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2050 World Energy Transitions

Dolf Gielen
Director, Innovation and Technology
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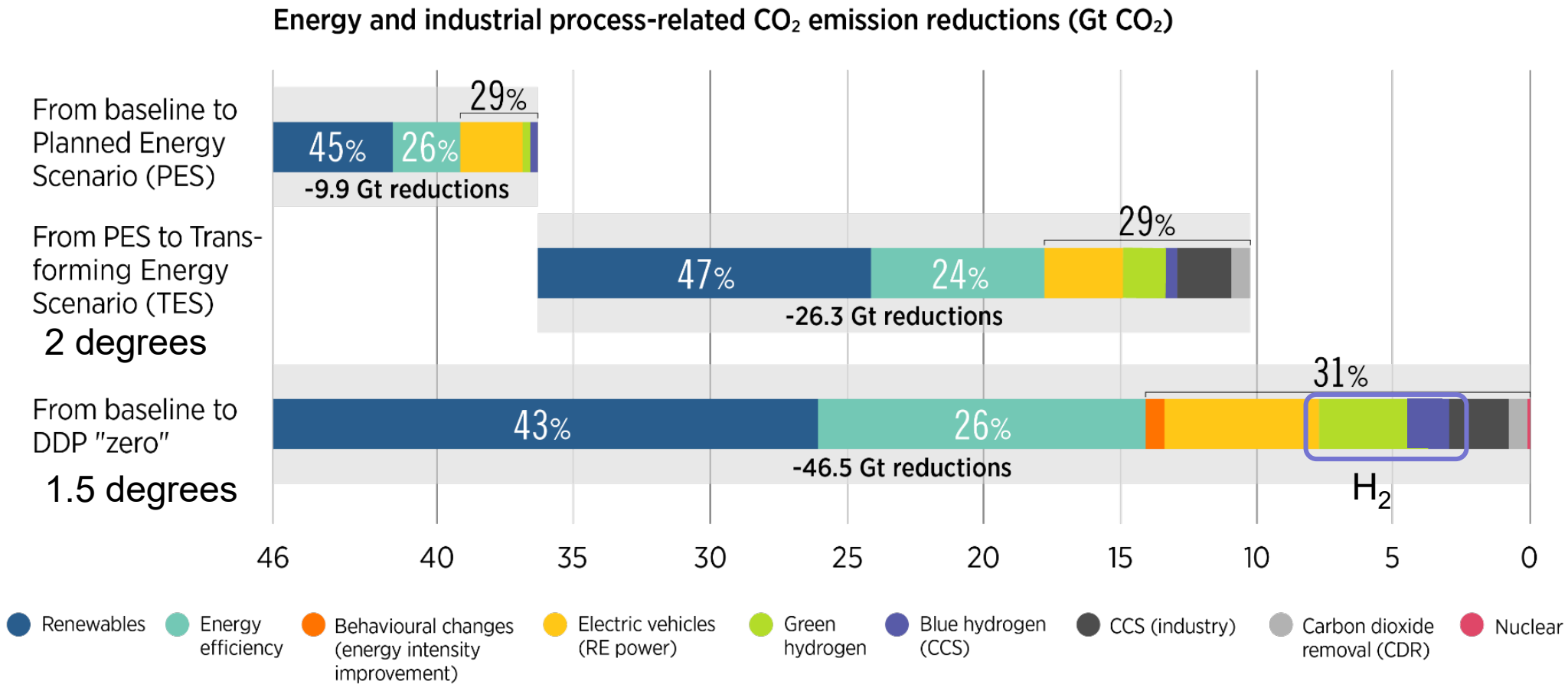
Energy transition is the central pillar for net-zero 2050 strategies

- Increase energy efficiency and reduce energy intensity through circular economy etc.
- Decarbonise the power sector with renewables
  - Offshore wind and solar PV are especially important in a Japanese context
- Enhance the flexibility of power systems
- Sector coupling solutions based on direct and indirect electrification

Source: The Conversation

Global Renewables Outlook outlines options to cut energy-related CO_2 emissions to 2050



Source: IRENA

Energy efficiency, renewables, end-use electrification, green hydrogen and synthetic fuels will play a crucial role in global decarbonisation.

