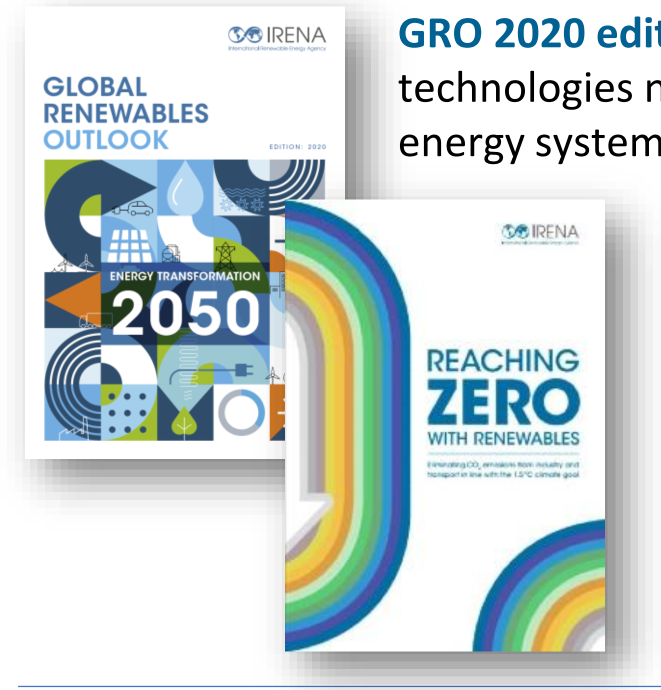
Reaching Zero with Renewables: understanding the potential of renewable-based solutions for industry and transport in support of the 1.5-degree-C goal

Paul Durrant, Head of End-use Sectors & Bioenergy, IRENA

UNFCCC Research Dialogues 2020

Wednesday, 25th November 2020 • 12:00 – 14:00 CET

Recent work on end-use sectors



GRO 2020 edition outlines the investments and technologies needed to decarbonise the entire energy system in line with the Paris Agreement.

Reaching Zero with Renewables focuses on how industry and transport could achieve zero emissions by 2060 and assesses the use of renewables and related technologies.

Collaborative Framework on Green Hydrogen

The umbrella for IRENA hydrogen engagement

- IRENA has established a **Collaborative Framework on Green Hydrogen** in June 2020, **to foster dialogue between governments and private sector**
- 65 countries, Hydrogen Council and IPHE participation. ***Co-facilitated by EC.***

Focus: **Innovative solutions for the energy-end-use sectors of transport & industry.** Showcased emerging **renewables based solutions** from around the world

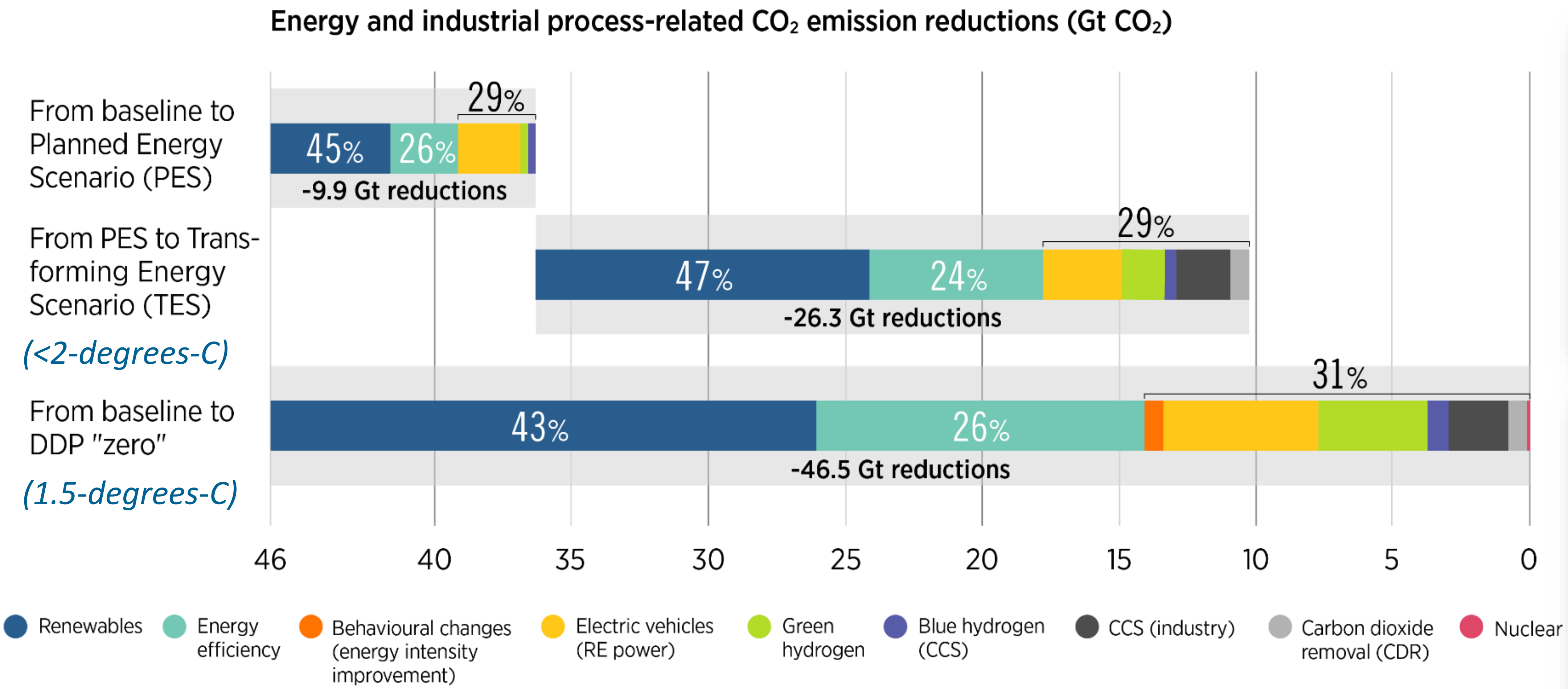
Collaborating with private sector, associations and other partners

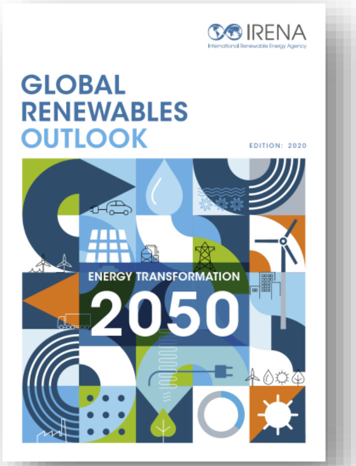
EPRI Electric Power Research Institute · Hydrogen Council · GBEP Global Bioenergy Partnership · International Transport Forum · Mission Possible Platform · SDG7 Youth Constituency · Initiate!

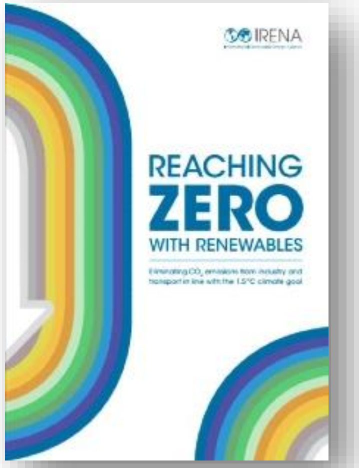
Summaries and recordings at http://innovationweek.irena.org

