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VISTA seminar

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Integrated Energy & Transport Systems

From Decarbonization to Zero Emission

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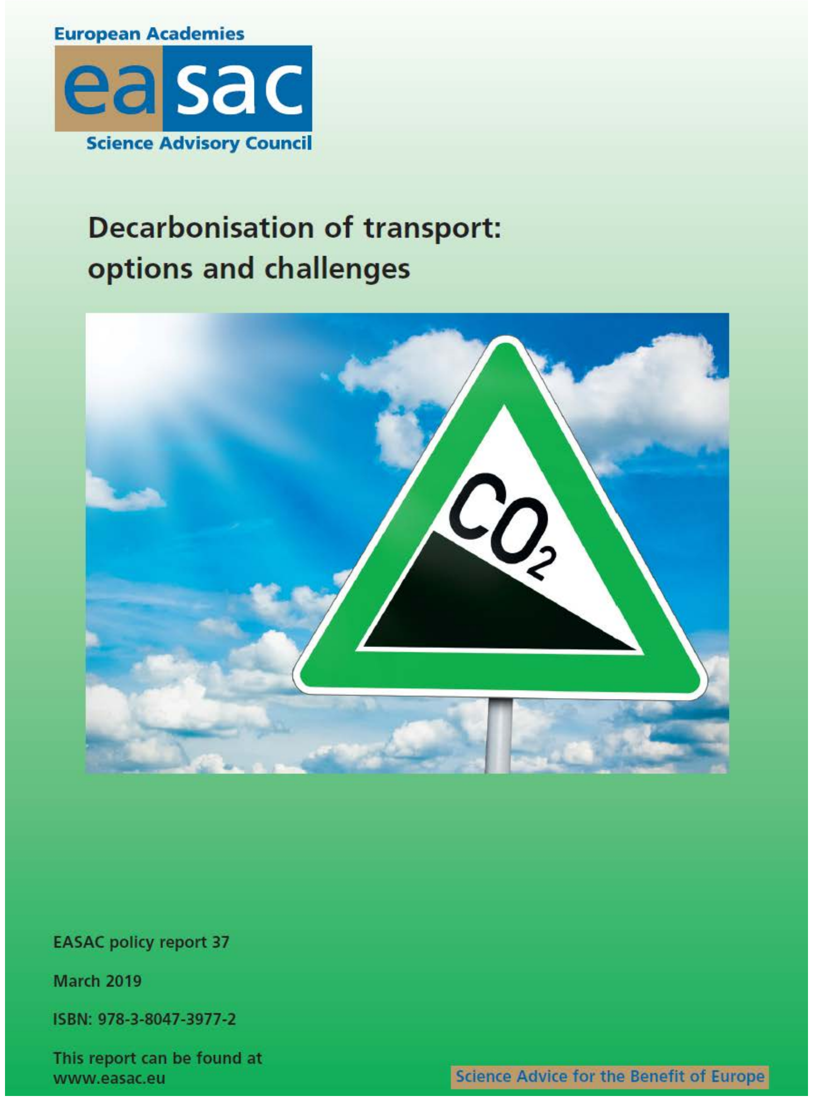
Background & References



MOZEES
Mobility Zero Emission Energy Systems

FME
CENTRE FOR ENVIRONMENT-FRIENDLY ENERGY RESEARCH
The Research Council of Norway

Chapters:

1. Introduction
2. Transport Demand
3. Transport Supply Options and Technologies
4. ICT and Autonomous Vehicles
5. Discussion and Conclusions
6. Advice for Policy Makers