Power sector transformation

- Clean power is a key pillar for energy transformation
- Three supply options:
  - Renewables
  - Fossil + CCS
  - Nuclear
- Costs of renewable power generation have fallen significantly and the field of applications continues to broaden
  - In a Japanese context e.g. floating offshore wind, building-integrated PV
  - Green ammonia as fuel for power generation (low lifecycle energy efficiency but offers import potential)
- More power systems flexibility is critical https://irena.org/publications/2020/Oct/Innovation-Toolbox
- CCS uptake in the power sector has been negligible for various reasons
  - Time window for deployment has closed, we need rapid decarbonisation with proven renewable technologies
- Global nuclear power generation has stabilised around 2600 TWh for the last two decades
  - 51 reactors under construction, no sign of nuclear renaissance despite efforts
  - Some very expensive and very delayed projects
  - Time window for deployment has closed, we need rapid decarbonisation with proven renewable technologies

Europe - a front runner in VRE integration
A global trend

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European electricity sector indicators for the period 01 Jan 2020 to 31 Dec 2020

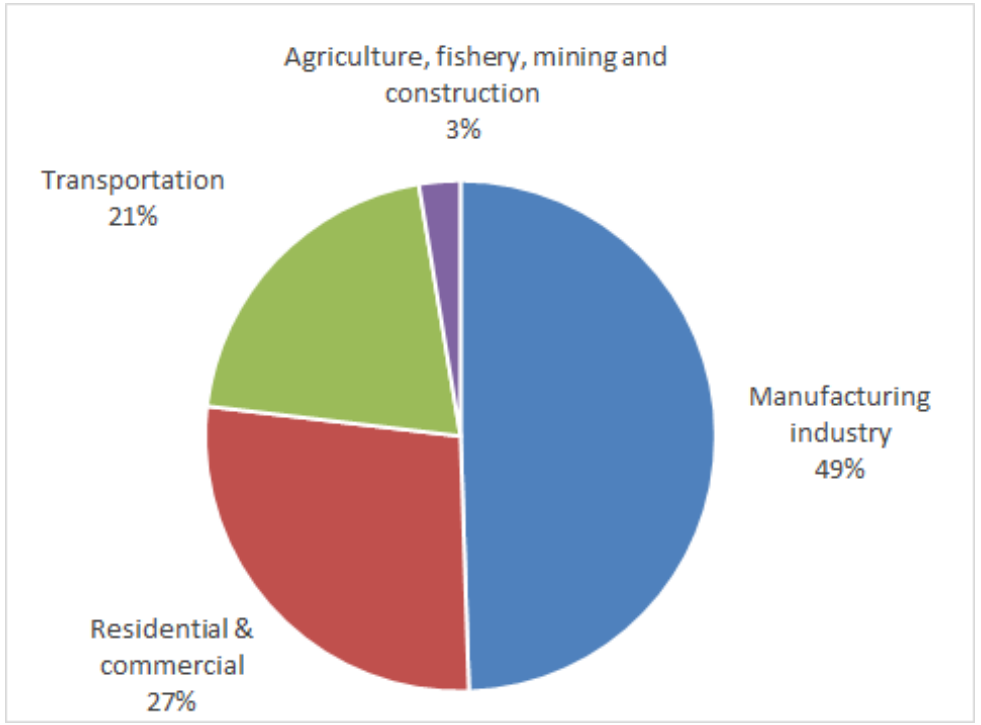
Indicator	Value	Relative change against last year (2019)
Total generation (TWh)	2,935	- 4.4%
Average share of RE power generation	**40%**	+ 4.9%
RE generation (TWh)	1,162 Solar 160 (est) Wind 470 (est) Hydro 360 (est) Biomass 200 (est)	**+ 8.3%**
Other sources generation (TWh)	1,773	- **18% Coal** - 11% Nuclear - 7% Gas
Top 3 days with highest share of RE generation	5 Jul: **55%** 6 Jun: 53% 24 May: 53%	