Roadmap for energy-related CO_2 emissions to 2050

IRENA
International Renewable Energy Agency

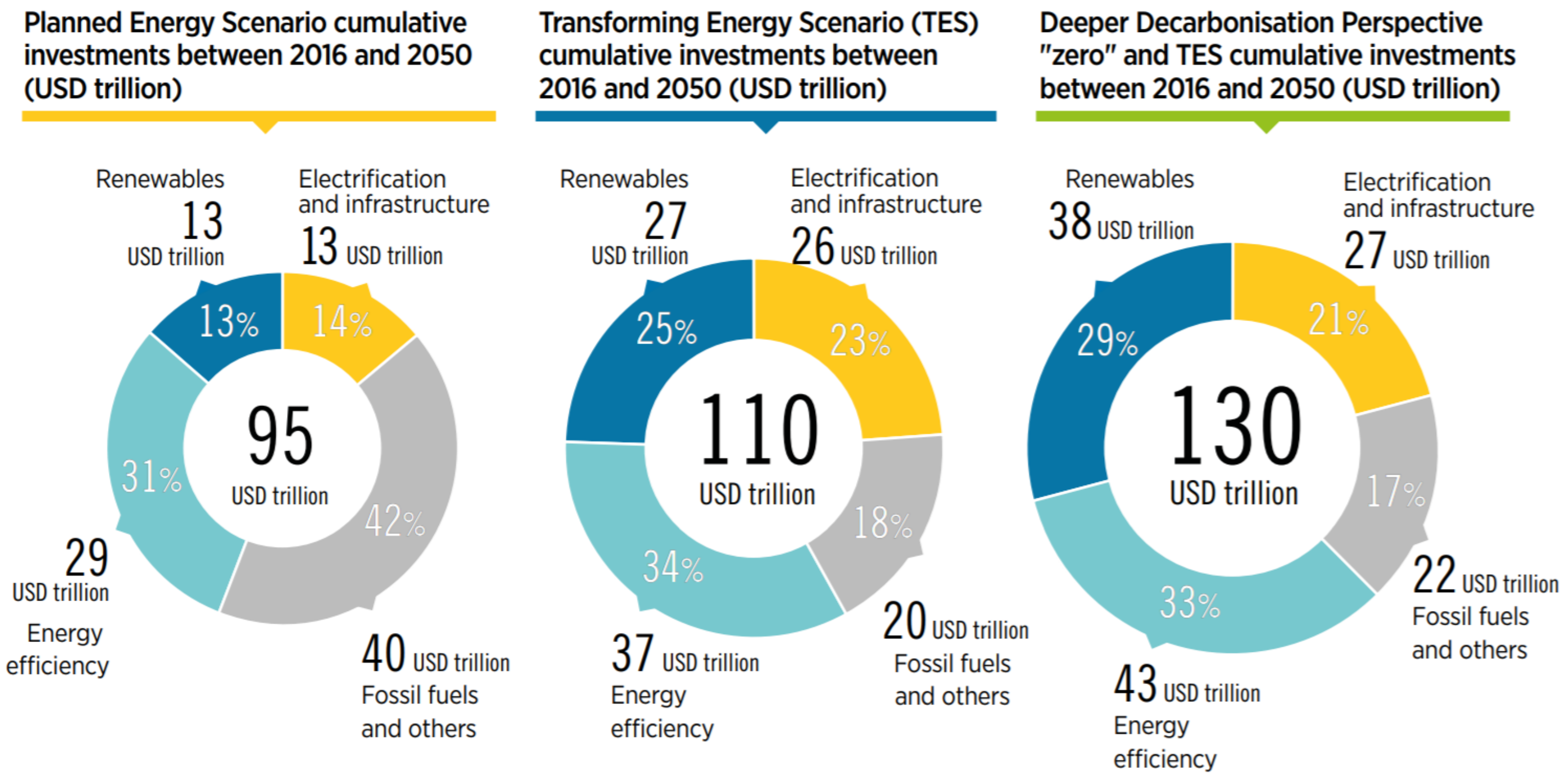






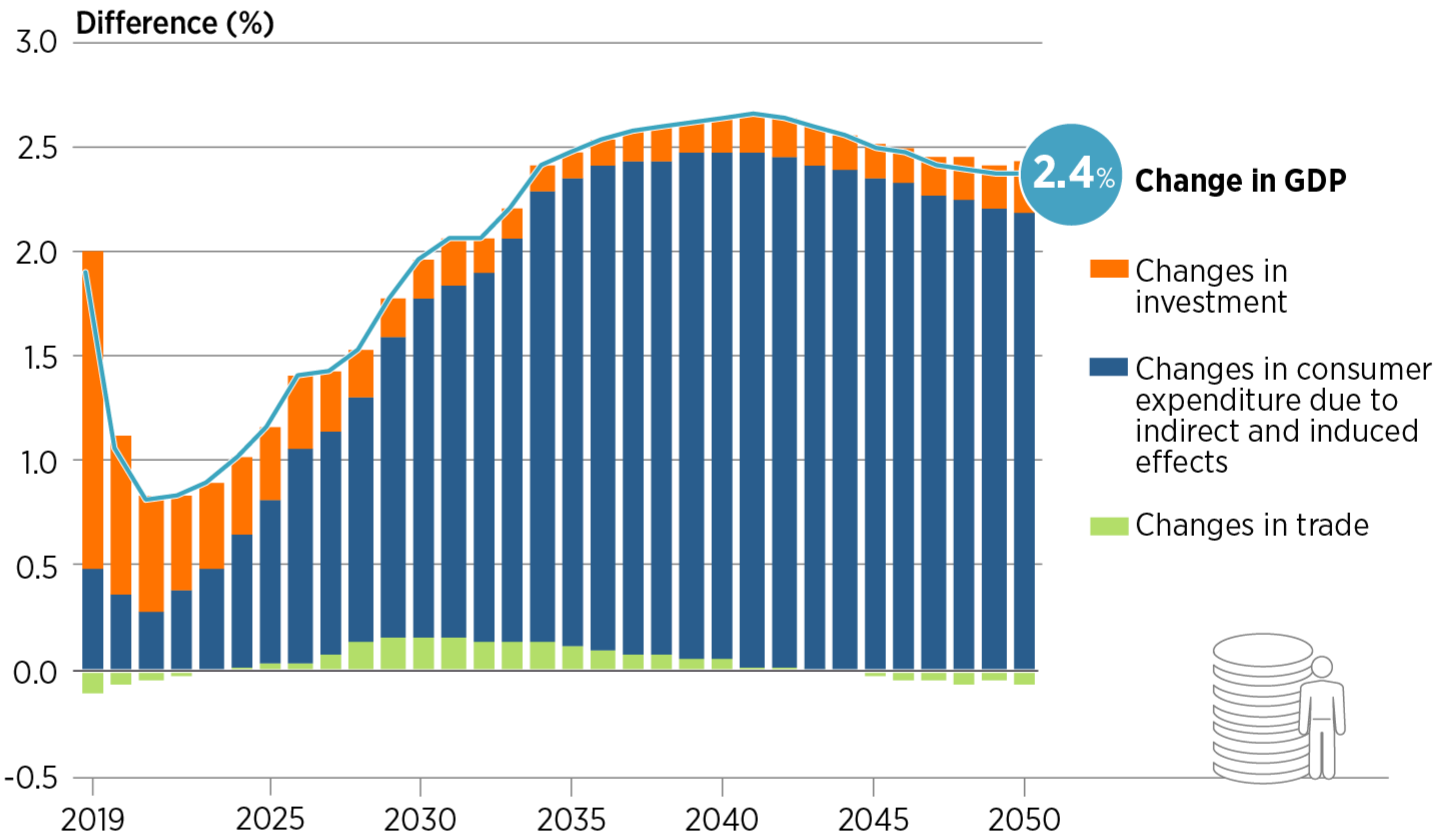
New investment priorities: renewables, efficiency & electrification

IRENA
International Renewable Energy Agency



- Total investment in the energy system in the Transforming Energy Scenario would reach USD 110 trillion by 2050, or around 2% of average annual GDP over the period.
- Of that total, over 80% needs to be invested in renewables, energy efficiency, end-use electrification, and power grids and flexibility.
- The Deeper Decarbonisation Perspective would require an additional investment of USD 20 trillion.

Energy transformation brings massive socio-economic gains

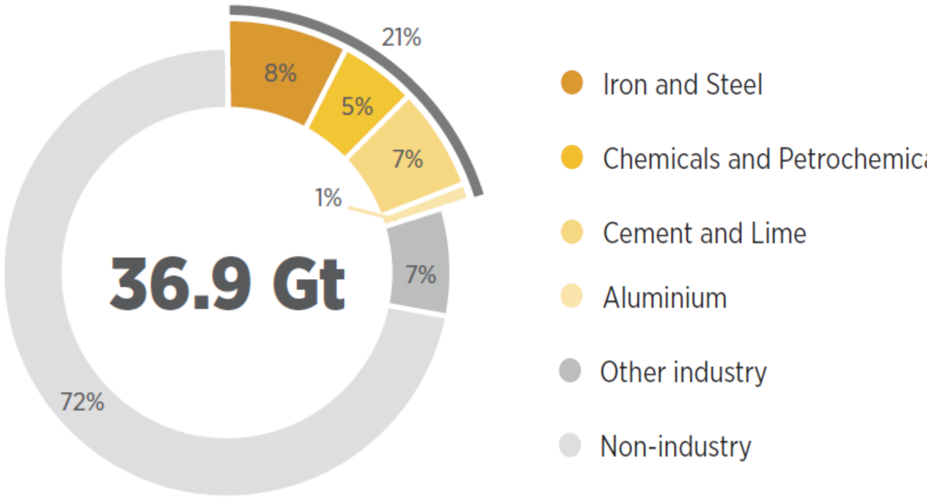


Global economy would grow, amounting GDP gains from now till 2050 to USD 98 trillion

Industry – Shares of Energy & Process Emissions

IRENA
International Renewable Energy Agency

Industry



2017

From all industries CO_2 emissions were 10.4 Gt/yr in 2017 – 28% of all energy & process emissions.

