INTERGOVERNMENTAL PANEL ON climate change

WMO UNEP

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Agenda item 5

Climate Change 2022

Mitigation of Climate Change

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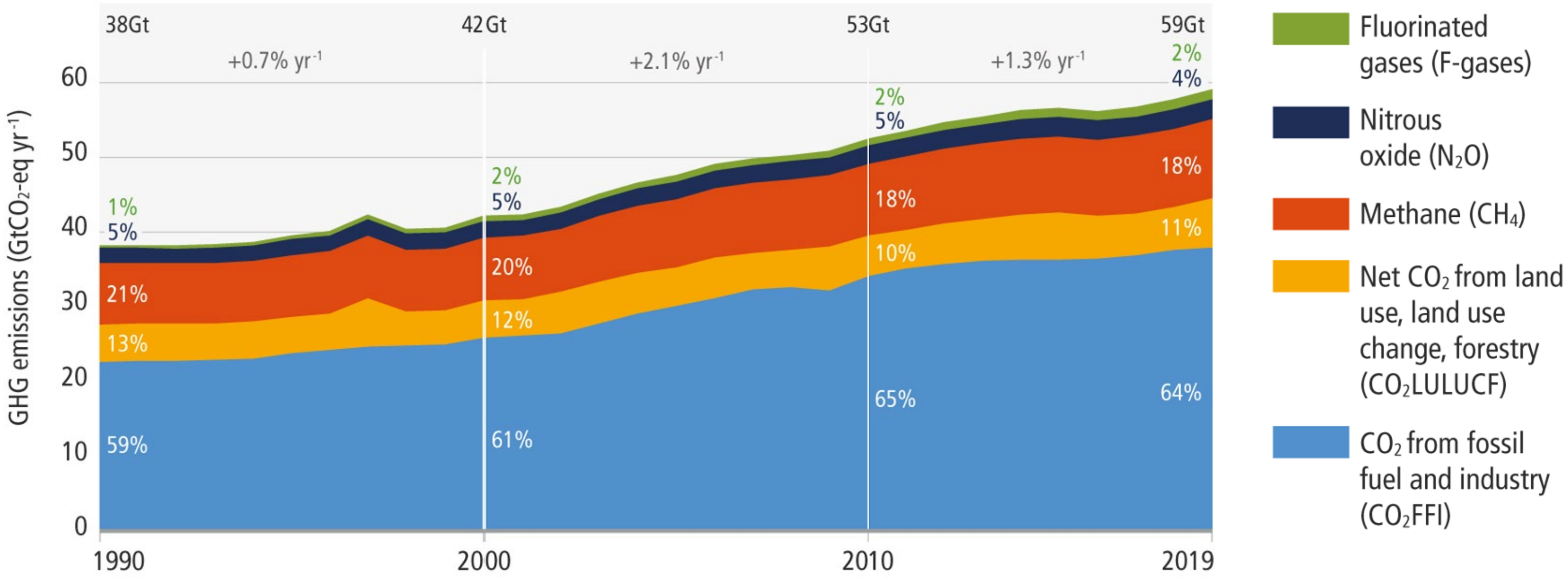
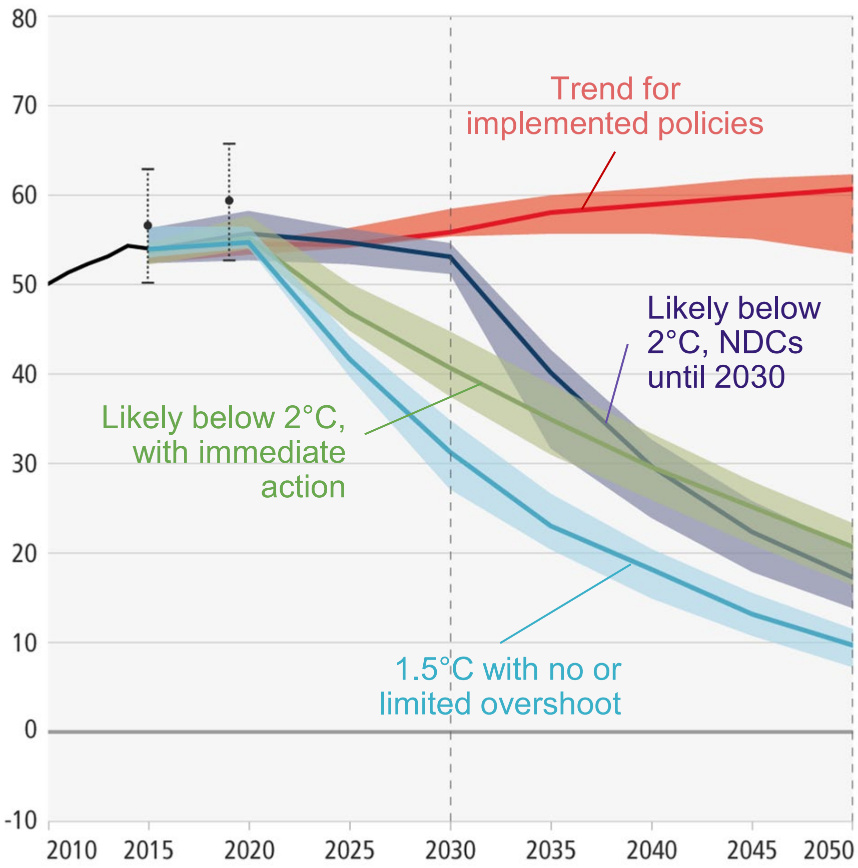
Informal Working Group on Life Cycle Assessment
Okinawa Convention Center
25 October 2022

[Matt Bridgestock, Director and Architect at John Gilbert Architects]

Where are we heading?

