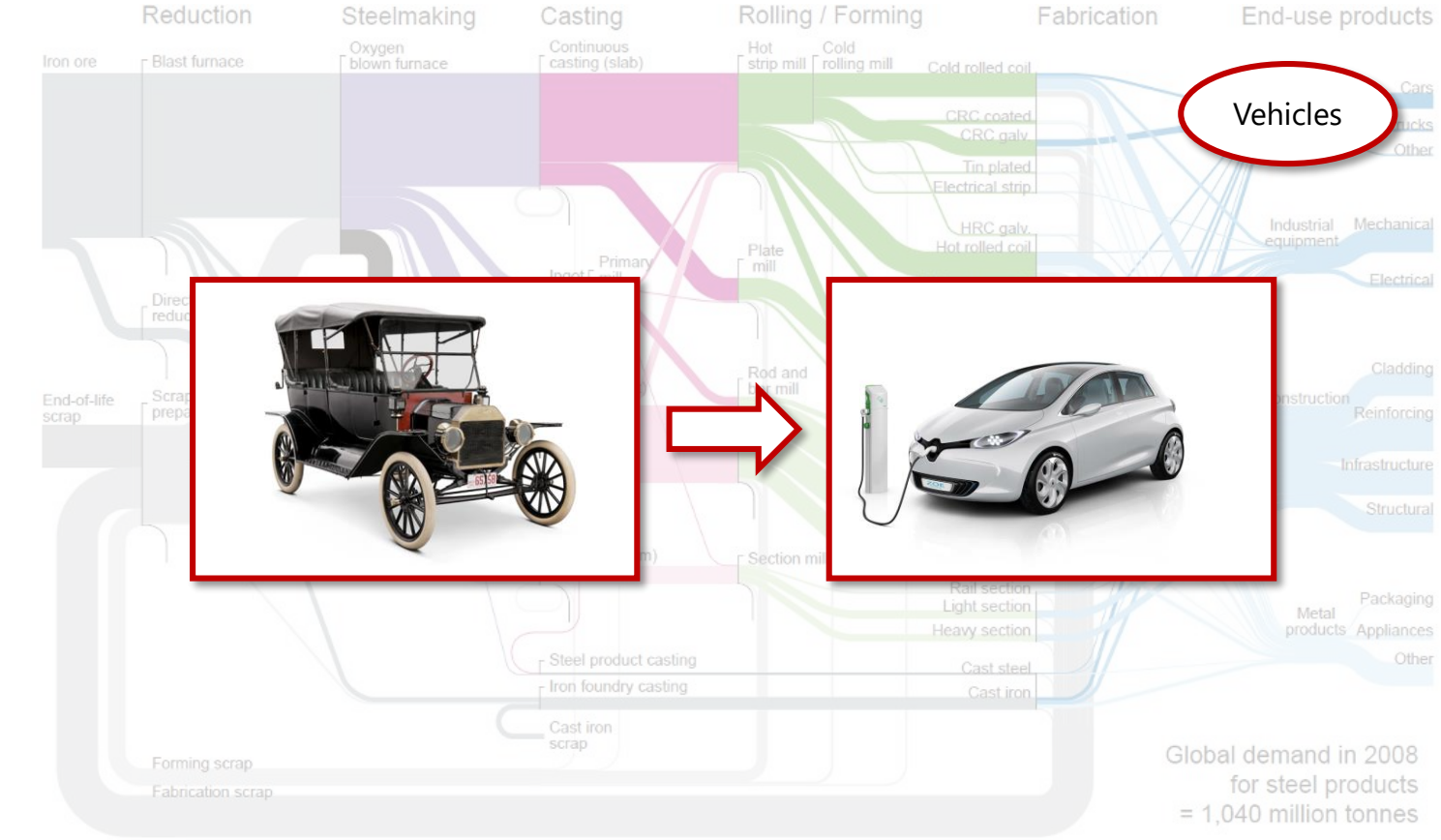
USE STAGE

- Life-time extension and repair
- More intensive use

END OF LIFE

- Re-manufacturing, re-purposing, and reuse
- Recycling

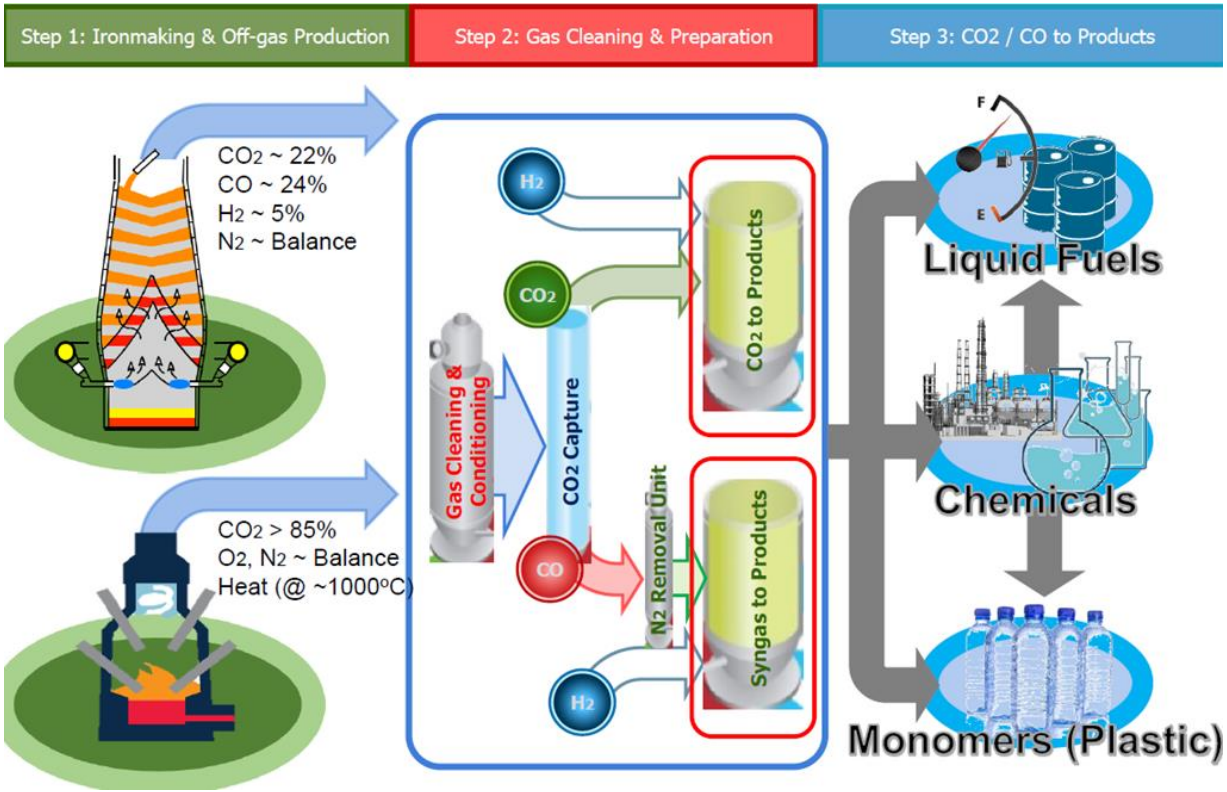
Understanding current and future supply value chains is critical