Emissions of 11.4 GT/yr remain in 2050 under planned policies.

TABLE 2: INDUSTRY SECTOR ENERGY DEMAND, EMISSIONS AND RENEWABLE ENERGY SHARE

Sectors	Metric	2017	2050 – Planned Energy Scenario	2050 – Transforming Energy Scenario	Progress made in CO_2 reduction from 2017 to TES	Additional progress needed in CO_2 reduction from TES to zero
Industry total	Energy (EJ/year)	157	246	190	6.7 Gt/yr reduction (64% of 2017 total)	3.7 Gt/yr reduction (36% of 2017 total)
	CO_2 emissions (Gt/year)[1]	10.4	11.4	3.7		
	Renewable energy share[2] (%)	11%	20%	52%		
Iron and steel	Energy (EJ/year)[3]	32	27	36	2.8 Gt/yr reduction (90% of 2017 total)	0.3 Gt/yr reduction (10% of 2017 total)
	CO_2 emissions (Gt/year)[1]	3.1	2.9	0.3		
	Renewable energy share[2] (%)	4%	12%	55%		
Chemicals and petro-chemicals	Energy (EJ/year)	46.8	79.8	53.4	0.7 Gt/yr reduction (41% of 2017 total)	1.0 Gt/yr reduction (59% of 2017 total)
	CO_2 emissions (Gt/year)[1]	1.7	2.5	1.0		
	Renewable energy share[2] (%)	3%	2%	29%		
Cement and lime	Energy (EJ/year)	15.6	13.3	10.3	1.9 Gt/yr reduction (75% of 2017 total)	0.6 Gt/yr reduction (25% of 2017 total)
	CO_2 emissions (Gt/year)[1]	2.5	2.6	0.6		
	Renewable energy share[2] (%)	6%	20%	56%		
Aluminium	Energy (EJ/year)	4.5	5.8	4.0	0.01 Gt/yr reduction (2% of 2017 total)	0.4 Gt/yr reduction (98% of 2017 total)
	CO_2 emissions (Gt/year)[1]	0.4	0.6	0.4		
	Renewable energy share[2] (%)	16%	38%	60%		

Notes:
1. Emissions include direct energy and process emissions.
2. Including electricity and district heating.
3. Energy demand for iron and steel includes blast furnaces and coke ovens. Demand increases under the Transforming Energy Scenario due to the addition of 500 Mt of steel based on direct reduced iron (DRI). This leads to increased steel production overall as it is now green steel.
Source: IRENA, 2020a; IEA, 2017

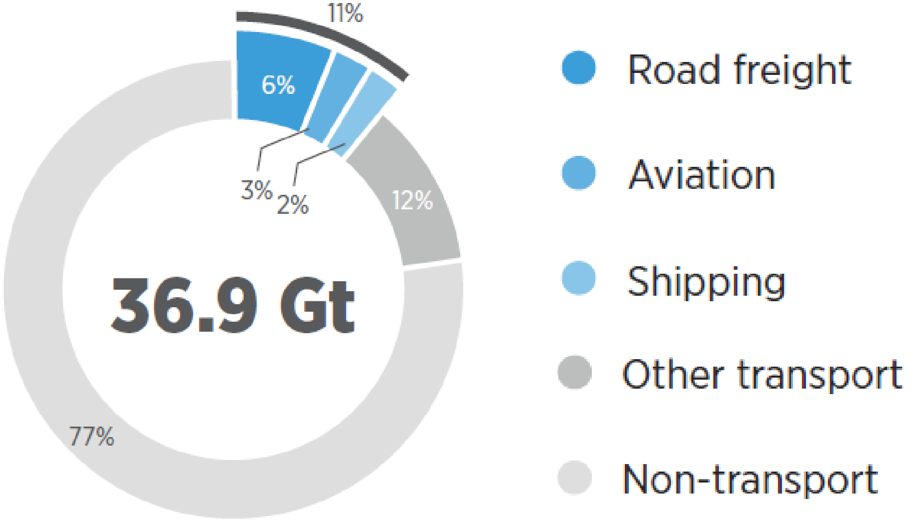
Transport – Shares of Energy & Process Emissions

TABLE 13: TRANSPORT SECTOR ENERGY DEMAND AND EMISSIONS

Sectors	Metric	2017	2050 - Planned Energy Scenario	2050 - Transforming Energy Scenario	Progress made in CO_2 reduction from 2017 to TES	Additional progress needed in CO2 reduction from TES to zero
Transport total	Energy (EJ/year)	117	135	86	6.1 Gt/yr reduction (72% of 2017 total)	2.4 Gt/yr reduction (28% of 2017 total)
	Energy-related CO_2 emissions (Gt/year)	8.5	8.6	2.4		
	Renewable energy share (%)	3%	10%	56%		
Road freight	Energy (EJ/year)	32.3	35.1	21.1	1.7 Gt/yr reduction (73% of 2017 total)	0.6 Gt/yr reduction (26% of 2017 total)
	Energy-related CO_2 emissions (Gt/year)	2.3	2.3	0.6		
	Renewable energy share (%)	1.5%	9%	62%		
Aviation	Energy (EJ/year)	13.5	30.8	15.1	0.3 Gt/yr reduction (27% of 2017 total)	0.7 Gt/yr reduction (72% of 2017 total)
	Energy-related CO_2 emissions (Gt/year)	0.9	2.1	0.7		
	Renewable energy share (%)	-	10%	40%		
Shipping	Energy (EJ/year)	11.3	13.7	7.4	0.4 Gt/yr reduction (43% of 2017 total)	0.5 Gt/yr reduction (57% of 2017 total)
	Energy-related CO_2 emissions (Gt/year)	0.9	1	0.5		
	Renewable energy share (%)	-	3%	12%		

Note: *Under IRENA's Deeper Decarbonisation Perspective.
Source: *IRENA, 2020a*; IEA, 2017