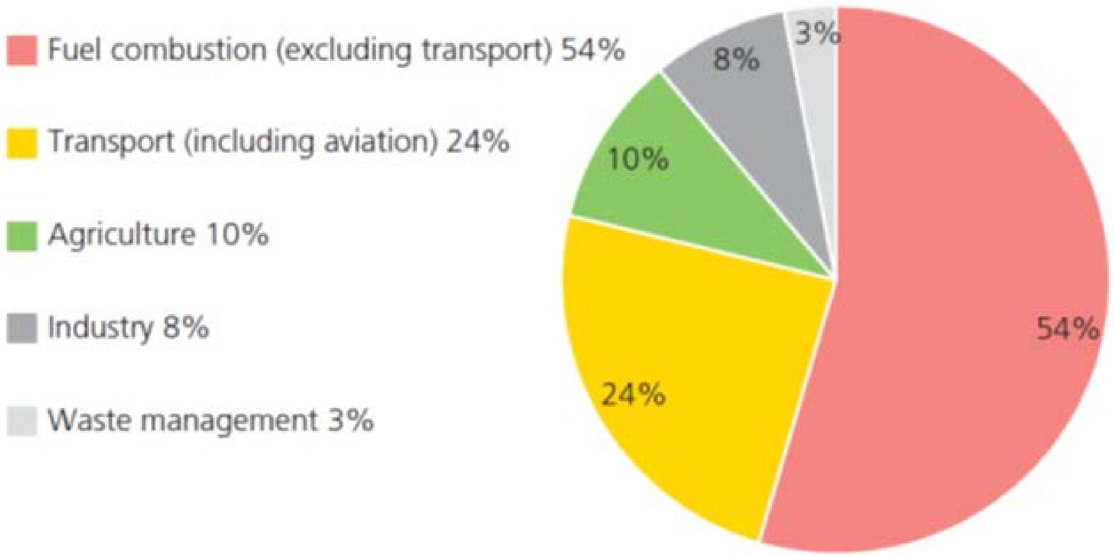
Greenhouse Gas (GHG) Emissions in the EU

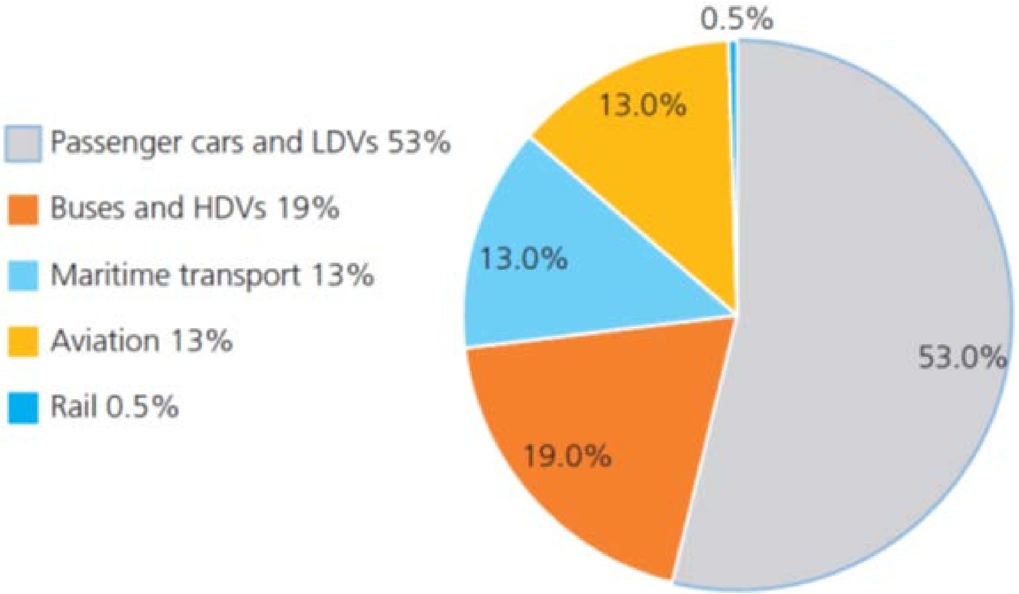
Overall:

22% reduction since 1990

Transport:

20% increase to 857 $MtCO_2$-eq.





Source: EASAC (2019)

EU Carbon Emission Targets (wrt. 1990)

- **Overall GHG Targets**
  - 40% reduction by 2030
  - 60% reduction by 2040
  - 80-95% reduction by 2050