Source: https://www.wartsila.com/energy/transition-lab; EMBER/Agora

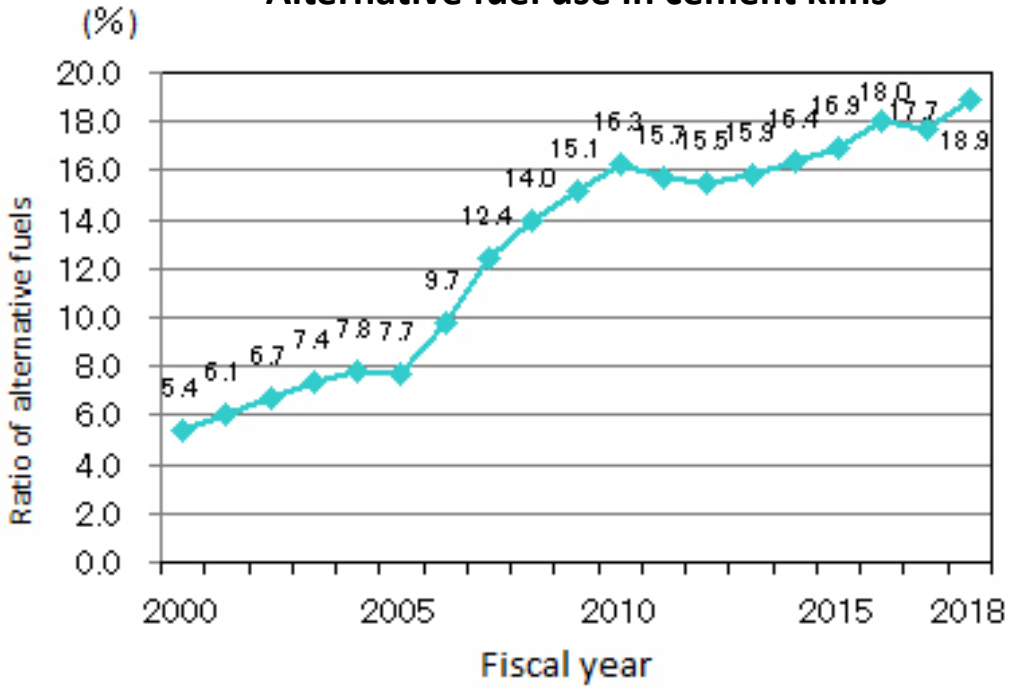
EU-27, UK, NO, SW

Industry matters in a Japanese context

- Manufacturing industry accounts for half of final energy + non-energy use
- Steel production 99 Mt (2019) 75% BF-BOF 25% EAF; 77 Mt pig iron production – 43% industrial fuel use
- Ethylene production 6.3 Mt (2019) - chemical industry 38% industrial fuel use
  - Oil feedstock accounts for a quarter of industrial fuel use
- Cement production 54 Mt (2019) - 5% industrial fuel use