Transport

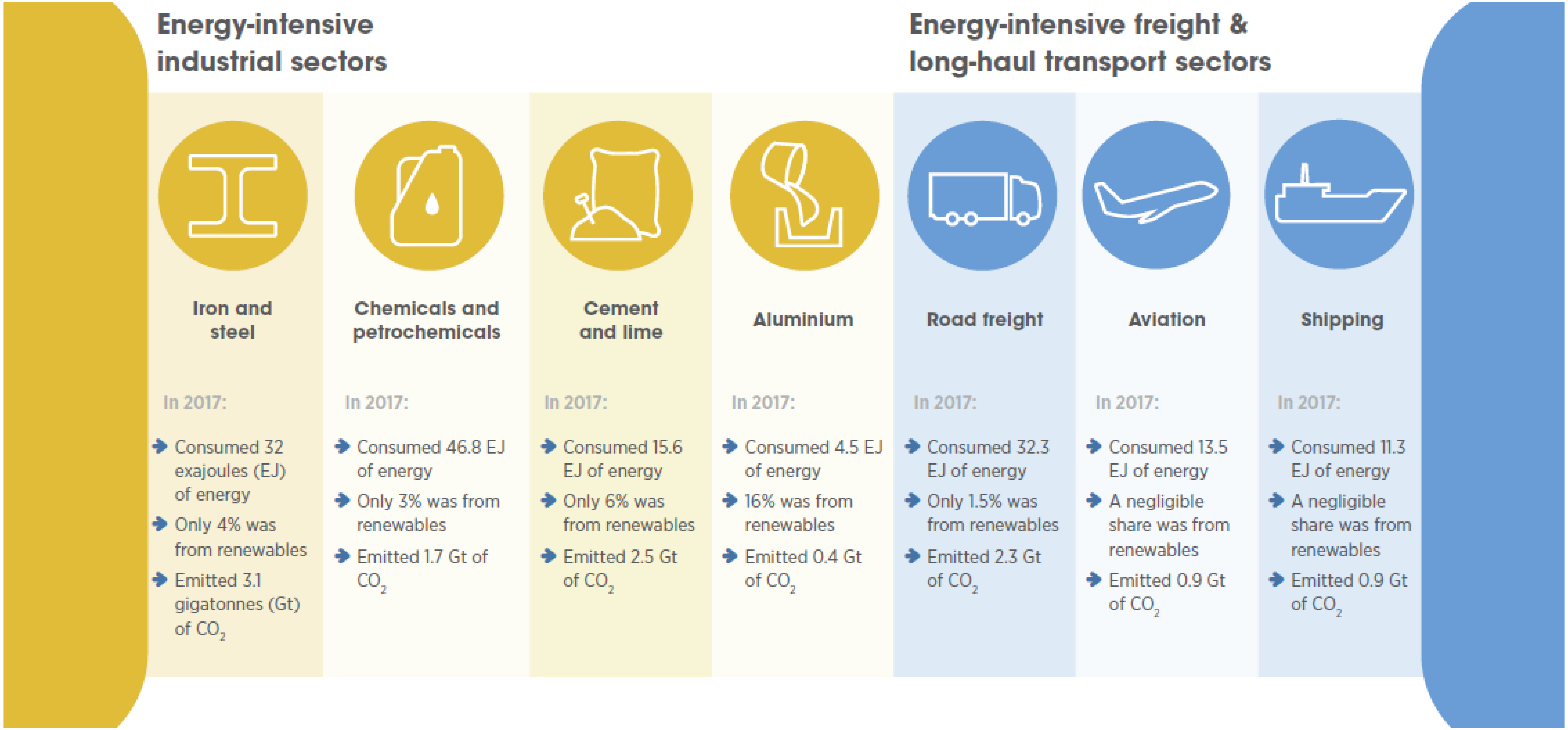


2017

Annual emissions in Transport increase by 0.1 GT/yr from 2017 to 2050 PES

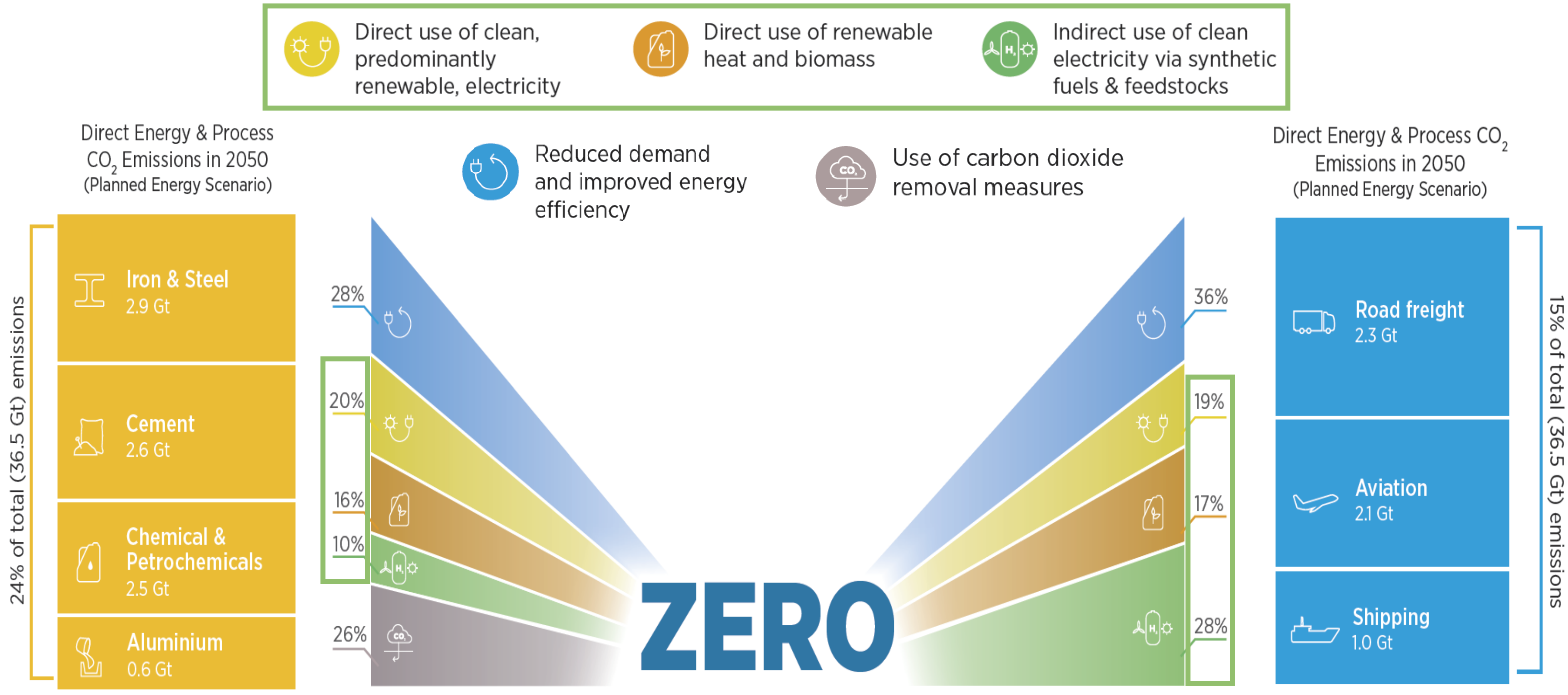
Emissions of 8.6 GT/yr remain in 2050

Seven challenging sectors



These seven will account for **38% of energy and process emissions and 43% of final energy use by 2050** unless major policy changes are pursued.