We are not on track to limit warming to 1.5 °C





Limiting warming to 1.5 °C

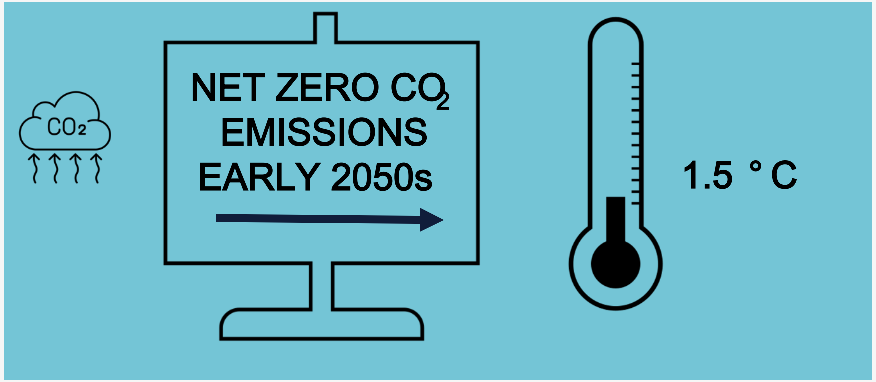
- Global GHG emissions peak before 2025, reduced by 43% by 2030.
- Methane reduced by 34% by 2030

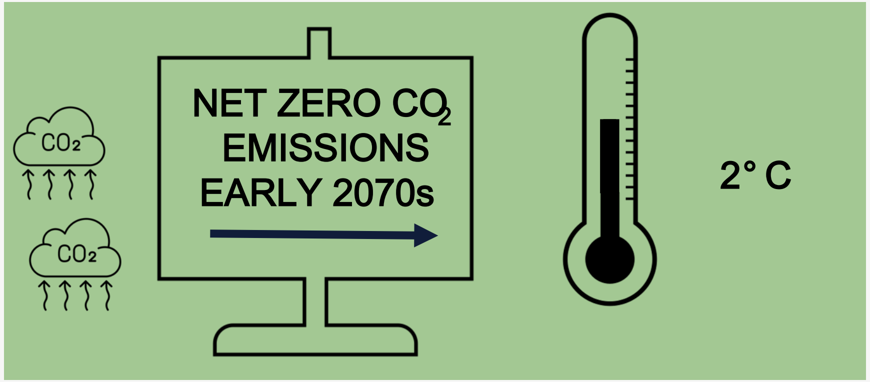
Limiting warming to around 2°C

- Global GHG emissions peak before 2025, reduced by 27% by 2030.

(based on IPCC-assessed scenarios)

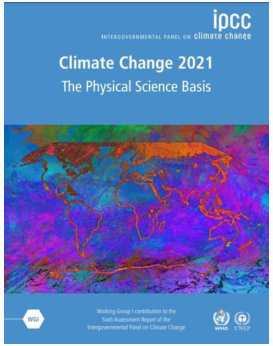
The temperature will stabilise when we reach net zero carbon dioxide emissions

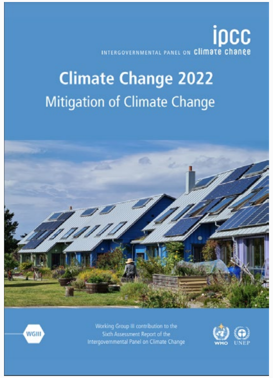




(based on IPCC-assessed scenarios)

While non-CO2 emissions from land transport affect climate for up to a couple of decades after their release, CO2 emissions become the dominating warming contribution on longer timescales.





