United Nations Framework Convention on Climate Change

Agenda item 4.c.ii

Enabling environment and capacity-building: Enabling environment to enhance replicability and scalability of technologies for sustainable transport

Technology Executive Committee, 24th meeting
22–25 March 2022 – hybrid meeting

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Background:

- Activity 3 thematic area EECB:
  - *Identify challenges and opportunities, including favorable market conditions, to strengthen enabling environments to enhance replicability and scalability of technologies for sustainable transport*

- Deliverables in 2022:
  - Background paper
  - Thematic dialogue

Approach to this work:

- Similar approach to that of technical paper on emerging technologies in the energy supply:
  - Similarities in objectives
  - Opportunities to explore emerging technologies in other sectors, as indicated by TF Innovation
  - Building on TEC previous work
  - Ensuring coherence in the overall work of the TEC

Scope of this work:

- Transport is a critical sector in terms of GHG emissions – also considered important by Parties through NDC, TNA submissions
- New technologies in transport sector and related infrastructures may offer comprehensive solutions to reduce emission – and close the gaps

- Transport sector is responsible for 24% of direct CO2 emissions from fuel combustion - 75% of which are from road vehicles
- Therefore – **focusing on road transport/mobility** is appropriate entry point for this work

- As with work on emerging technologies in the energy supply, the work on technologies for sustainable transport will look at:
  a) access to new markets;
  b) social, institutional, economic and business preconditions, and
  c) social acceptability of the technologies.

Deliverables

- Background paper / Technical paper
- Thematic dialogue: Climate Week or COP 27 (tbc)
- Key messages & recommendations to COP/CMA

Deep decarbonization technologies for sustainable road mobility

Prepared for the
United Nation Framework Convention on Climate Change (UNFCCC)

Technology Executive Committee (TEC)

By: Dr. Jonn Axsen

March 23, 2022

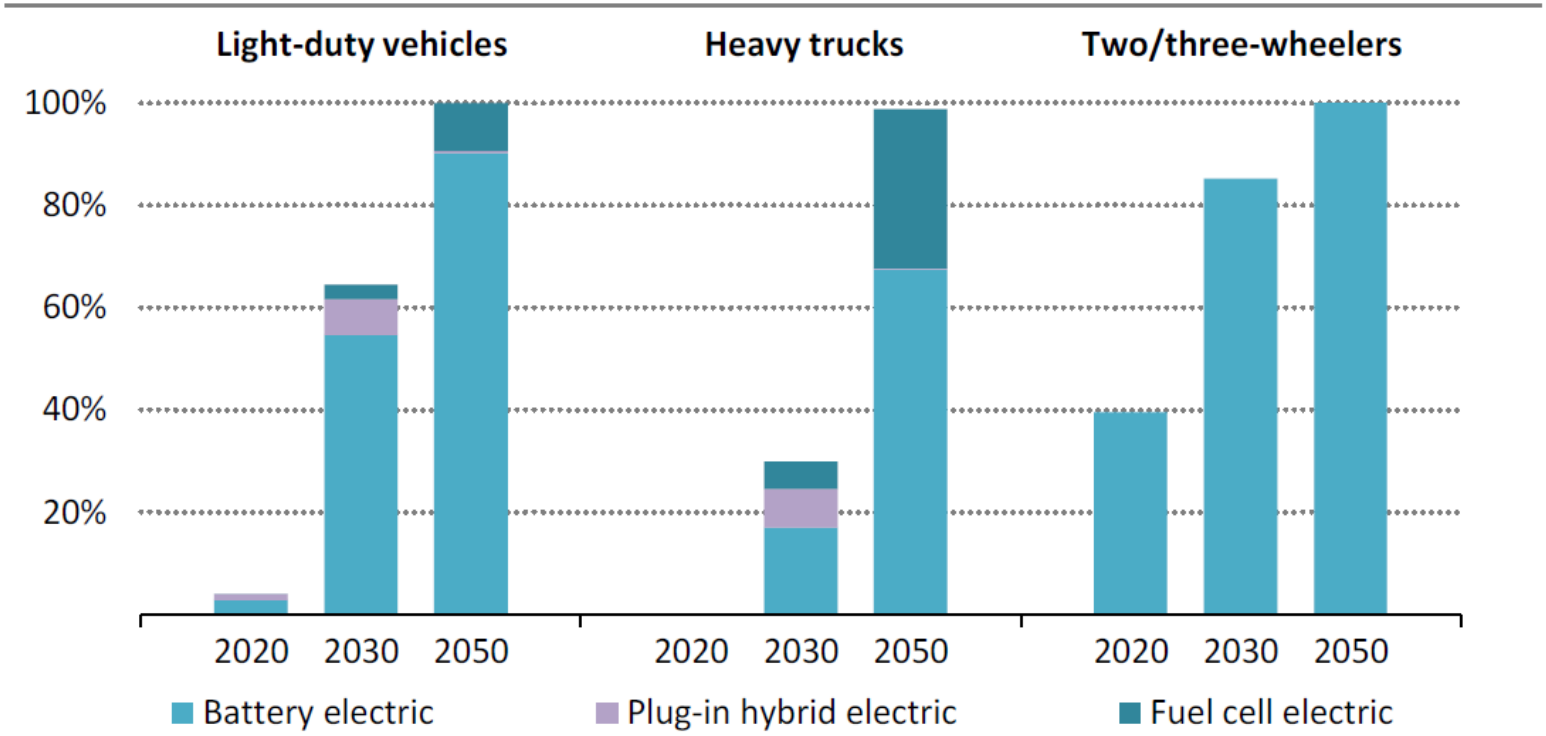
Context:

International Energy Agency's Net Zero Emissions scenario (NZE) summarizes the rapid transformations needed for **road transport**, including:

- 100% zero-emissions vehicle sales by 2035, mostly **electric vehicles** for light-duty vehicles
- Rapid advancement in **green hydrogen**, to fuel 30% of heavy-duty vehicles by 2050
- Rapid progress in **advanced biofuels** (low-carbon and sustainable)
- **Behaviour change**: 20-50% reduction in private vehicle use

Context:

International Energy Agency's Net Zero Emissions scenario (NZE) summarizes the rapid transformations needed for **road transport**, including:



Sales of battery electric, plug-in hybrid and fuel cell electric vehicles soar globally

Research Objectives:

1. Provide an overview of the technologies and their **state of play**, including information on their **technology readiness** and potential **climate change mitigation** impacts;

2. Briefly summarize some social, institutional, economic and business **opportunities** related to their development and effective deployment; and

3. Identify innovative **policy options**, opportunities and challenges for policymakers to effectively support the deployment of these technologies.

Method:
Technology Readiness Level (TRL) from NASA and IEA:

Broad stage	TRL	Narrow stage
Conceptual/research phase	1	Initial idea
	2	Application formulated
	3	Concept needs validation
Small prototype	4	Early prototype
Large prototype	5	Large prototype (validated in relevant environment)
	6	Full prototype at scale
Demonstration/Deployment	7	Pre-commercial demonstration
	8	First-of-a-kind commercial **(<0.1% sales)**
	9	Commercial operation in relevant environment **(0.1% to 1% sales)**
Early Adoption	10	Integration needed at scale **(1-10% sales)**
Mature	11	Proof of stability: predictable growth **(>10%)**

Methods:

Literature review (+130 references), including key documents from:

- International Energy Agency (IEA)
- International Council for Clean Transportation (ICCT)

GHG emissions, note differences between

- Tailpipe emissions: generally not used here
- **Well-to-wheel (WTW) emissions**: considers lifecycle impact of fuel production (electricity generation) and fuel usage.
- **Full lifecycle analysis (LCA):** considers WTW fuel emissions, plus manufacturing and disposal of vehicle

Results overview:

Technology	Sub-type	TRL	2020 penetration	Carbon impacts	Role in IEA NZE 2050 Scenario
Plug-in electric vehicle	Light-duty	10-11	Many countries: 1-10% Norway: 75%	NA/EU: 60-77% cuts China/India: 19-56% cuts	2030: 60% of global sales 2050: 90%
	Heavy-duty	8-11	Heavy trucks: <0.1% Buses: 5-60%	34-98% cuts	2030: 17% of global sales 2050: 68%
Hydrogen fuel-cell vehicles	Light-duty	8	<0.1% sales	Grey H2: 26-40% cuts Green H2: 76-80% cuts	2050: ~10% of global sales
	Heavy-duty	8	<0.1% sales	Green H2: 65-97% cuts	2050: ~30% of global sales
Advanced biofuels	Ethanol	7-8	3% of gasoline, <0.1% is advanced	Up to 81% cuts	Advanced ethanol increases to 28% of ethanol by 2030
	Biodiesel	9	16% is advanced	85-92% cuts	Advanced biofuels meet 14% of transport energy by 2050
Shared mobility	Ride-hailing	9-11	~3% US adults are regular users	Unclear	"Behaviour" shift? 2050: 20-50% less private vehicle use
	Car-share	9-10	Over 30 million members globally	Unclear	"Behaviour" shift?
	Micromobility	9-10	Available in 650 cities	Unclear;.	"Behaviour" shift?
	Mobility as a Service	8	Very low, dozens of projects globally	Unclear;	"Behaviour" shift?
Fully automated vehicles	Light/heavy	4+	Demonstration only	Highly uncertain; halve or double GHG emissions;	Not addressed

Plug-in electric vehicles (PEVs):

Technology	Sub-type	TRL	2020 penetration	Carbon impacts	Role in IEA NZE 2050 Scenario
Plug-in electric vehicle	Light-duty	10-11	Many countries: 1-10% Norway: 75%	NA/EU: 60-77% cuts China/India: 19-56% cuts	2030: 60% of global sales 2050: 90%
	Heavy-duty	8-11	Heavy trucks: <0.1% Buses: 5-60%	34-98% cuts	2030: 17% of global sales 2050: 68%

Background

- Battery electric and plug-in hybrid vehicles
- Improving performance, range, variety

Market penetration

- Success for light-duty and buses in developed countries
- Still limited for heavy trucks (long-haul)

GHG emissions

- Needs low-carbon electricity
- Cuts GHGs by two-thirds in developed countries, one-quarter to one half in China/India

Opportunities

- More widespread implementation of strong PEV policy
- More focus on Global South (including two and three-wheelers)
- Exploration of smart charging (Vehicle-to-grid, etc.)
- Heavy-duty: “Mega-chargers” and catenaries

Hydrogen fuel-cell vehicles (HFCVs)

Technology	Sub-type	TRL	2020 penetration	Carbon impacts	Role in IEA NZE 2050 Scenario
Hydrogen fuel-cell vehicles	Light-duty	8	<0.1% sales	Grey H2: 26-40% cuts Green H2: 76-80% cuts	2050: ~10% of global sales
	Heavy-duty	8	<0.1% sales	Green H2: 65-97% cuts	2050: ~30% of global sales

Background

- Green hydrogen (renewable) versus black/grey/blue
- Improving range (500-700km), but still high prices/costs
- Limited H2 fueling infrastructure (540 in 2020)

Market penetration

- 25,000 light-duty HFCVs in 2020 (Korea, USA and China)
- 9,000 heavy-duty (buses and trucks), mostly in China

GHG emissions

- Deep cuts possible with green hydrogen

Opportunities

- Continued subsidies in short-term, regulations for long-term
- Technology breakthrough needed in long-term (international alliances)
- More green hydrogen production, and more fueling infrastructure