5 Measures for Reaching Zero

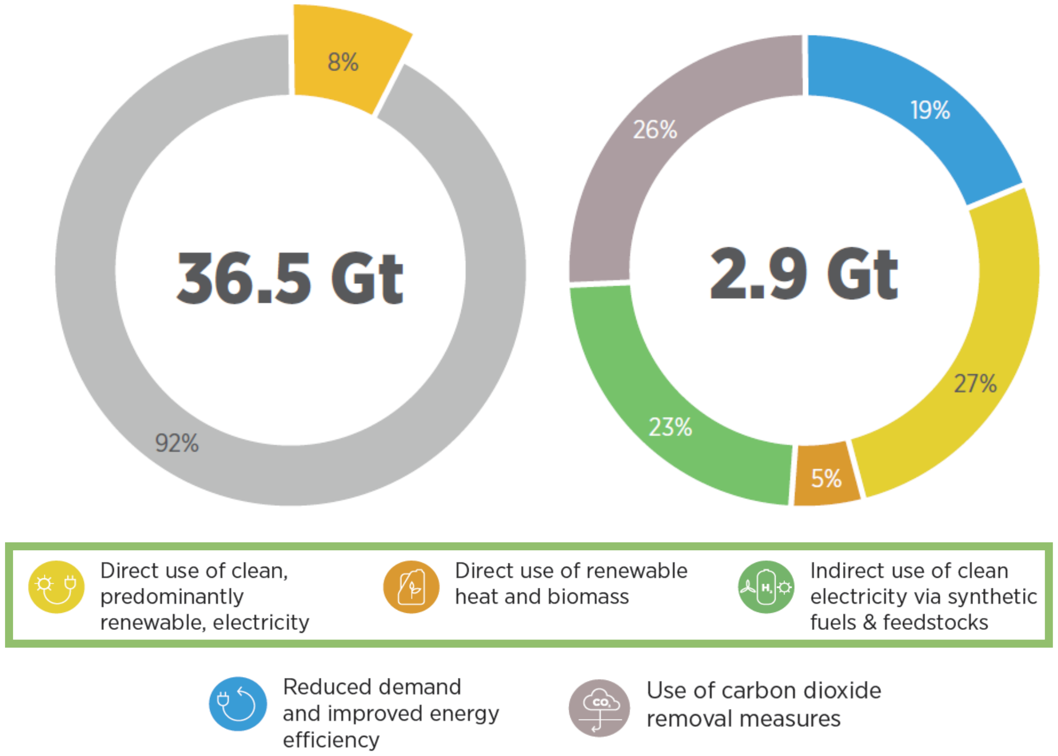


Iron & Steel

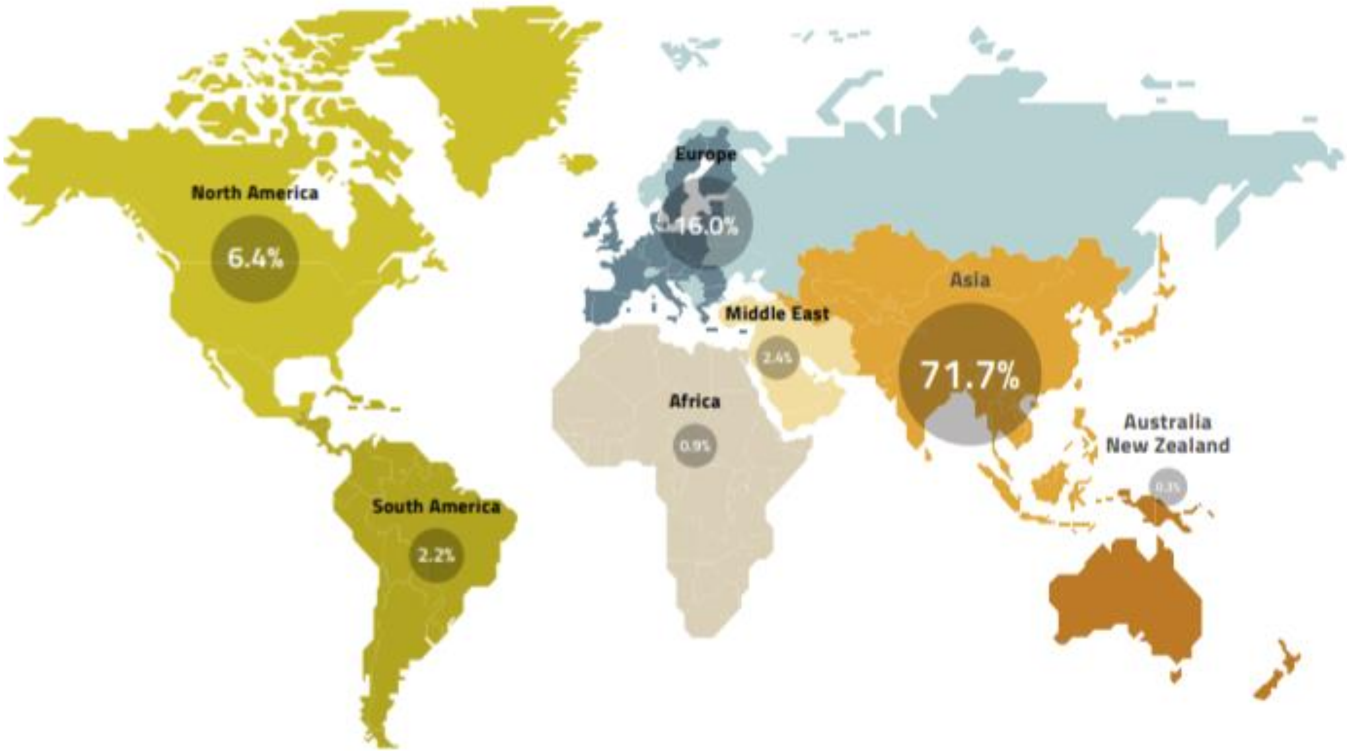
IRENA
International Renewable Energy Agency

Iron and steel share of total energy and process-related CO_2 emissions in 2050 Planned Energy Scenario (Gt).

Estimated role of key CO_2 emission reduction measures to reduce steel Planned Energy Scenario emissions to zero.



Steel Production by Region



Source: ECOWAS, 2019

Iron & Steel

IRENA
International Renewable Energy Agency

2 options compatible with reaching zero emissions

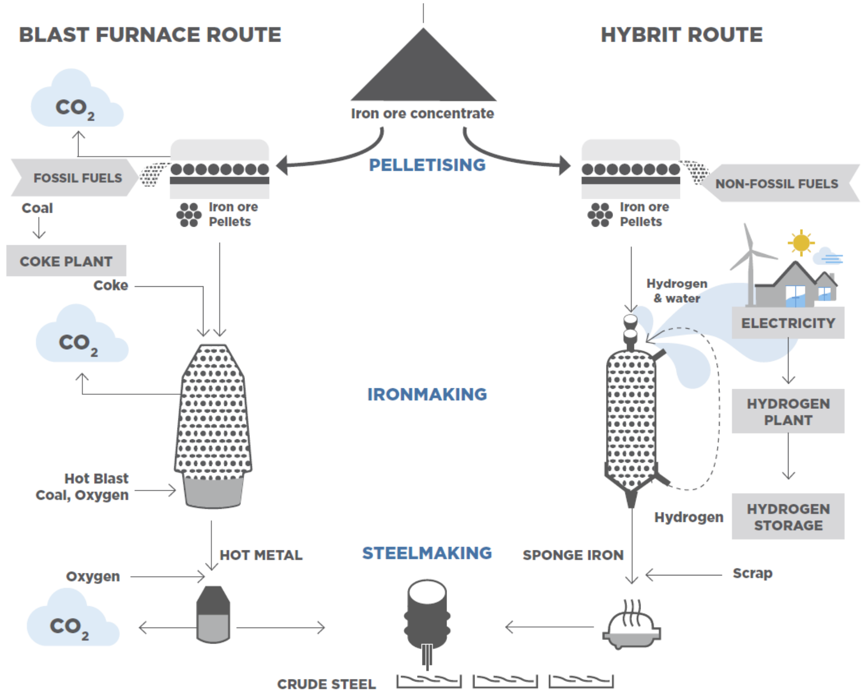
ZERO

Hydrogen-based direct reduction of iron and electric arc furnace-based steel production

- Produce iron via the direct reduction process using clean, preferably green, hydrogen as a reducing agent.
- Produce steel using electric arc furnaces.
- Source all heat and electricity inputs from renewables.

Capturing and storing process and waste emissions, and using renewables for energy

- Apply CCUS to existing iron and steel production processes.
- Source all heat and electricity inputs from renewables.

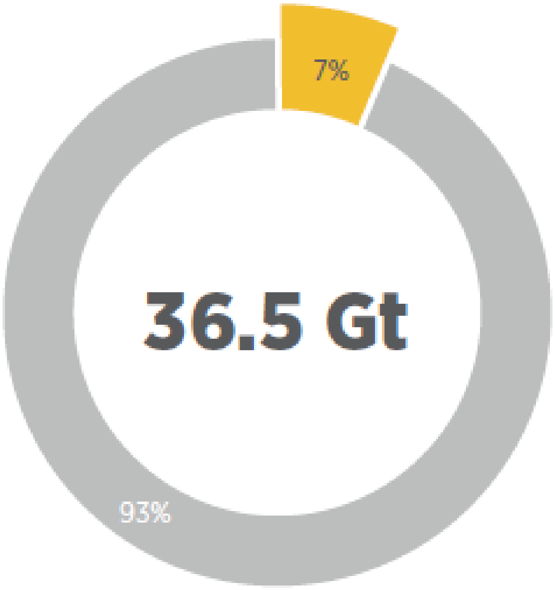


Renewable hydrogen-based DRI-EAF route being piloted in Sweden compared to the conventional BF-BOF route

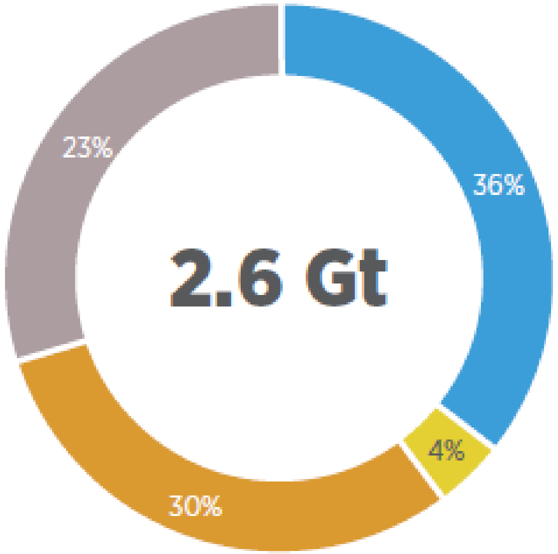
Cement – Strategy for reaching zero

IRENA
International Renewable Energy Agency

Cement share of total energy and process-related CO_2 emissions in 2050 Planned Energy Scenario (Gt).



Estimated role of key CO_2 emission reduction measures to reduce cement Planned Energy Scenario emissions to zero.



- Direct use of clean, predominantly renewable, electricity
- Direct use of renewable heat and biomass
- Indirect use of clean electricity via synthetic fuels & feedstocks
- Reduced demand and improved energy efficiency
- Use of carbon dioxide removal measures

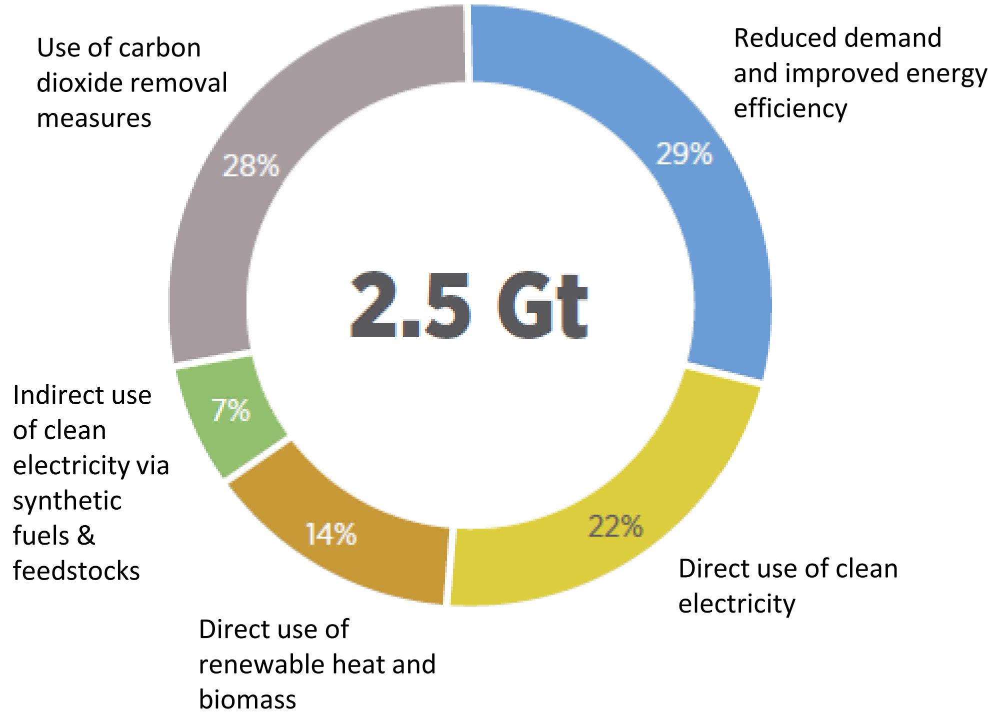
1. Reduce demand for conventional cement (through a combination of material efficiency, alternative construction techniques, alternative cement types and alternative building materials).
2. Eliminate energy emissions for all cement (through fuel switching to renewables).
3. Reduce process emissions from conventional cement (through reduction in clinker use, i.e., by lowering ratios of clinker-filler and/or the use of alternative binders).
4. For the remaining emissions:

   Apply CCS to a proportion of plants.