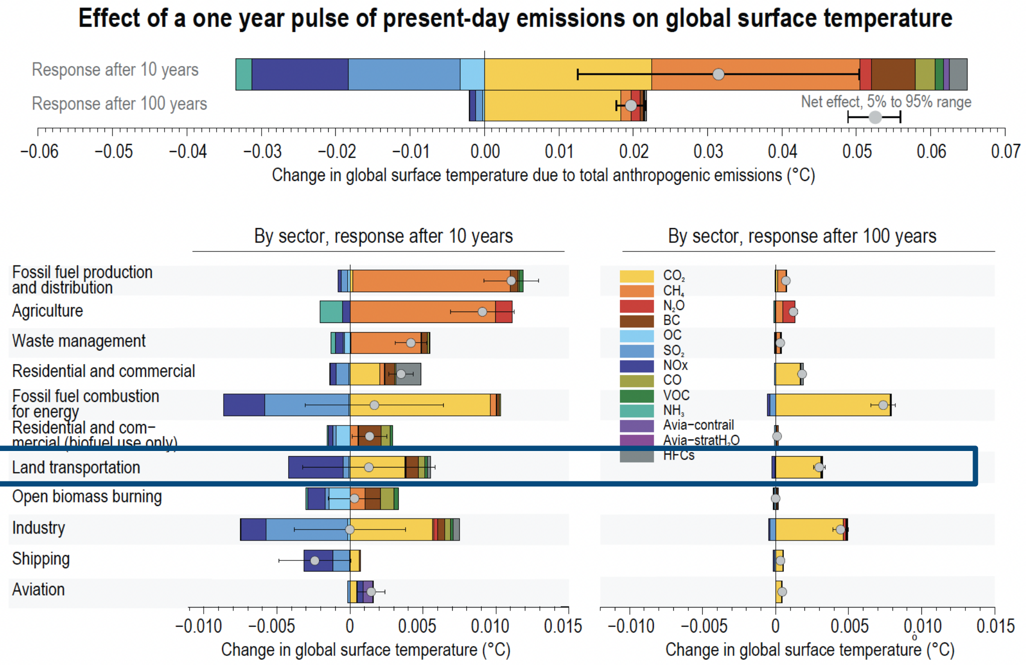


Figure TS.20 | Global surface temperature change 10 and 100 years after a one-year pulse of present-day emissions. *The intent of this figure is to show the sectoral contribution to present-day climate change by specific climate forcers, including carbon dioxide (CO_2) as well as short-lived climate forcers (SLCFs).* The temperature response is broken down by individual species and shown for total anthropogenic emissions (top), and sectoral emissions on 10-year (left) and 100-year time scales (right). Sectors are sorted by (high-to-low) net temperature effect on the 10-year time scale. Error bars in the top panel show the 5–95% range in net temperature effect due to uncertainty in radiative forcing only (calculated using a Monte Carlo approach and best estimate uncertainties from the literature). Emissions for 2014 are from the Coupled Model Intercomparison Project Phase 6 (CMIP6) emissions dataset, except for hydrofluorocarbons (HFCs) and aviation H2O, which rely on other datasets (see Section 6.6.2 for more details). CO_2 emissions are excluded from open biomass burning and residential biofuel use. {6.6.2, Figure 6.16}

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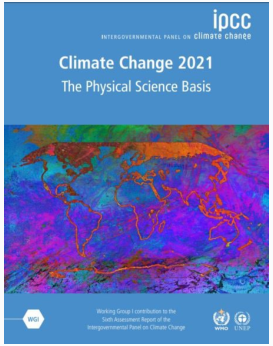

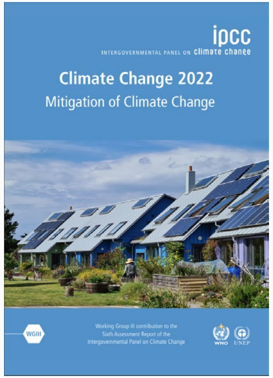

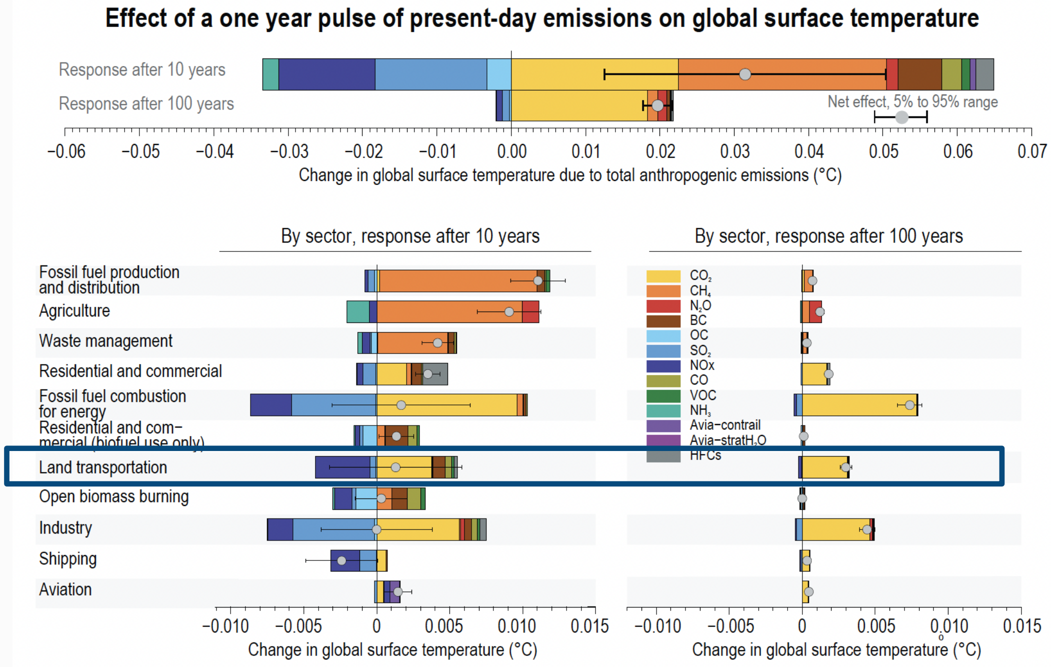

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What are our options?

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There are options available **now** in every sector that can at least **halve** emissions by 2030