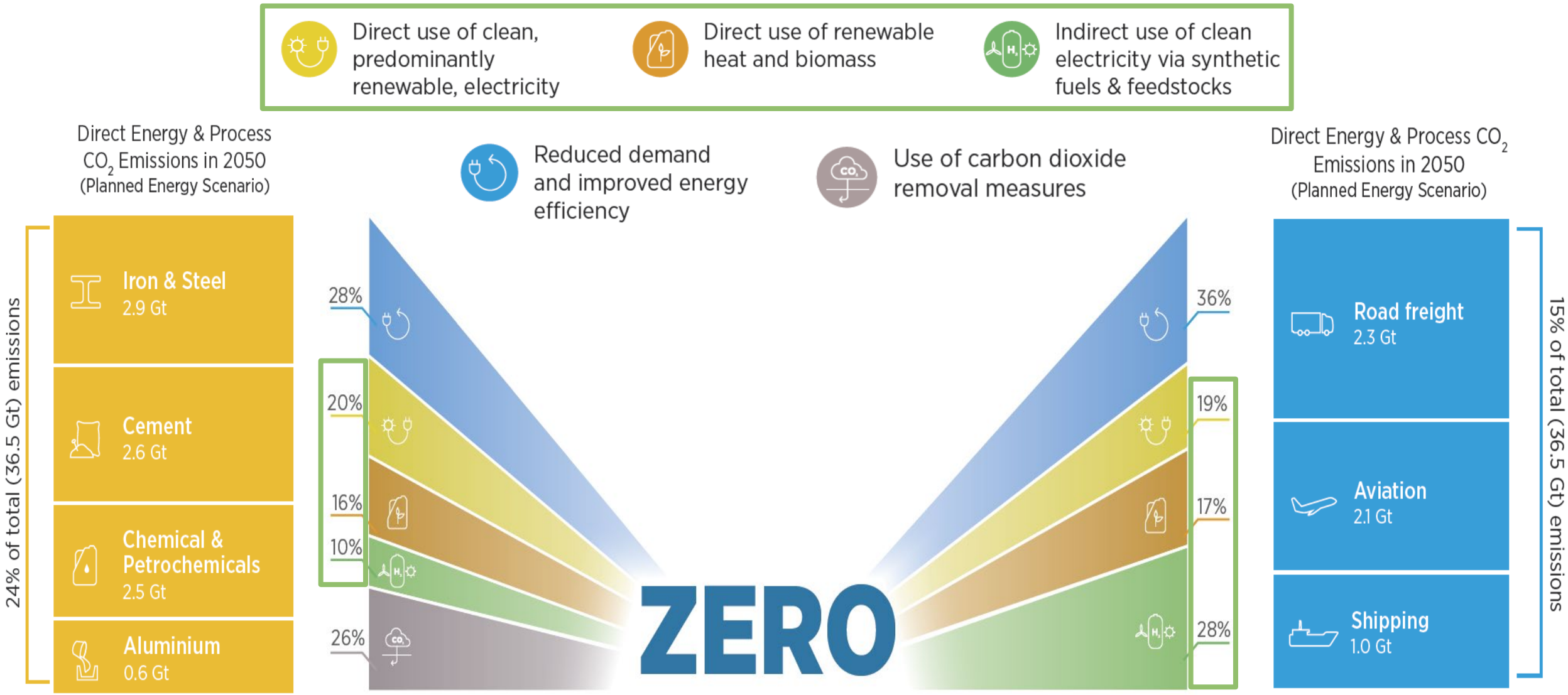


Alternative fuel use in cement kilns



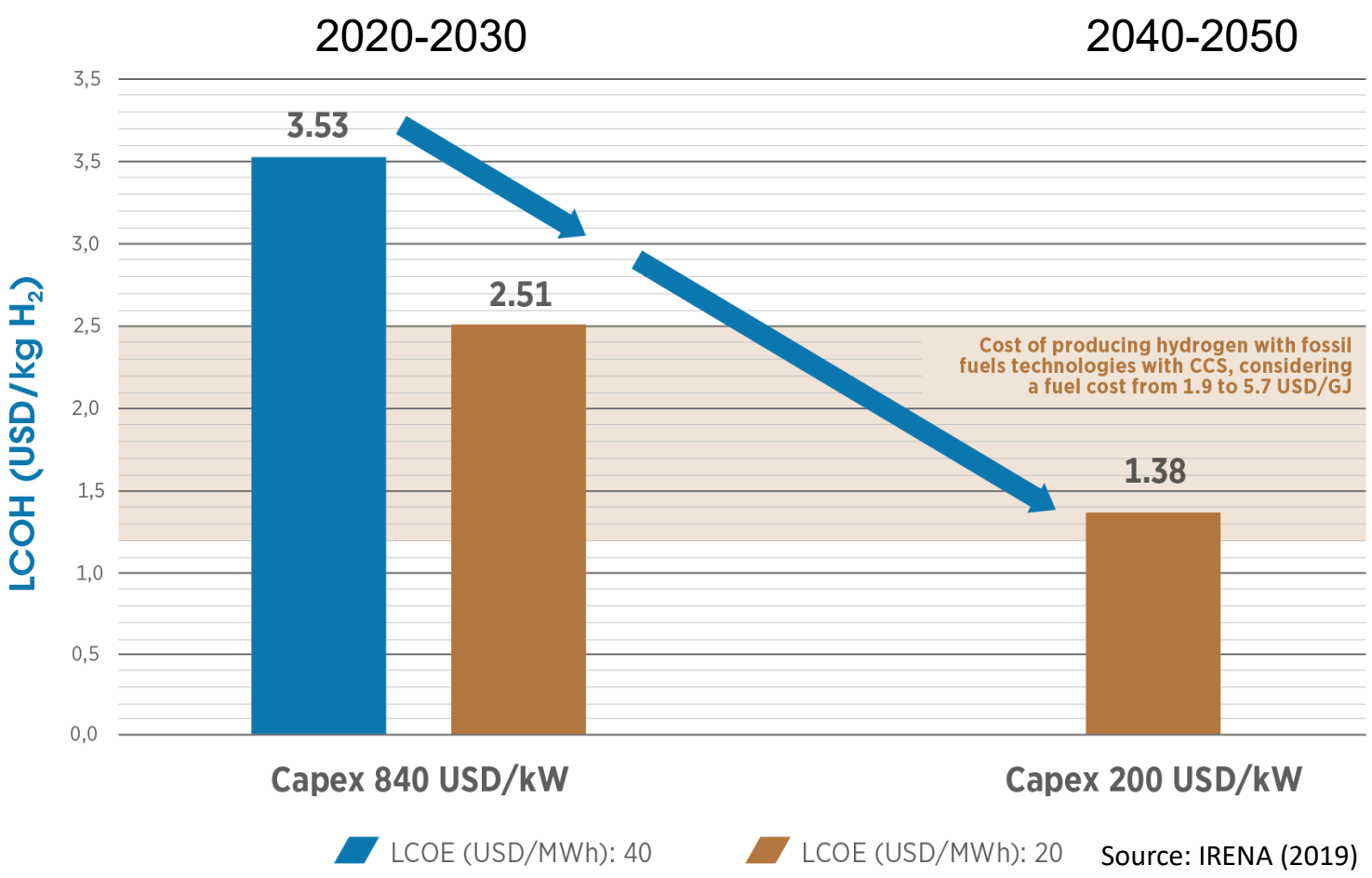
Source: Japan cement association

Five Measures for Reaching Zero – key role for renewables



Green hydrogen and green commodities

Green hydrogen will be cheaper than blue hydrogen

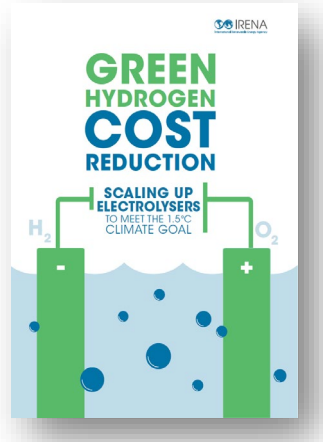


Source: IRENA (2019)

Key assumptions electrolyser: Load factor: 4200 hours (48%), conversion efficiency 65% (today), 75% (2050)

Today:

- 98% grey hydrogen supply
- 1% of all hydrogen supply is green and 1% is blue
- 0.3 GW electrolysers
- 60 -80 GW pipeline of electrolysers



December 2020

2050:

- 2/3 of supply is green and 1/3 is blue – 2 - 4x today's hydrogen demand
- Electrolyser system cost may drop to 200 USD/kW in 2050
- Electrolyser efficiency may improve to 45 kWh/kg
- Hydrogen production can increase RE power demand significantly and provide additional flexibility

Electrification of passenger vehicles and road freight

- 3.1 million EV sales in 2020 – 4% market share
  - Driven by support policies
  - Battery cost have dropped to 137 USD/kWh and continue to fall
- Charging infrastructure remains a challenge and market structure for public charging is fragmented
- Smart charging needed for effective grid integration
- IRENA scenario 50% BEV stock share by 2050

- Electric trucks can benefit from battery advancements for EVs
  - Battery energy density may double next ten years, potential to quadruple while cost per kWh halve
  - A 40 t electric truck would have 4 t additional weight
- Delivery vans going electric
- The jury is out regarding heavy duty trucks

Decarbonising aviation with renewables

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Aviation

New report launching soon

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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.