   Offset emissions from the remaining unabated plants through negative emission technologies – for example, BECCS, concrete reabsorption or CO_2 stored in wood used for construction.

Chemicals and petrochemicals – Options for reaching zero

Estimated role of key CO_2 emission reduction measures to reduce chemicals and petrochemicals Planned Energy Scenario emissions to zero



3 options compatible with reaching zero emissions

Using biomass for feedstocks and renewables for energy

- Source all heat and electricity inputs from renewables.
- Use biomass for chemical feedstocks – replacing primary petrochemicals with bio-based chemicals or replacing fossil fuel-derived polymers (particularly plastics) with alternatives produced from biomass.

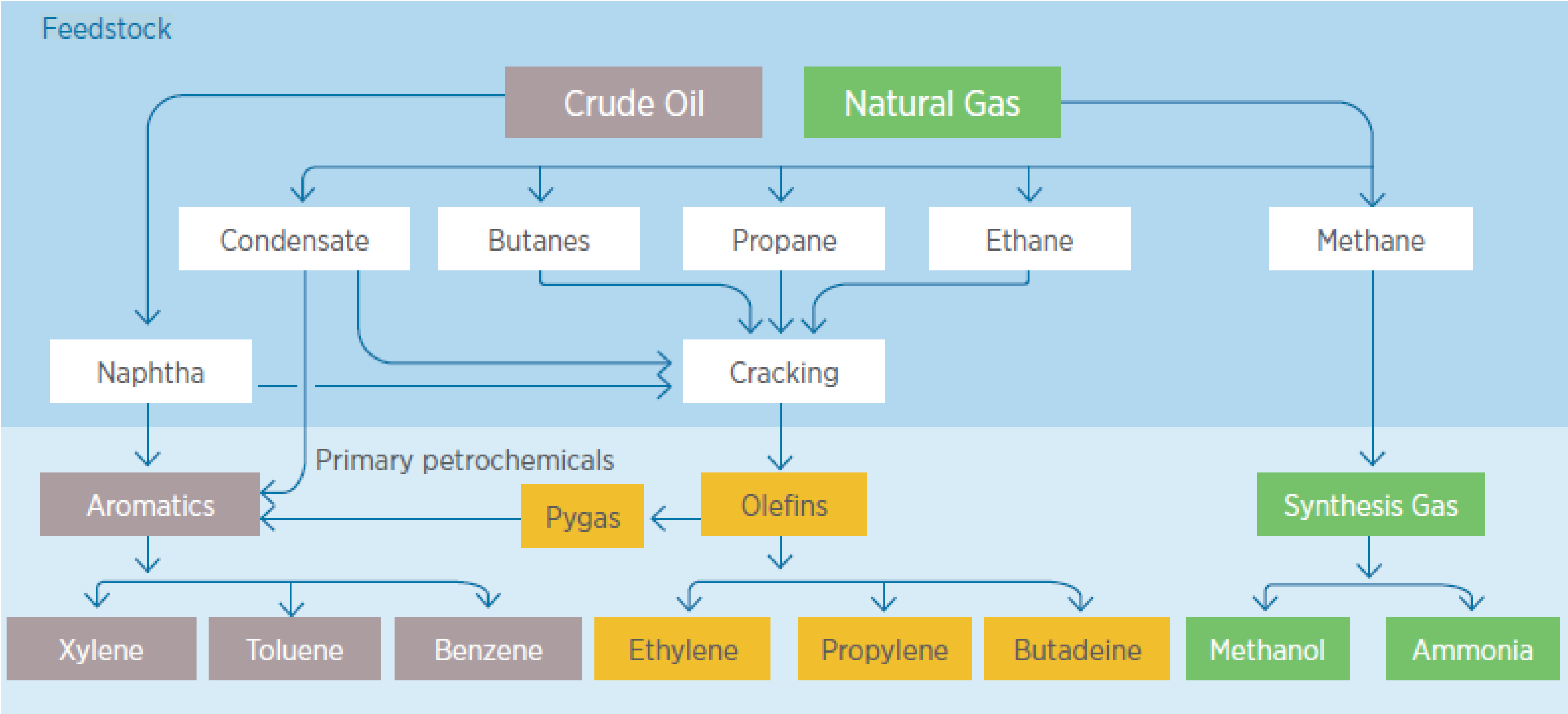
Using synthetic hydrocarbons for feedstocks and renewables for energy

- Source all heat and electricity inputs from renewables.
- Use synthetic hydrocarbons – produced from green hydrogen and clean CO2 sources – for chemical feedstocks.

Capturing and storing process and waste emissions, and using renewables for energy

- Apply CCUS to existing production processes.
- Source all heat and electricity inputs from renewables.
- Apply measures for the permanent storage of the carbon in products – *e.g.*, a highly efficient circular economy, the long-term storage of waste products or CCUS applied to end-of-life combustion.

Petrochemical tree: Feedstock and primary petrochemicals



Polyester Chain

Poly-Urethane

Phenolic chain
Nylon intermediates
Styrenic chain

Source: ABB

Decarbonising road freight transport with renewables

IRENA
International Renewable Energy Agency

Road freight

Road freight transport accounted for 27% of all transport-related emissions or over 6% of global CO_2 emissions in 2017.

3 options compatible with reaching zero emissions

ZERO

Battery electric vehicles

- Use electric motors powered by a battery pack, charged with renewable electricity.

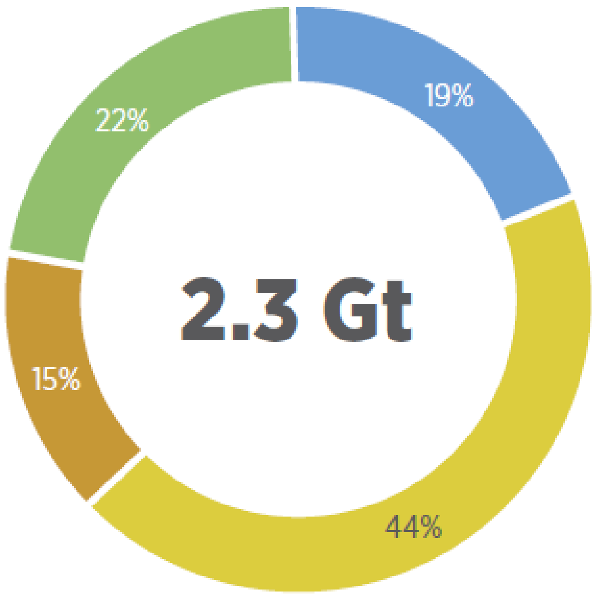
Fuel cell electric vehicles

- Use electricity produced by fuel cells powered by compressed (green) hydrogen.

Advanced biofuels

- Use biomass-based fuel substitutes, such as biodiesels and renewable diesels.

Estimated role of key CO_2 emission reduction measures to reduce road freight Planned Energy Scenario emissions to zero.



Reduced demand and improved energy efficiency

Direct use of clean, predominantly renewable, electricity

Direct use of renewable heat and biomass

Indirect use of clean electricity via synthetic fuels & feedstocks

Key takeaways from IRENA's joint Pentalateral EV truck webinar

IRENA
International Renewable Energy Agency

- At this nascent stage of development, road freight transport companies are hesitant to invest in a specific technology until they are confident that it will emerge as the clear winner.
- When compared to hydrogen fuel cell trucks, battery e-trucks are twice as efficient.
- Besides economic benefits for truck operators, this reduces pressure on renewable electricity supply needed to produce green hydrogen.