Demand and services

Energy

Land use

Industry

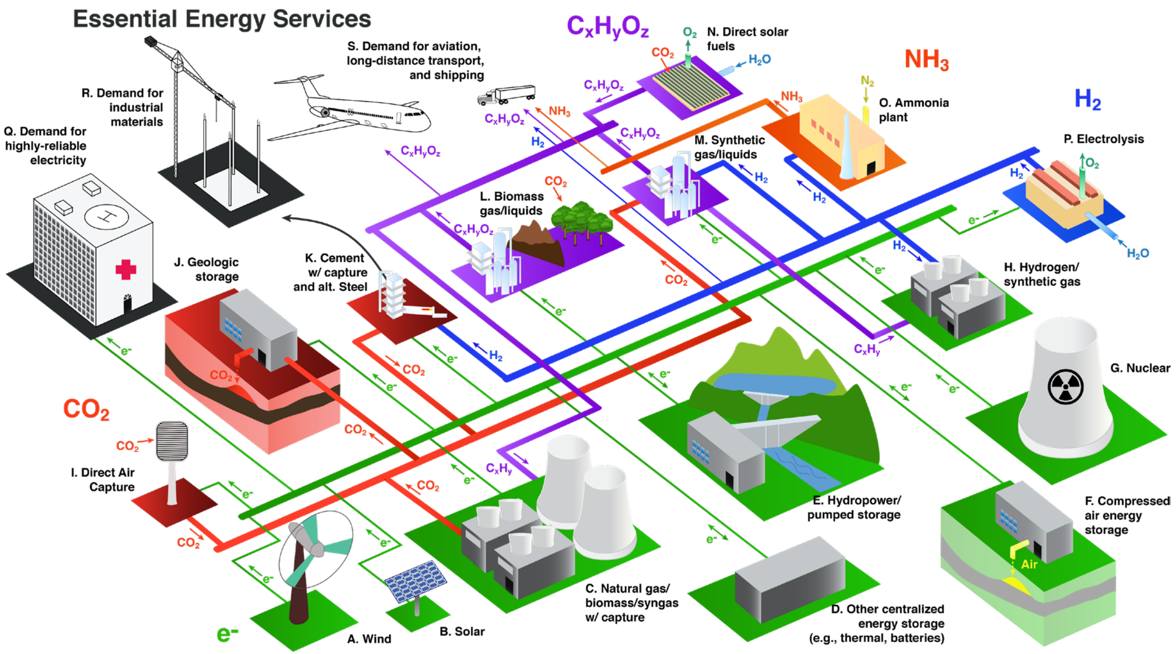
Urban

Buildings

Transport

ENERGY
20 $GtCO_2$-eq
34% of annual anthropogenic GHGs (2019)

A net zero energy system entails



- limited use of fossil fuels;
- electricity systems that emit no CO2 or capture CO2 from the atmosphere;
- widespread electrification of end uses;
- energy carriers such as hydrogen, biofuels, ammonia
- energy conservation and efficiency.

- CDR will be needed to counter-balance residual emissions

SPM C.4.1, FIGURE 6.23

Total CO_2 emissions over the lifetime of existing and currently planned fossil fuel infrastructure without additional abatement exceed the total cumulative net CO_2 emissions in pathways that limit warming to 1.5°C

SPM C.4.4

TRANSPORT

8.7 $GtCO_2$-eq

15% of annual anthropogenic GHG (2019)

In 2019, direct greenhouse gas (GHG) emissions from the transport sector were 8.7 Gt CO2-eq (up from 5.0 Gt CO2-eq in 1990) and accounted for 23% of global energy-related CO2 emissions.

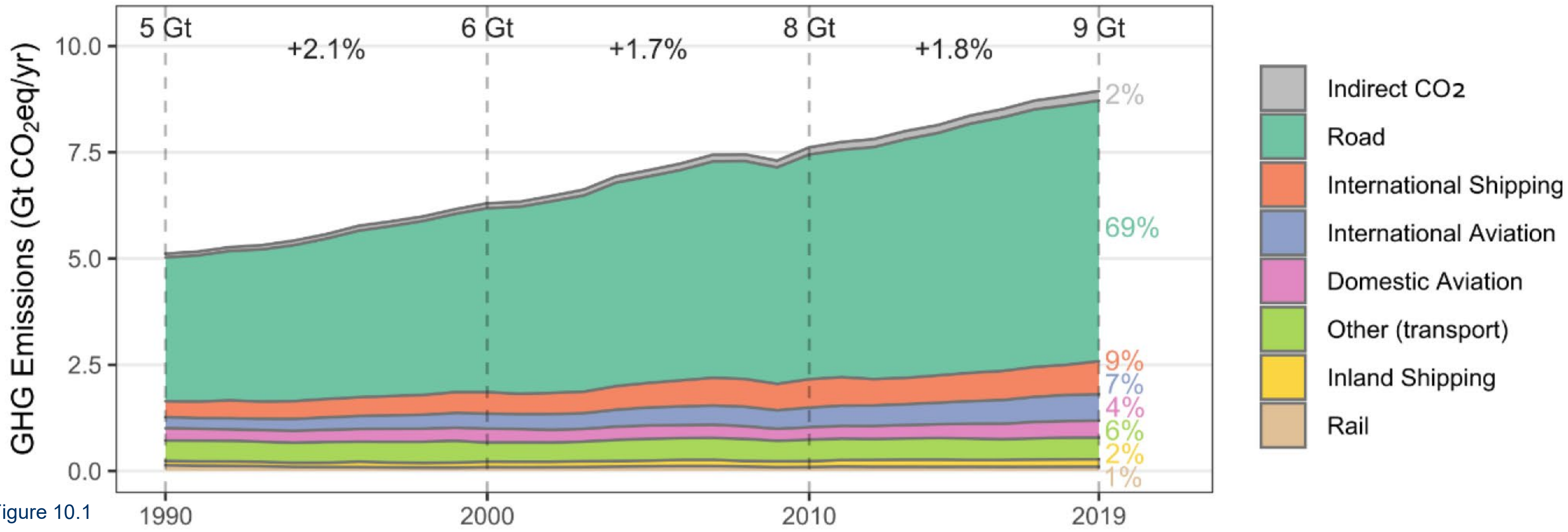


Figure 10.1

70% of direct transport emissions came from road vehicles, while 1%, 11%, and 12% came from rail, shipping, and aviation, respectively.