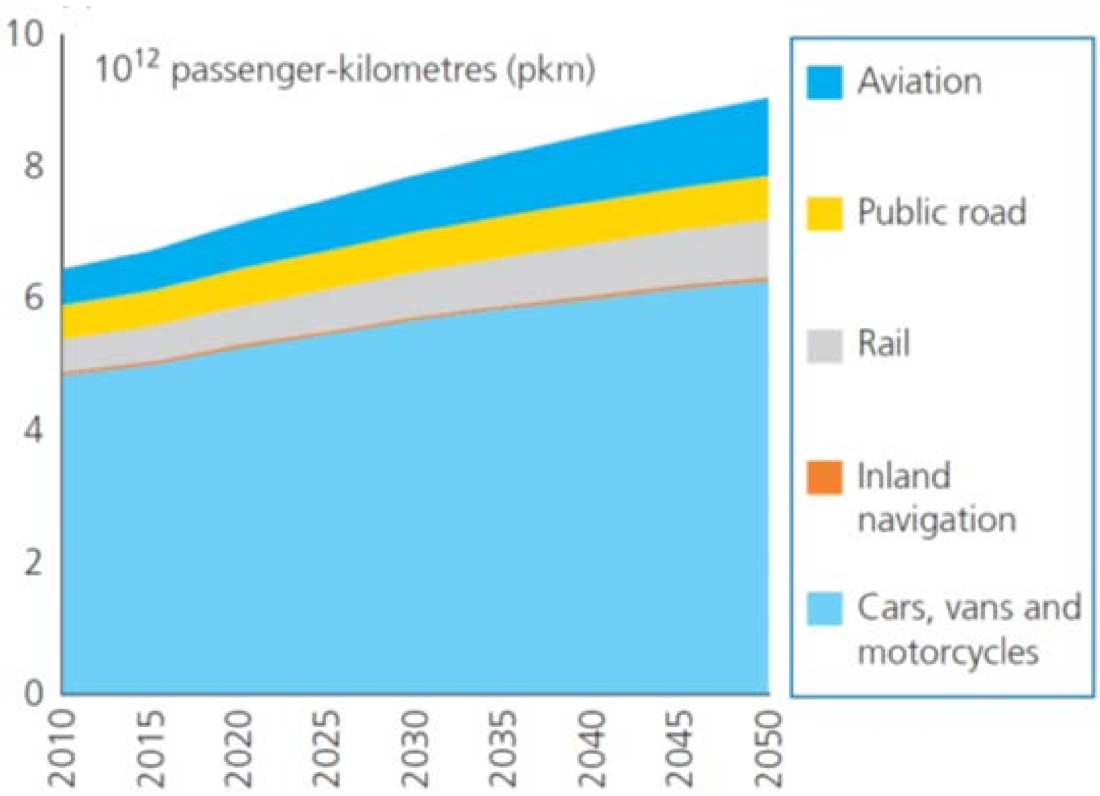
- **Transport GHG Targets**
  - 60% reduction by 2050
  - New Cars: 95 g CO_2/km in 2021 (130 g CO_2/km in 2015)
  - New Vans: 147 g CO_2/km in 2021 (3.5 t LDVs)

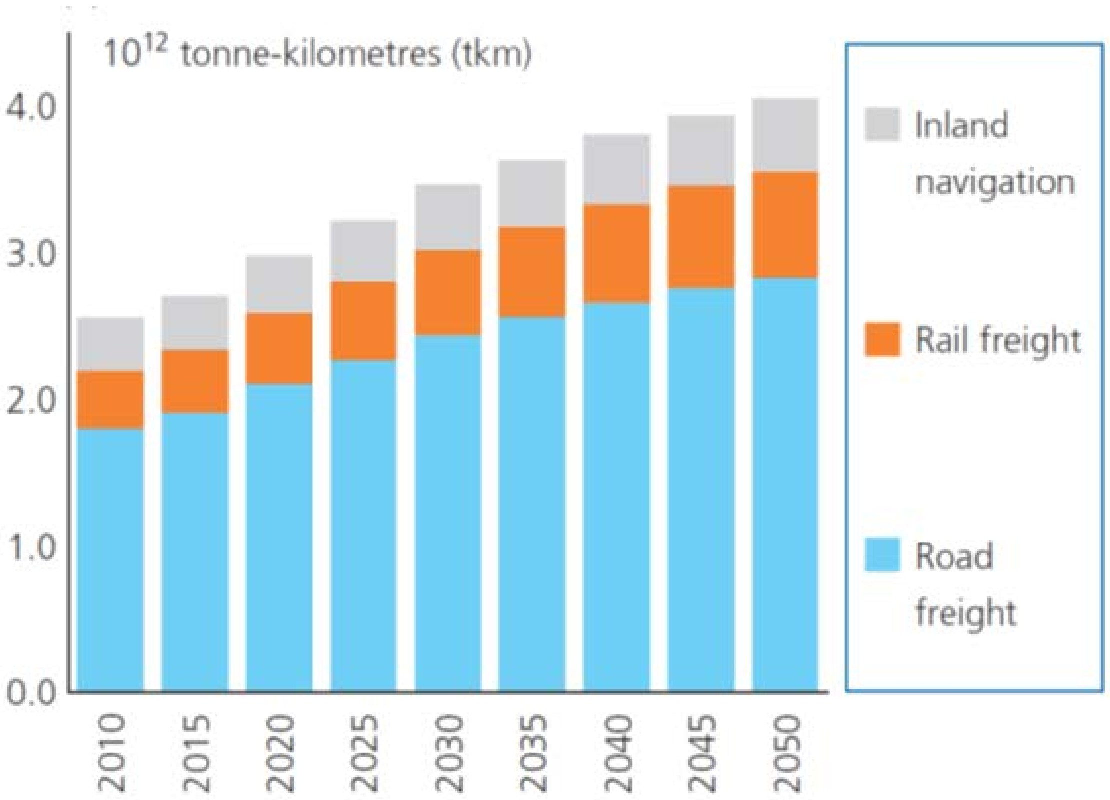
Source: EASAC (2019)