Pathway	Range (km/100 kWh)	Cost (EUR cents/km)	Efficiency (well-to-wheel)
Battery e-truck	48	20	62%
Hydrogen fuel cell truck	24	55	29%
Power-to-gas CNG-truck	17	70	20%

- Depot charging will dominate, need to consider smart charging strategies

Potential policy measures:

- Establishment of zero-emission zones for delivery vehicles;
- New zero-emissions truck sales requirements (specific targets tailored to specific categories of truck, based on size and weight);
- Incentives for upfront costs;
- Infrastructure investments to match vehicle incentives;
- Reduced road tolls for E-trucks;
- Increased road weight limits for e-trucks to account for battery weight (2 t extra is currently being discussed at the EU level).

Decarbonising shipping with renewables

IRENA
International Renewable Energy Agency

Shipping

Shipping accounted for 10% of all transport emissions, or 2.3% of global CO_2 emissions in 2017.

2 options compatible with reaching zero emissions

ZERO

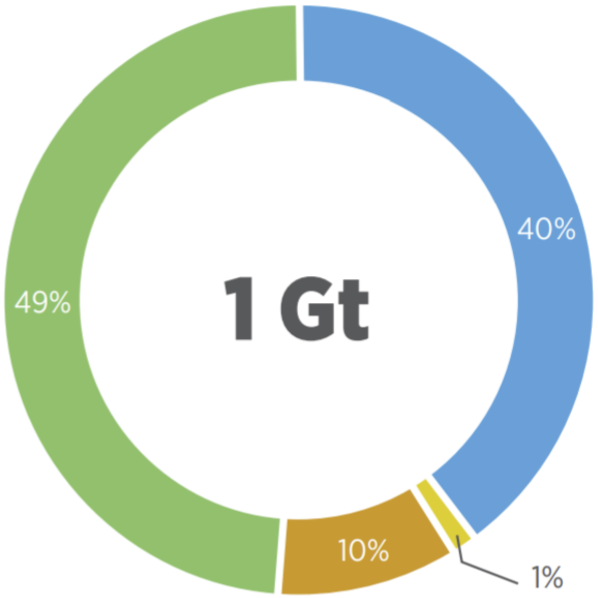
Advanced biofuels

- Use biomass-based fuels such as biodiesel, renewable diesel, bio-methanol, bio-fuel oil and liquefied biogas.

E-fuels

- Use green hydrogen or synthetic fuels such as green methanol, ammonia and methane.

Estimated role of key CO_2 emission reduction measures to reduce shipping Planned Energy Scenario emissions to zero.



Reduced demand and improved energy efficiency

Direct use of clean, predominantly renewable, electricity

Direct use of renewable heat and biomass

Indirect use of clean electricity via synthetic fuels & feedstocks

Decarbonising aviation with renewables

IRENA
International Renewable Energy Agency

Aviation

Aviation accounted for 11% of all transport emissions, or 2.5% of global CO_2 emissions in 2017.

3 options compatible with reaching zero emissions

ZERO

Biojet fuel

- Use fuels produced from sustainably sourced biomass.

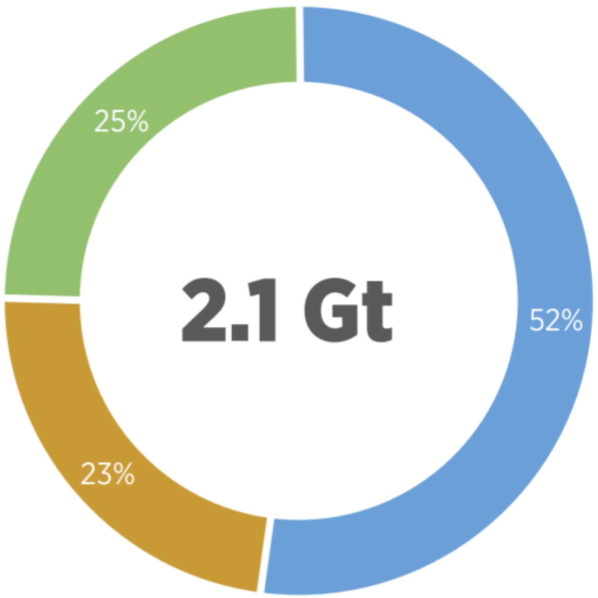
E-fuels

- Use synthetic fuels produced from cleanly sourced CO_2 and green hydrogen.

Battery-powered aircraft

- Use propulsion systems powered by batteries charged with renewable electricity.

Estimated role of key CO_2 emission reduction measures to reduce aviation Planned Energy Scenario emissions to zero.



- Reduced demand and improved energy efficiency
- Direct use of clean, predominantly renewable, electricity
- Direct use of renewable heat and biomass
- Indirect use of clean electricity via synthetic fuels & feedstocks

Biofuels for aviation

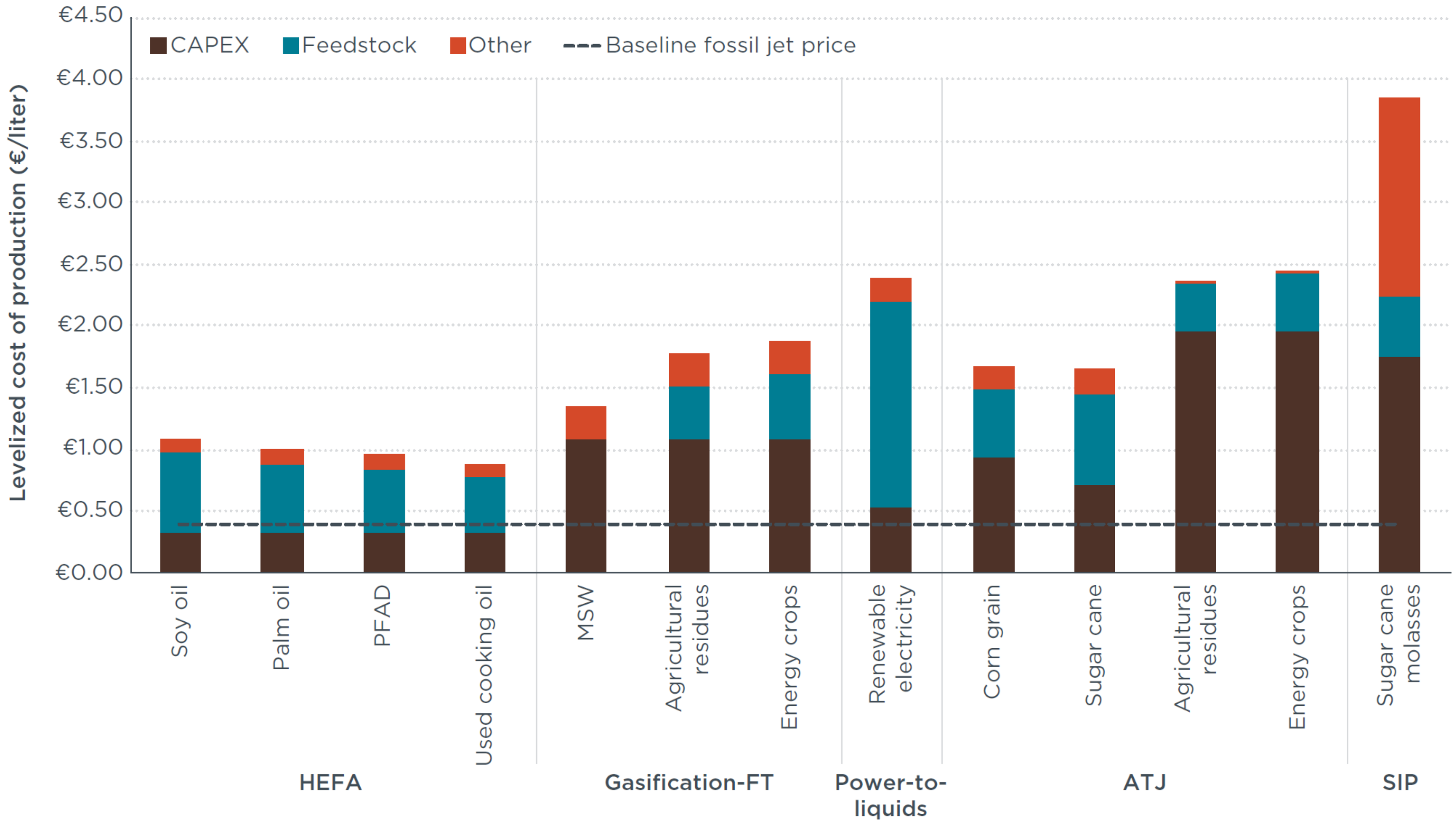


Figure 1. Comparison of levelized costs of production for alternative jet fuel across different fuel conversion pathways and different feedstocks (graph from the ICCT report on Cost of Supporting Alternative Jet Fuels in Europe (A. N. Pavlenko, Searle, and Christensen 2019)

Biojet /Sustainable Aviation Fuels likely to play a major role – how major will depend on sustainable feedstocks and cost reduction.