Transport-related emissions in developing regions of the world have increased more rapidly than in Europe or North America

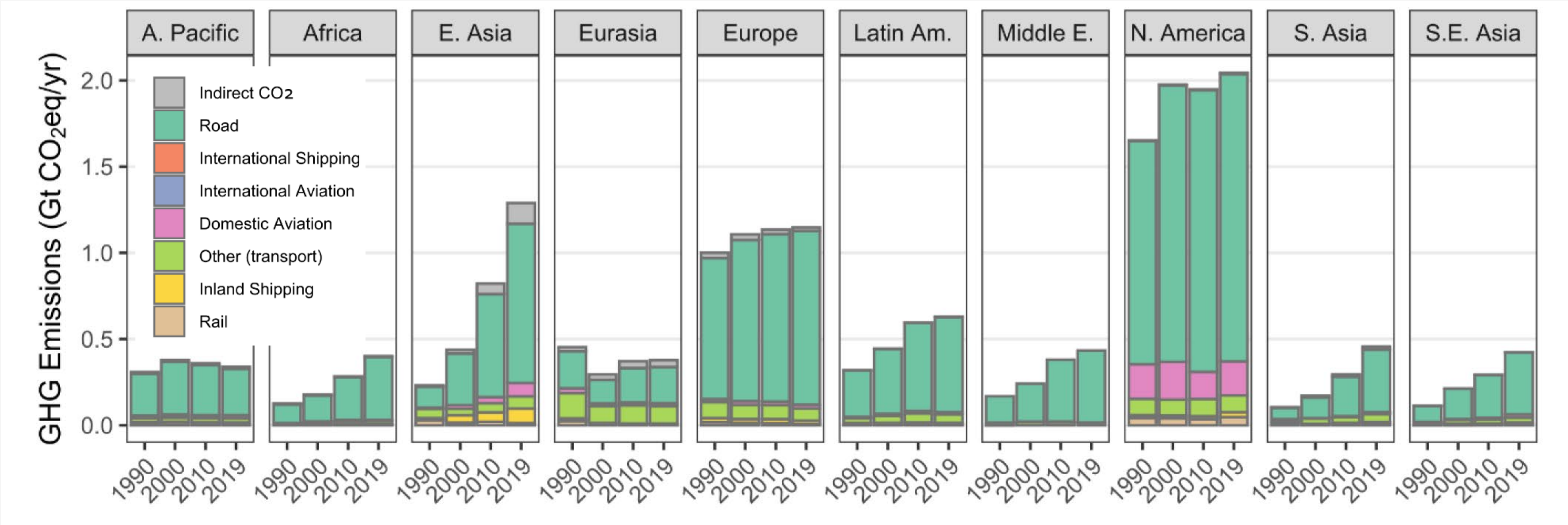


Figure 10.1

Behavior and Demand-side options

- **Changes in urban form in combination with programmes that encourage changes in consumer behavior.**
- **Investments in public inter- and intra-city transport and active transport infrastructure.**
- **Combinations of systemic changes including, teleworking, digitalization, supply chain management, and smart and shared mobility.**
- **Some of these changes could lead to induced demand – Rebound.**