Material efficiency

Source: Cullen et al. (2012), "*Mapping the Global Flow of Steel: From Steelmaking to End-Use Goods*", *Environ. Sci. Technol. 46, 24, 13048-13055.*

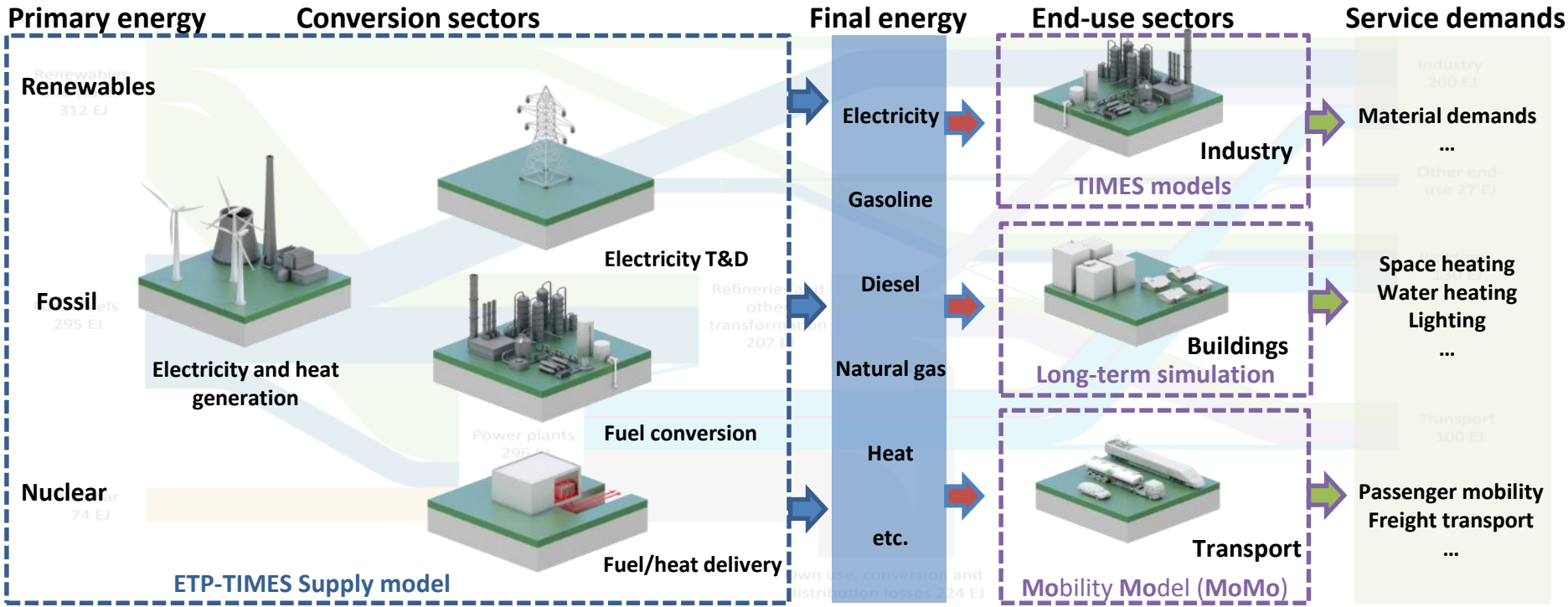
Exploring further sustainability opportunities