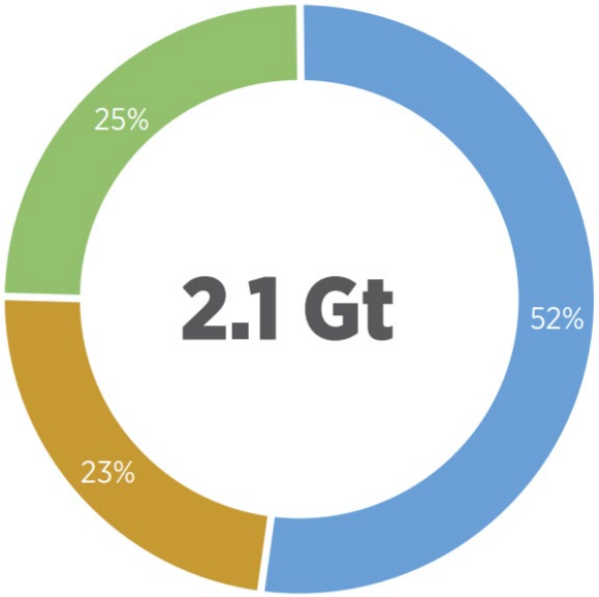
E-fuels

- 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

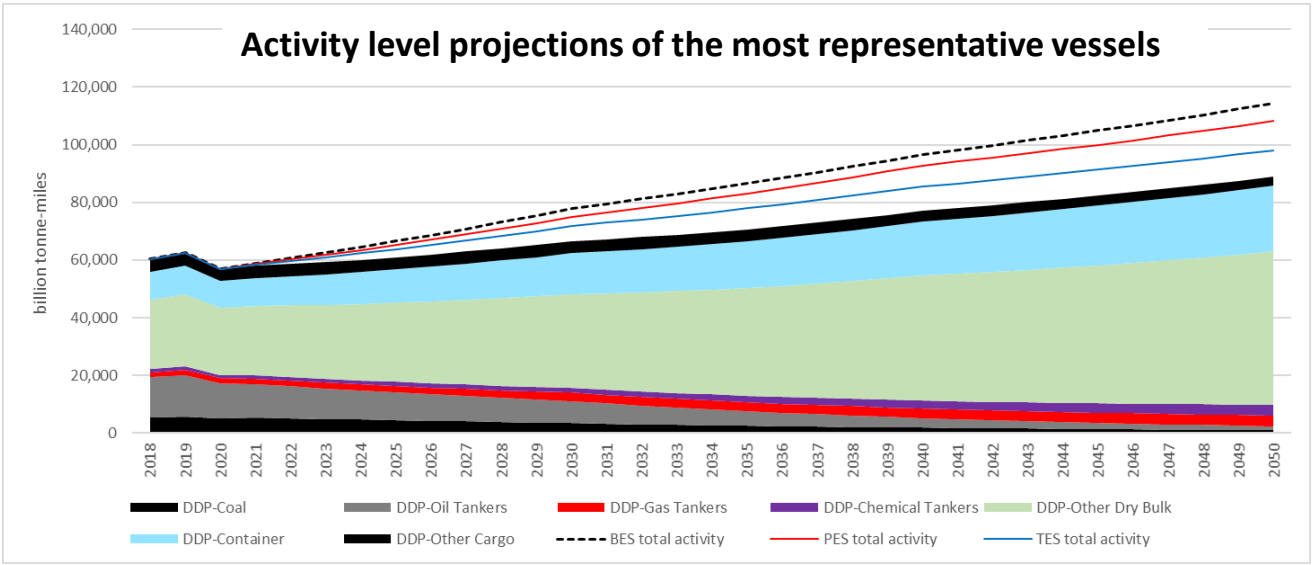
Indirect use of clean electricity via synthetic fuels & feedstocks