SPM C8
SPM C8.2

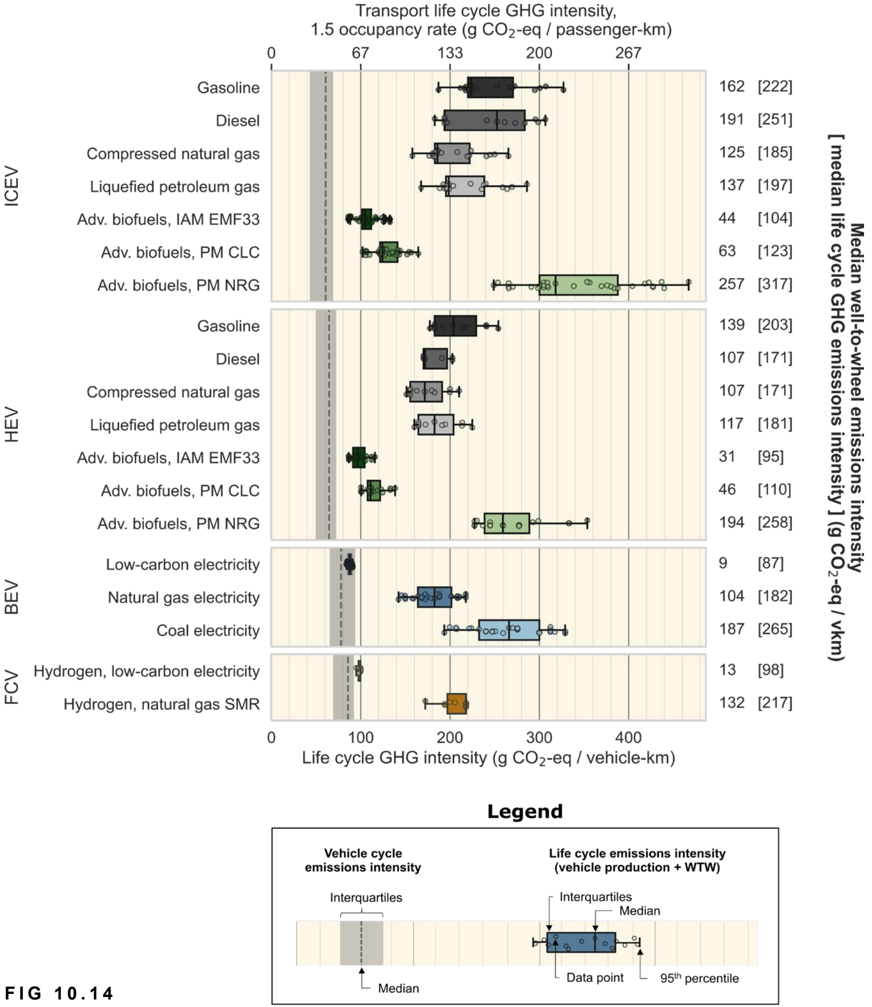


FIG 10.14

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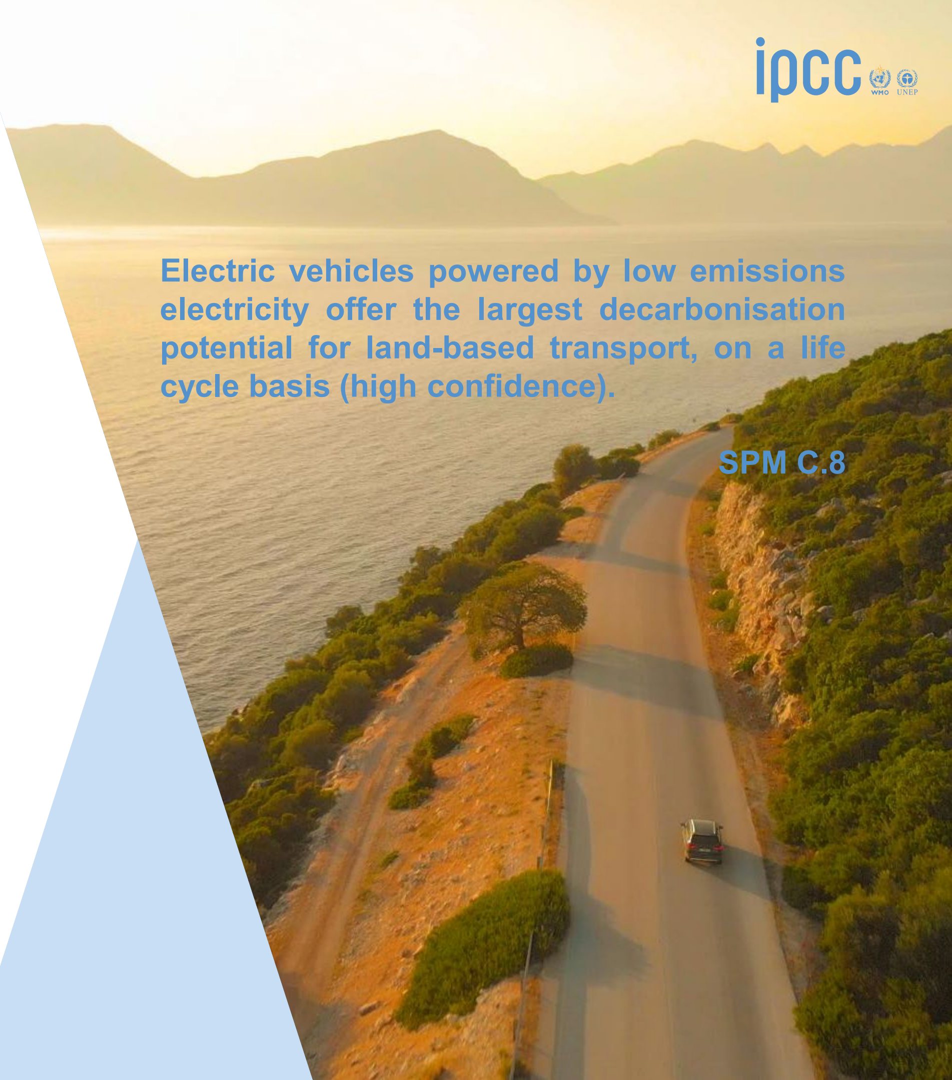


Electric vehicles powered by low emissions electricity offer the largest decarbonisation potential for land-based transport, on a life cycle basis (high confidence).

SPM C.8

BEV and FCV buses and passenger rail powered with low carbon electricity or low carbon Hydrogen, could offer reductions in GHG emissions compared to diesel-powered options.