System-level sustainable benefits

Source: Adapted from *Tata Steel presentation from kick-off workshop* for the *IEA Global Iron & Steel Technology Roadmap*, 2017

ETP modelling: the engines behind the analysis



Bottom-up, technology-rich modelling to yield sector-specific insight

Enabling policies & mechanisms is the topic of today's discussion…

- What are the key barriers to accelerating the sustainable transition?
  - Technological? Innovation? Costs? Trade?
- What mechanisms and schemes can support the transition and overcome challenges?
  - Innovation finance? Regulations? Carbon pricing? Differentiated markets? Public-private partnerships?
- How can international regionally asymmetric regulatory frameworks be prevented?
  - International cooperation? Carbon border adjustments?
- How can wide international deployment of low carbon technologies be achieved?
  - Technology transfer? International partnerships?
- What metrics can be used to track and assess progress on technologies and the impact of policy mechanisms and finance?
  - Technology readiness assessment? Benchmarking efforts? Reporting initiatives?

Session 1

Private and public-private sustainable iron and steel development initiatives

Private and public-private sustainable iron and steel development initiatives

- *Speakers:*
  - Åsa Ekdahl – World Steel Association (moderator)
  - Yilong Zhang – Baoshan Iron and Steel
  - Francisco Leal – Asociacion Latinoamericana del acero
  - Paul Balserak – American Iron and Steel Institute
  - Jean-Theo Ghenda – Eurofer

- *Discussion questions:*
  - What are the key barriers to accelerate the sustainable transition of the iron and steel sector?
  - How can policy help?
  - What are the possible mechanisms that could support this transition while preventing regionally asymmetric regulatory frameworks? Which specific features would make these more effective?
  - How can the impact of policy mechanisms be more effectively tracked to improve effectiveness?

Session 2

Policy mechanisms effecting the sustainable transition

Policy mechanisms effecting the sustainable transition

- *Speakers:*
  - Gwenole Cozigou – European Commission, Directorate General GROW (moderator)
  - Hiroyuki Tezuka – Japan Iron and Steel Federation
  - Karl Buttiens – ArcelorMittal
  - Melina Boneva – European Commission, Directorate General CLIMA
- *Discussion questions:*
  - What are the economic and regulatory contexts required for these initiatives to deploy technologies after successful demonstration?
  - What metrics can be used to assess progress on these initiatives?
  - How can progress be accelerated?

Session 3

Mobilising investment and reducing risks

Mobilising investment and reducing risks

- *Speakers:*
  - Gianpiero Nacci – European Bank for Reconstruction and Development (moderator)
  - Christopher Beauman – European Bank for Reconstruction and Development
  - Andrey Nikolaev – S&P Global Ratings

- *Discussion questions:*
  - What are the key barriers to mobilise investment in the sustainable transition of the sector?
  - How can targeted schemes and mechanisms help?
  - Which specific features would make these more effective?
  - How can the impact of de-risking investment mechanisms be more effectively tracked to improve effectiveness?

Session 4

International engagement and technology transfer

International engagement and technology transfer

- *Speakers:*
  - Peter Levi – International Energy Agency (moderator)
  - Andrew Purvis – World Steel Association
  - Valentin Vogl – Lund University
  - Tony Zhang – Global CCS Institute

- *Discussion questions*
  - What are the challenges that can prevent technology transfer or a wide international deployment of a given technology?
  - What schemes can promote and accelerate technology transfer across regions?
  - What features such schemes should have to make them more effective?

Key milestones for the Iron and Steel Roadmap

Timeline

- Project kick-off – *November 2017, Paris*
- Materials demand trends in Transportation and Construction – *March 2018, Paris*
- Asian Steel Experts Dialogue – *May 2018, Shanghai*
- American Steel Experts Dialogue – *August 2018, São Paulo*
- Indian Steel Experts Dialogue – February 2019, New Delhi
- Enabling policies and mechanisms workshop – this Friday 29th March, Paris
- Modelling and analysis commences – April 2019
- Tentative launch – Q4 2019

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