Oilseed crops on restored land (upgrade biodiesel)

- Europe (rapeseed), China, Americas
- FORBIO project – set aside land in EU

Wood residues (thermochemical routes)

- Uncollected logging residue in Scandinavia
- Unrealised forestry potential in SE Europe

Sugar/Energy cane (1G+2G ethanol plus conversion)

- Brazil, Southern Africa, Caribbean
- Economies from shared 1G/2G process steps
- Future potential enhanced by high-yield energy cane

Ten priorities for action (current global efforts are patchy)

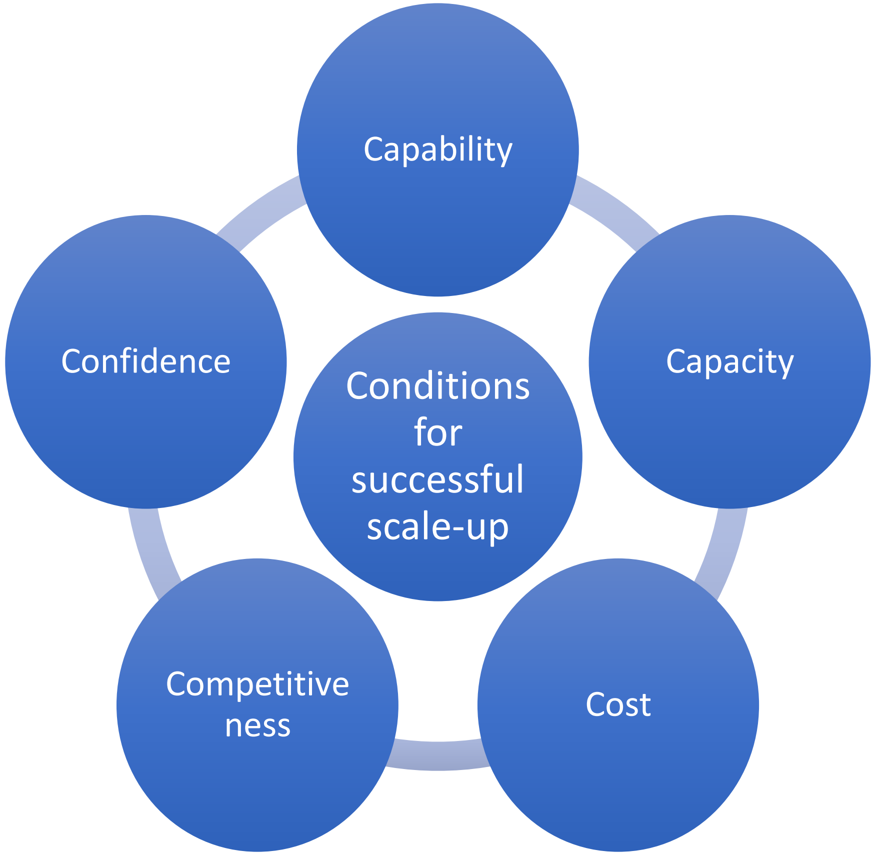
IRENA
International Renewable Energy Agency

Co-develop strategies & plans		Address enabling conditions		Enhance business models	
Pursue a renewables-based with an end goal of zero emissions.	Develop a shared vision and strategy and co-develop practical roadmaps.	Build confidence and knowledge among decision makers.	Plan and deploy enabling infrastructure early on.	Foster early demand for green products and services.	Develop tailored approaches to ensure access to finance.
• Requires linked sectoral strategies at the local, national and international levels • Plans built on the five technology pillars.	• Must be supported by all key actors • So co-develop with broad engagement nationally and internationally to build consensus. • International and inter-governmental bodies can assist.	• Decision makers need to better understand the risks. • Many more demonstration and lighthouse projects are needed. • Those who can must lead, showing what is possible.	• New approaches will require substantial new infrastructure. • Investment needs to come ahead of the demand. • Requires carefully co-ordinated planning & targeted incentives.	• Creating early sources of demand for green fuels, materials, products and services will help scale of production and reduce costs. • Use public procurement, corporate sourcing, regulated minimum percent requirements, etc.	• Sectors have specific needs i.e., high CAPEX, long payback periods, etc. • So tailored financial instruments along the whole innovation cycle are needed. • Co-operation between public and private financial institutions can help.

Work international			Support further innovation
Collaborate across borders.	Think globally, utilise national strengths.	Establish pathways for evolving regulation & international standards.	Support RD&D and systemic innovation.
• A global challenge, and the solutions needed are complex and expensive. • Countries working alone will not be able to explore all options in the necessary depth. • Countries can share the burden.	• Relocating industrial production to access low-cost renewable energy could reduce costs and create new trade opportunities. • Countries with large or expanding production should be supported in getting on the right (zero-carbon-compatible) track early on.	• Regulations and standards are both enablers and barriers for change • Requires careful planning to ensure that they shift at the same pace as the technological changes.	• Large gaps in capability and large cost differences still remain. • Increased investment in RD&D is needed across a range of technologies to reduce costs, improve performance and broaden applicability. • Innovation support needs to be systemic.

Some of what we don't know… (to be explored further)

- Transition pathways – speed, early actions, decision points at global/regional/national levels.
- Cost trends and cost reduction measures.
- Implications for energy supply:
  - Electricity & hydrogen demand;
  - Where will the electricity come from to produce all this H2?
  - Sector coupling and energy system integration.
- Infrastructure needs – in place ahead of demand
- Standards, certification and monitoring
- Actions to stimulate early demand for green products and services
- Global trade flows implications - for feedstocks, fuels and 'green' commodities.
  - Export implications - new trade opportunities for traditional fossil exporters as well as others with vast renewable resources
  - Geopolitical implications
  - Competitiveness risks and measures e.g. border taxes etc



Delving deeper – some of IRENA's upcoming analysis

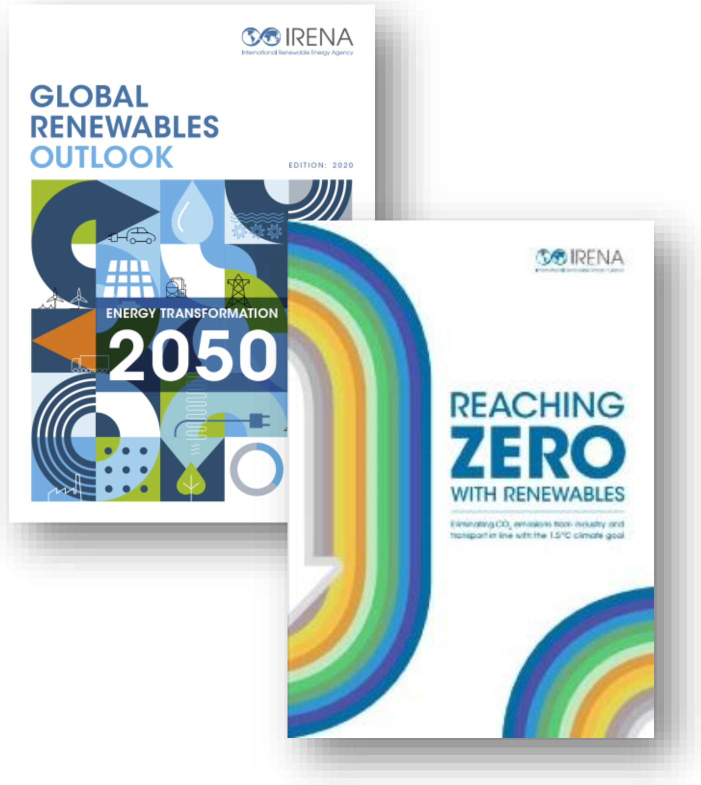
Re Reaching Zero - Coming shortly – briefing documents on:

- Electrolyser Cost Reduction report
- Biojet fuels report
- Renewable Methanol report
- Deeper dives into the scale of the challenge on Steel and Chemicals
- Policy briefs on Hydrogen & Bioenergy

Re Reaching Zero - Coming up in 2021:

- Regional perspectives: deeper dives into some specific regions / countries
- Closer look at cost and cost reduction drivers
- Closer look at key enabling conditions, infrastructure standards, global trade.
- 2021's Global Renewables Outlook – 1.5-degree /net-zero pathway
- Innovation landscape for electricity use in end-use sectors.

IRENA
International Renewable Energy Agency



Thanks for your attention!

pdurrant@irena.org

www.irena.org

www.twitter.com/irena

www.facebook.com/irena.org

www.instagram.com/irenaimages

www.flickr.com/photos/irenaimages

www.youtube.com/user/irenaorg