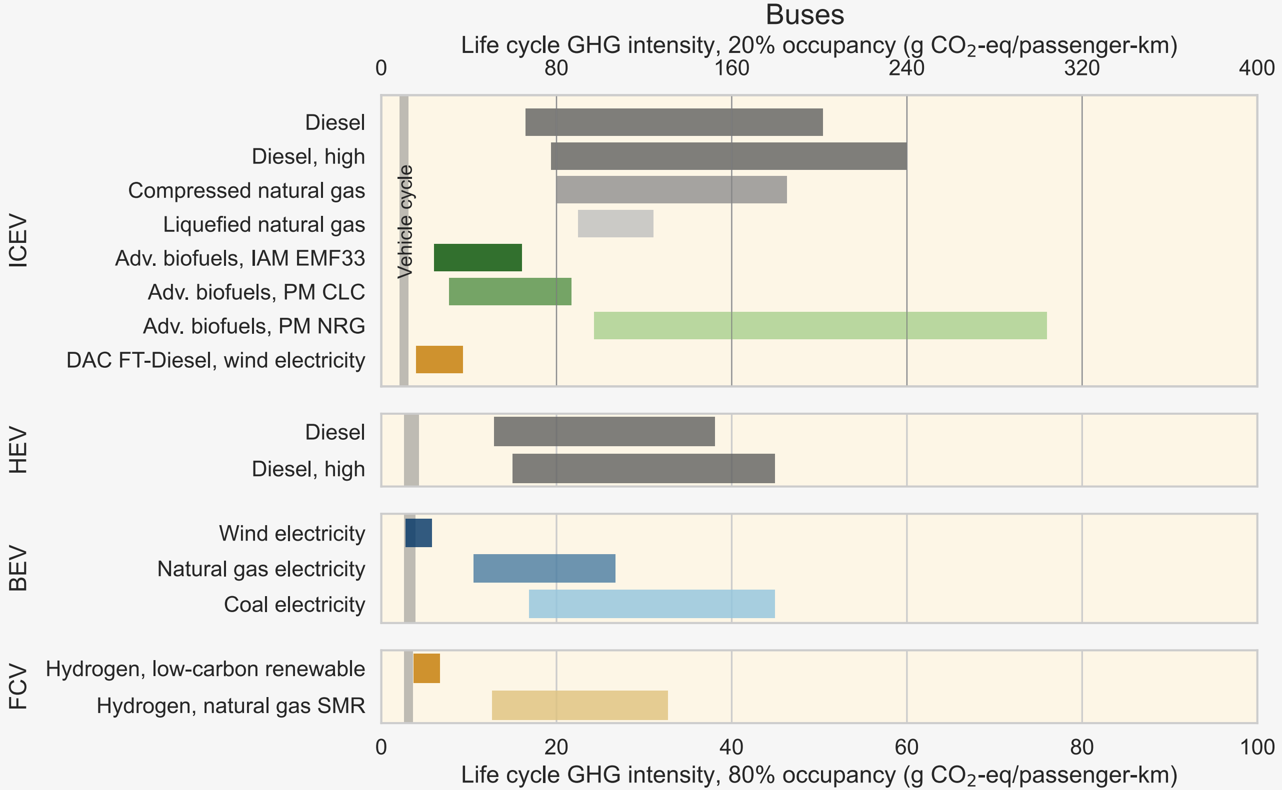


Figure 10.6

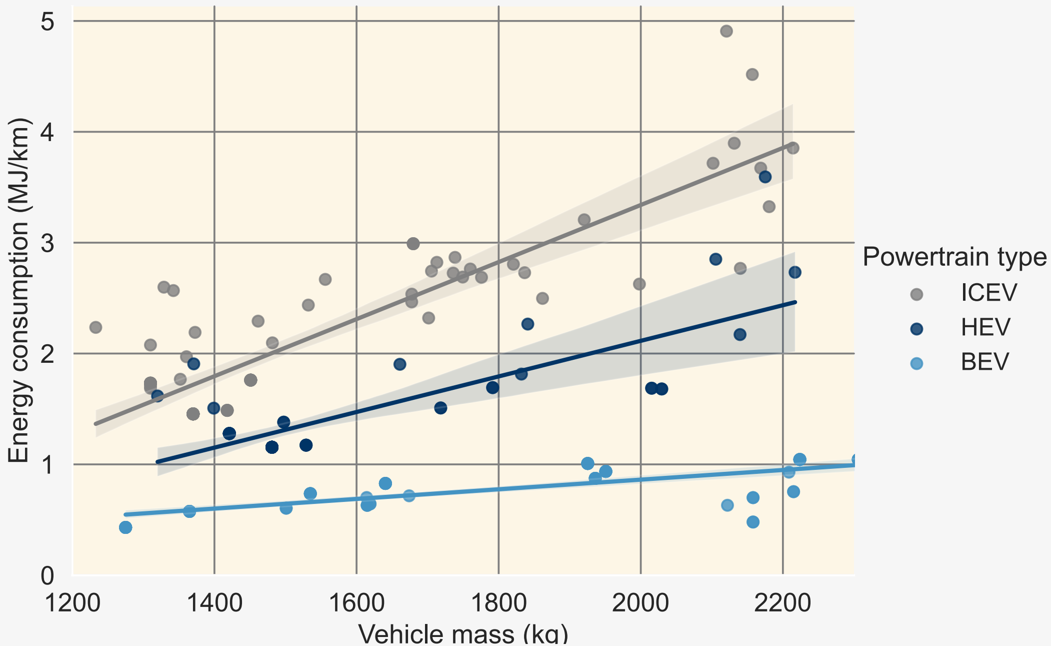
In mid-2020, the IPCC, in collaboration with the Norwegian University of Science and Technology, released a request for data from the life cycle assessment community, to estimate the life cycle greenhouse (GHG) emissions of various passenger and freight transport pathways.

The data requested included information about vehicle and fuel types, vintages, vehicle efficiency, payload, emissions from vehicle and battery manufacturing, and fuel cycle emissions factors, among others.

Data submissions were received from approximately 20 research groups, referencing around 30 unique publications. These submissions were supplemented by an additional 20 studies from the literature.

While much of this literature was focused on LDVs and trucks, relatively few studies referenced bus and rail pathways.

Vehicle size trends and implications on the fuel efficiency of LDVs



BOX 10.3 – FIG 1.

$$Life\ cycle\ GHG\ intensity = \frac{FC}{P} * EF + \frac{VC}{P * LVKT}$$

Life cycle GHG intensity represents the normalized life cycle GHG emissions associated with each transportation mode, measured in g CO2 eq/passenger-km or g CO2-eq/tonne-km

- FC is the fuel consumption of the vehicle in MJ or kWh per km
- P represents the payload (measured in tonnes of cargo) or number of passengers, at a specified utilization capacity (e.g , 50% payload or 80% occupancy)
- EF is an emissions fac or representing the life cycle GHG intensity of the fuel used, measured in gCO2-eq/MJ or g CO2 eq/kWh. A single representative EF value is selected for each fuel type. When a given fuel type can be generated in different ways with substantially different upstream emissions factors (e g., H2 from methane steam reforming vs H2 from water electrolysis), these are treated as two different fuel categories. The fuel emissions factors that were used are presented in Table 10.8
- VC are the vehicle cycle emissions of the vehicle, measured in g CO2-eq /vehicle. This may include vehicle manufacturing, maintenance and end-of-life, or just manufacturing.
- LVKT is the lifetime vehicle kilometres travelled

Table 10.8 Fuel emissions factors used to estimate life cycle greenhouse gas (GHG) emissions of passenger and freight transport pathways