Advanced biofuels

Technology	Sub-type	TRL	2020 penetration	Carbon impacts	Role in IEA NZE 2050 Scenario
Advanced biofuels	Ethanol	7-8	3% of gasoline, <0.1% is advanced	Up to 81% cuts	Advanced ethanol increases to 28% of ethanol by 2030
	Biodiesel	9	16% is advanced	85-92% cuts	Advanced biofuels meet 14% of transport energy by 2050

Background

- Blended into gasoline/diesel at 5-20%
- Flex-fuel vehicles can handle higher blends (+85%)
- Drop-in fuels can be put into existing engines at high blends
- Lots of feedstocks, but dominated by conventional sources (corn, sugarcane and soybeans)
- **Advanced:** significant GHG reduction, non-food crop, doesn't compete for land, no other sustainability impacts

Market penetration

- Little advanced ethanol (wheat straw, wood/agric. waste)
- 16% advanced biodiesel (cooking oil, waste animal fat)

GHG emissions

- Advanced: 80-90% lifecycle GHG reductions

Opportunities

- Need policy to account for lifecycle emissions, such as low-carbon fuel standard
- Comprehensive policy coverage to avoid leakage/shuffling

Shared mobility

Technology	Sub-type	TRL	2020 penetration	Carbon impacts	Role in IEA NZE 2050 Scenario
Shared mobility	Ride-hailing	9-11	~3% US adults are regular users	Unclear	"Behaviour" shift? 2050: 20-50% less private vehicle use
	Car-share	9-10	Over 30 million members globally	Unclear	"Behaviour" shift?
	Micromobility	9-10	Available in 650 cities	Unclear	"Behaviour" shift?
	Mobility as a Service	8	Very low, dozens of demos globally	Unclear	"Behaviour" shift?

Background

- Ride-hailing is sharing of rides (Uber/Lyft)
- Car-share and micromobility are sharing of vehicles (car, bike, e-bike, scooter, e-scooter)

Market penetration

- Widespread uptake in many major cities

GHG emissions

- Unclear evidence for reduced car ownership or reduced vehicle travel
- What mode is displaced? Often substitute for transit, active travel, or taxi

Opportunities

- More support for pooled ride-hailing (multi-passenger)
- Regulations that require electric ride-hailing and car-share

Fully automated vehicles

Technology	Sub-type	TRL	2020 penetration	Carbon impacts	Role in IEA NZE 2050 Scenario
Fully automated vehicles	Light/heavy	4+	Demonstration only	Highly uncertain; halve or double GHG emissions;	Not addressed

Background

- Level 4/5 automation drives the vehicle without driver input

Market penetration

- Still in demonstration phase, testing continues
- Full automation is not available for sale