Projections for Transport Activity in the EU

Passenger Transport:
40% increase from 2010 to 2050

Freight Transport:
50% increase from 2010 to 2050

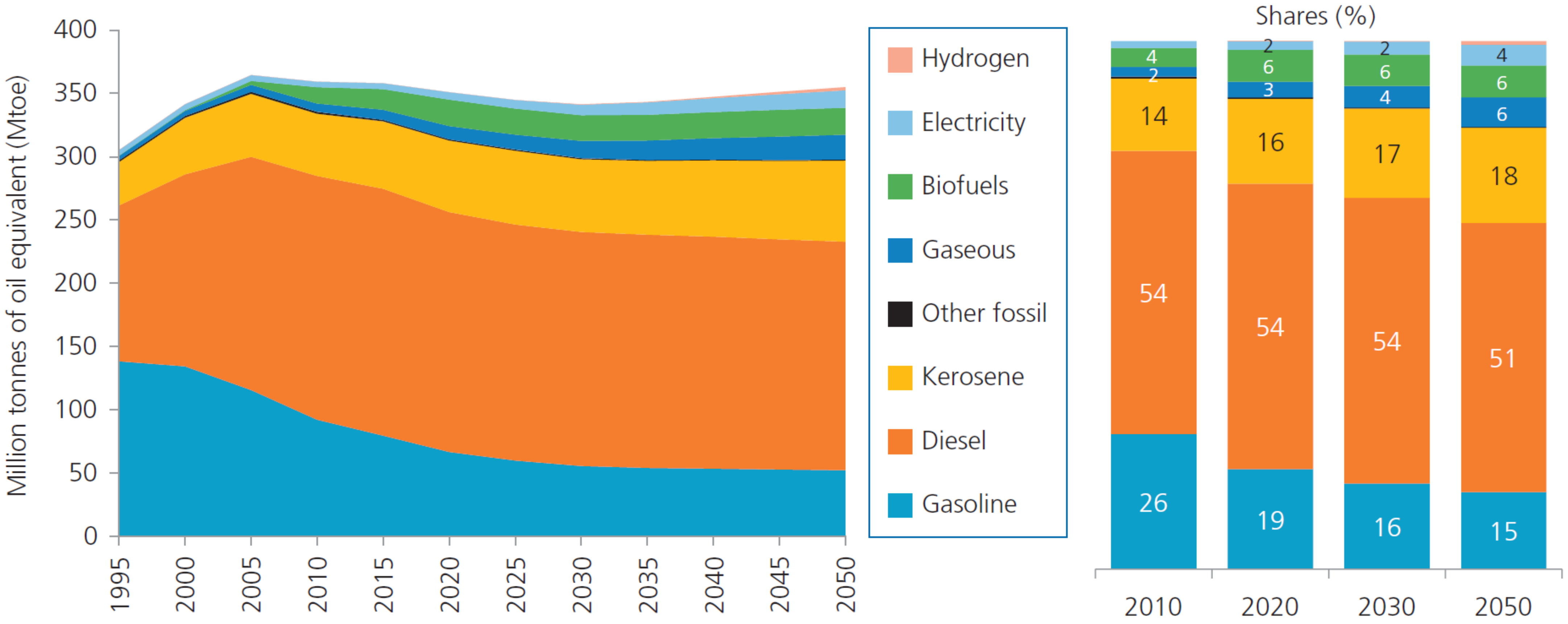




Source: EASAC (2019)