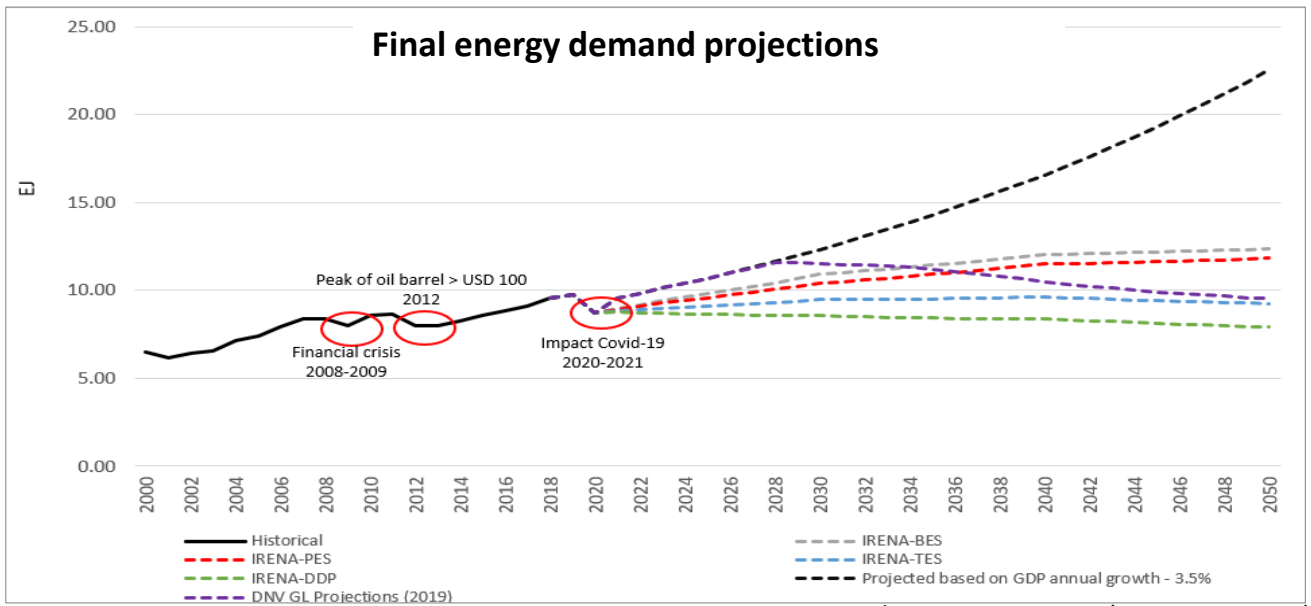
International shipping accounts for around 9% of global transport sector emissions

Annual CO_2 emissions associated with international shipping have increased from around 0.35 Gt in 1970 to 1 Gt in 2018.

The current energy needs of the shipping sector are mostly met by heavy fuel oil (82%), marine gas and diesel oil (18%).

Under a business as usual behaviour, the latest global trade volume is estimated to grow at 4% per year over the next five years.





Source: IRENA Shipping Report 2.0 (upcoming-2021)

Clean fuel options for shipping

- Green ammonia (e-fuel) and blue ammonia (CCS)
- Renewable methanol (biomass based and e-fuel)
- Other biofuels (liquids and biomethane)
- Availability, cost, toxicity, standards will play a role
- Wind assisted propulsion are being deployed

- Hydrogen, batteries are being developed for coastal and inland shipping but are currently not suited for oceangoing vessels

Example: Ammonia

- Global production 200 Mt/yr

- Today mainly used as feedstock for N-fertilizer
- Can also be used as fuel
  - For ships
  - In power plants

- Blue ammonia (with CCS) or green ammonia (from green hydrogen and renewable electricity) options
- Current LCOA green ammonia USD 475/t, by 2030 USD 350/t (current ammonia price USD 200-300/t)
  - Several commercial scale projects under development (Saudi, Australia, others)
- Consider import of green ammonia

- Need for green sourcing standards and certification (Guarantees of Origin)

Example Direct reduction of iron ore with hydrogen

- The bulk of direct CO_2 emissions is related to iron making process
- Today iron making is coke and coal based
- Interesting opportunities to use green hydrogen
- Hydrogen-based Direct Reduced Iron (DRI) production is technically feasible
- Also natural gas based DRI production with CO_2 capture and storage is feasible
  - Emirates steel project UAE (CO2-EOR project)
- DRI is a bulk commodity than can be shipped
- Increasing attention for hydrogen DRI in Europe, Australia

Photo copyright: Steel-360

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 and Morocco.***
- Ongoing work on standardization and Guarantees of Origin

IRENA VIRTUAL EDITION
INNOVATION WEEK 2020

4 days | 8 sessions | 23 panels | 101 speakers | from 35 countries | 1 600+ audience | from around 1 250 companies and organisations and 137 countries

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 YOUTH IN SUSTAINABLE ENERGY · Initiate!

Summaries and recordings at http://innovationweek.iren

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