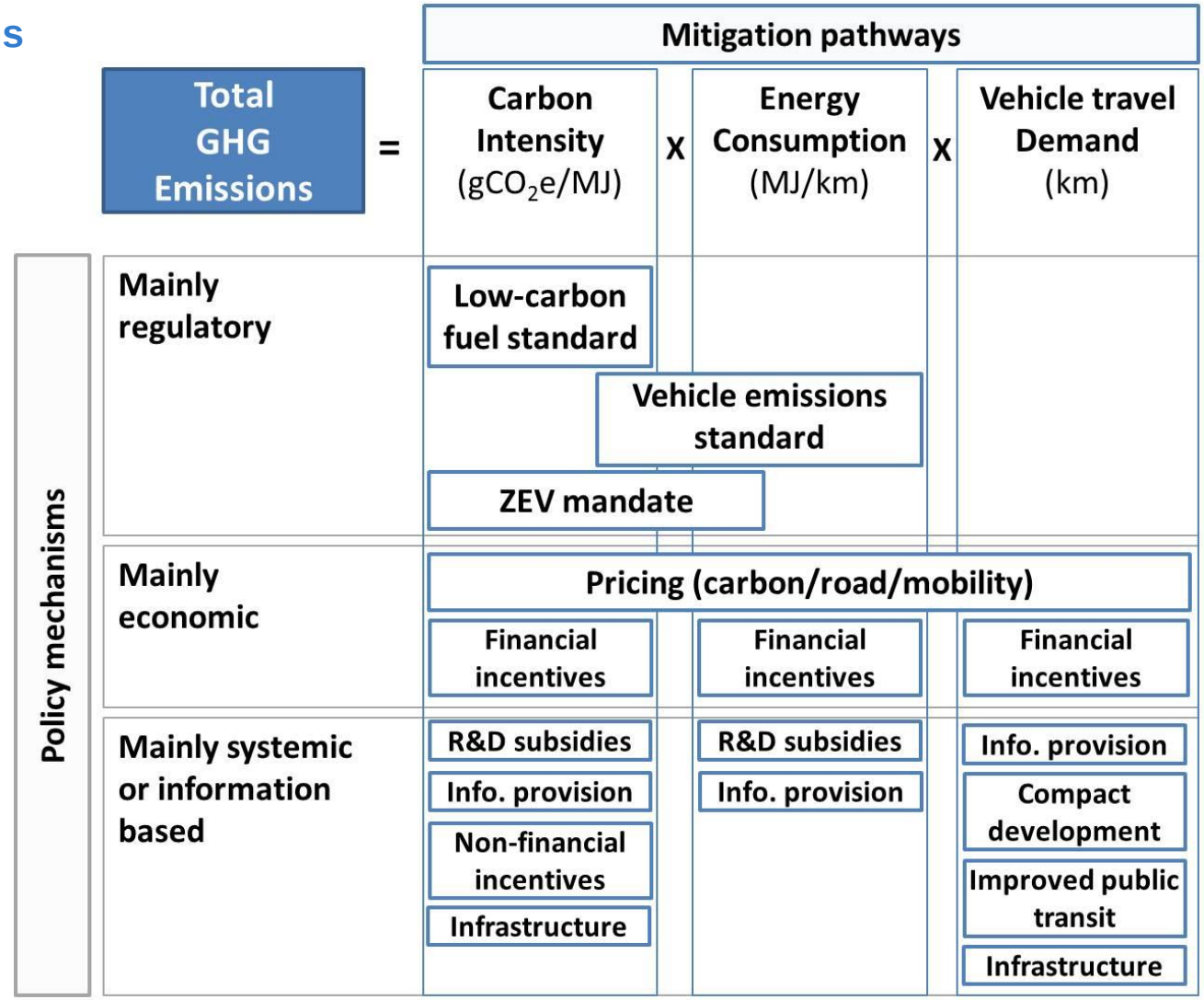
GHG emissions

- Huge range of potential impacts
- Can cut emissions if it leads to vehicle sharing, downsizing, or eco-driving
- Can increase emissions with increase to vehicle travel, higher highway speeds, new user groups, “dead-heading”

Opportunities

- ZEV-supporting regulations can reduce emissions per km
- Carbon pricing can mitigate rebound effects (travel increase)

Policy Options



Summary

- Considered key technologies related to net-zero emissions (NZE) scenario
- Highest technology-readiness (TRL) for plug-in electric light-duty vehicles and buses
- Lower readiness for:
  - Heavy-duty trucks (notably long-haul)
  - Fuel-cell hydrogen vehicles
  - Advanced biofuels (ethanol and biodiesel)
- Shared mobility and automation have unclear roles in decarbonization, though climate policy can induce more climate benefits

Next steps

- More comprehensive analysis of the social, institutional, economic and business barriers and opportunities for each technology
- Additional detail on the barriers and opportunities for developing countries, including countries in Africa, Southeast Asia, and Central & South America
- Further evaluate the noted climate policy categories, particularly their ability to overcome these identified barriers

TEC consideration:

Provide guidance to the taskforce with regard to:

- Background paper, including on next steps
- Thematic dialogue on this topic (RCW or COP27)
- Key messages and recommendations to COP27/CMA 4

Thank you!

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