Future Projections for Passenger and Freight Transport

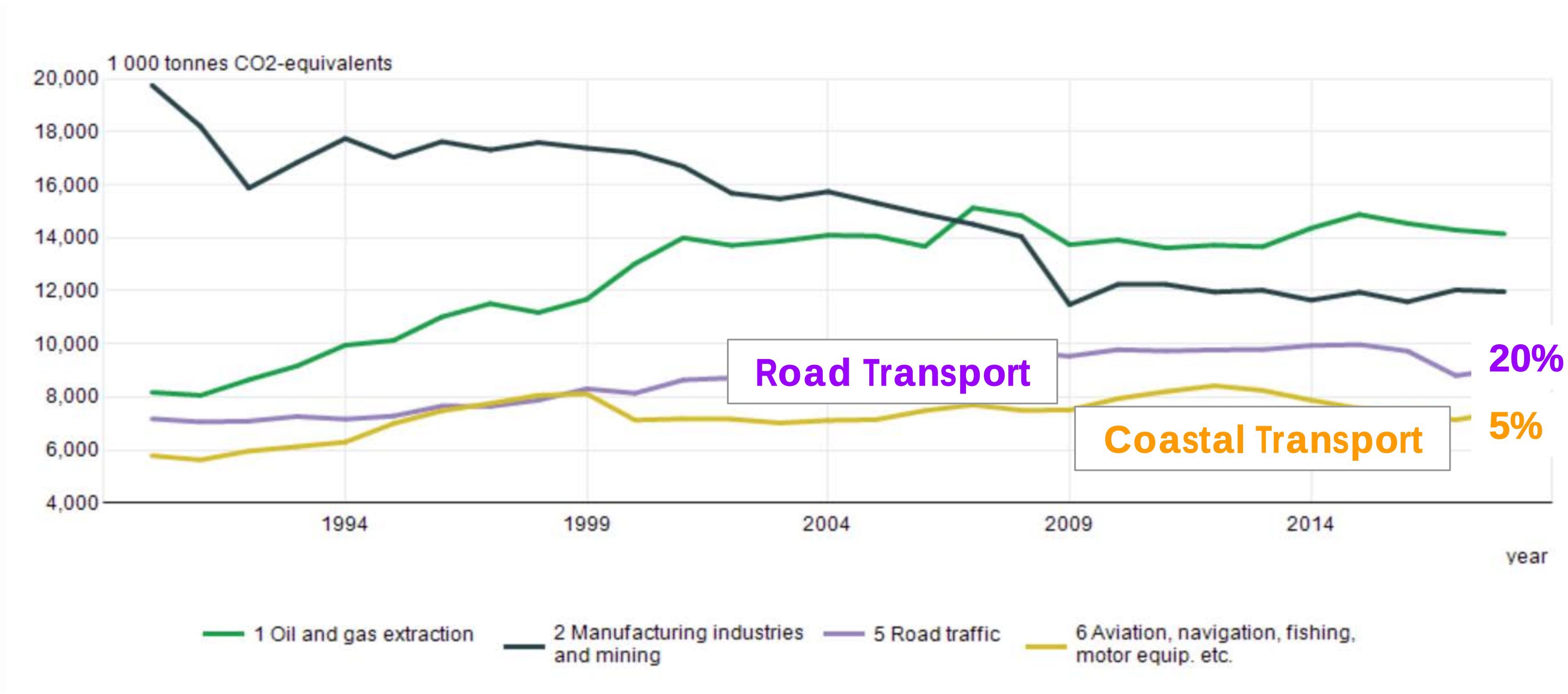
- Energy demand by fuel type projected in EU Reference Scenario (2016)



Source: EASAC (2019)