Fuel	Emissions factor	Units	Source
Gasoline	92	g CO_2-eq MJ^{-1}	Submissions to IPCC data call (median)
Diesel	92	g CO_2-eq MJ^{-1}	Submissions to IPCC data call (median)
Diesel, high	110	g CO_2-eq MJ^{-1}	Diesel from oil sands: average of in-situ pathways (Guo et al. 2020)
Biofuels, IAM EMF33	25	g CO_2-eq MJ^{-1}	From Chapter 7
Biofuels, partial models CLC	36	g CO_2-eq MJ^{-1}	From Chapter 7
Biofuels, partial models NG	141	g CO_2-eq MJ	From Chapter 7
Compressed natural gas	71	g CO_2-eq MJ^{-1}	Submissions to IPCC data call (median)
Liquefied natural gas	76	g CO_2-eq MJ^{-1}	Submissions to IPCC data call (median)
Liquefied petroleum gas	78	g CO_2 eq MJ^{-1}	Submissions to IPCC data call (median)
DAC FT-Diesel, wind electricity	12	g CO_2-eq MJ^{-1}	From electrolytic Hydrogen produced using low-carbon electricity (Liu et al. 2020a)
DAC FT-Diesel, natural gas electricity	370	g CO_2-eq MJ^{-1}	From electrolytic Hydrogen produced using natural gas electricity; extrapolated from (Liu et al. 2020a)
Ammonia, low carbon renewable	3.2	g CO_2-eq MJ^{-1}	From electrolytic Hydrogen produced using low-carbon electricity via Haber-Bosch (Gray et al. 2021)
Ammonia, natural gas SMR	110	g CO_2-eq MJ^{-1}	From H_2 derived from natural gas steam methane reforming; via Haber-Bosch (Frattini et al. 2016)
Hydrogen, low carbon renewable	10	g CO_2-eq MJ^{-1}	From electrolysis with low-carbon electricity (Valente et al. 2021)
Hydrogen, natural gas SMR	95	g CO_2-eq MJ^{-1}	From steam-methane reforming (SMR) of fossil fuels (Valente et al. 2021)
Wind electricity	9.3	g CO_2-eq kWh^{-1}	Submissions to IPCC data call (median)
Natural gas electricity	537	g CO_2-eq kWh^{-1}	Submissions to IPCC data call (median)
Coal electricity	965	g CO_2-eq kWh^{-1}	Submissions to IPCC data call (median)

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Table 10.9 Range of fuel efficiencies for light duty vehicles by fuel and powertrain category, per vehicle kilometre

Fuel	Powertrain	Fuel efficiency (MJ/vehicle-km)		Electric efficiency (kWh/vehicle-km)	
		Low	High	Low	High
Compression ignition	ICEV	1.34	2.6		
Spark ignition	ICEV	1.37	2.88		
Spark ignition	HEV	1.22	2.05		
Compression ignition	HEV	1.15	1.51		
Electricity	BEV			0.12	0.242
Hydrogen	FCV	1.14	1.39		

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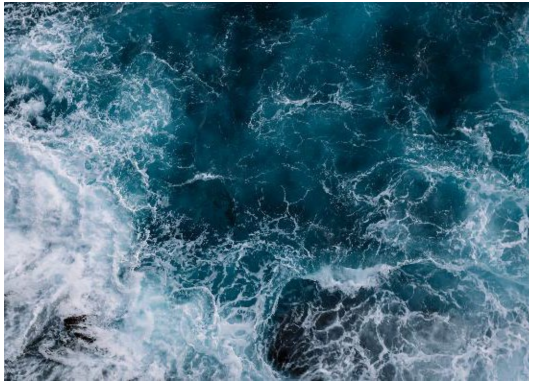
ELECTRIC

Electric vehicles powered by low-GHG emissions electricity have large potential to reduce land-based transport GHG emissions, on a life cycle basis (high confidence).

BIOFUELS

Sustainable biofuels can offer additional mitigation benefits in land-based transport in the short and medium term (medium confidence).



HYDROGEN AND SYNTETIC FUELS

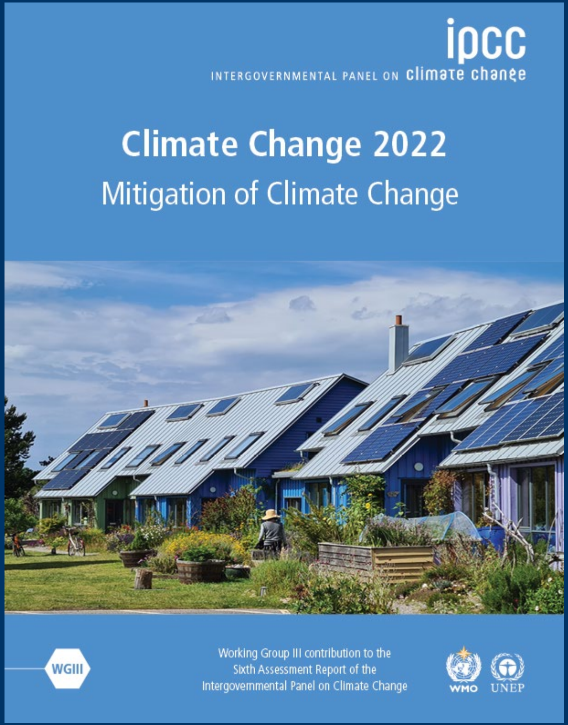
Sustainable biofuels, low emissions hydrogen and derivatives (including synthetic fuels), can support mitigating of CO2 emissions from shipping and aviation, and heavy-duty land transport

Technology transfer and financing can support developing countries leapfrogging or transitioning to low emissions transport systems thereby providing multiple co-benefits.

SPM C8.5

"

- **Not on track for 1.5°C nor 2°C**
- **The options are available**
- **The time for action is now**



[Matt Bridgestock, Director and Architect at John Gilbert Architects]

Thank You

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