Greenhouse Gas Emissions from Transport in Norway

- 52 million tonnes of CO_2-equivalents in 2018: ca. 30 % from transport



Source: SSB (1 Nov 2019)

Greenhouse Gas Emissions from Transport in Norway

- 52 million tonnes of CO_2-equivalents in 2018: ca. 30 % from transport

Norway's National Transport Plan (NTP 2018-2029):

Road Transport:

- 2025: 100% zero emission light-duty trucks
- 2030: 100% zero emission medium-heavy trucks

  50% zero emission heavy-duty trucks

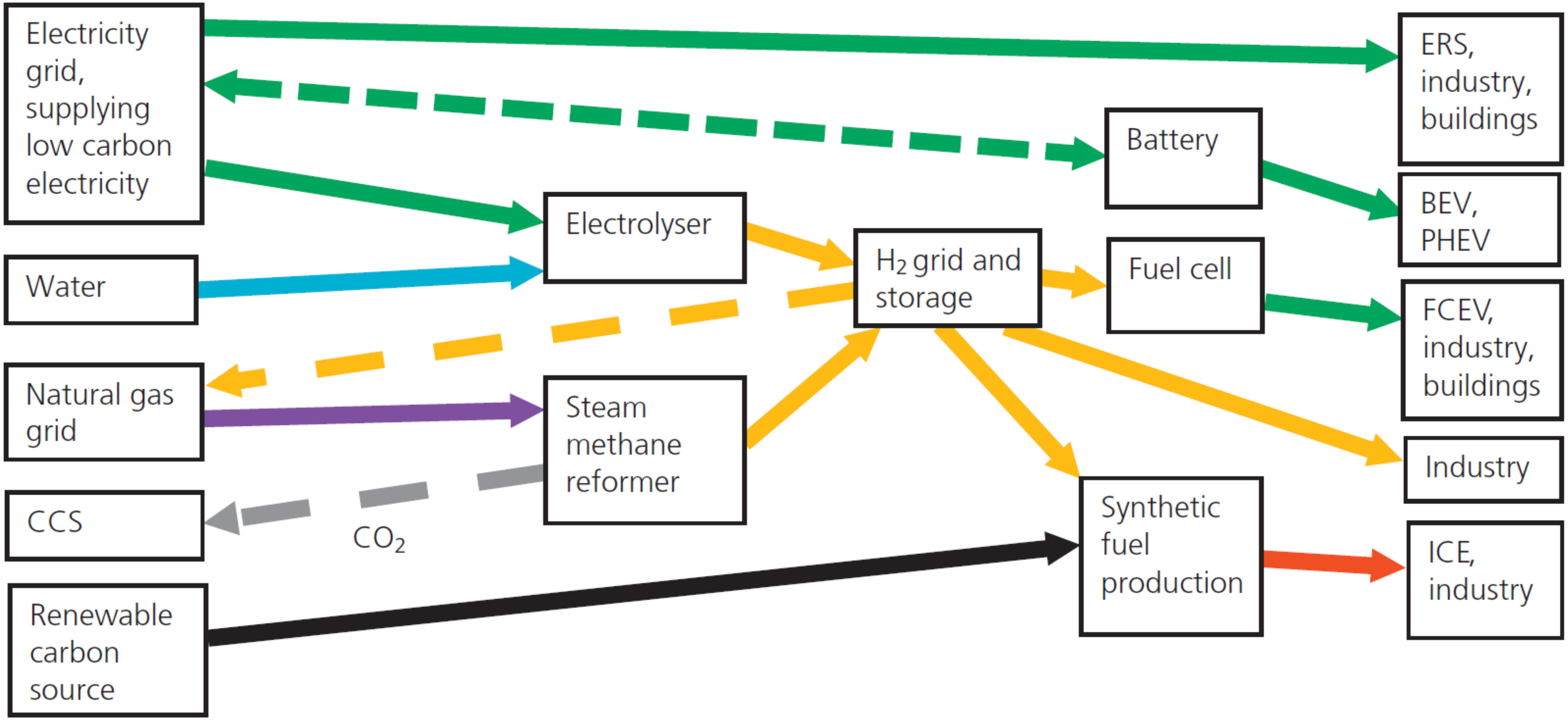
  CO_2-neutral distribution in cities

Ferries:

- Low- and zero emission, *when the technology is ready for use*

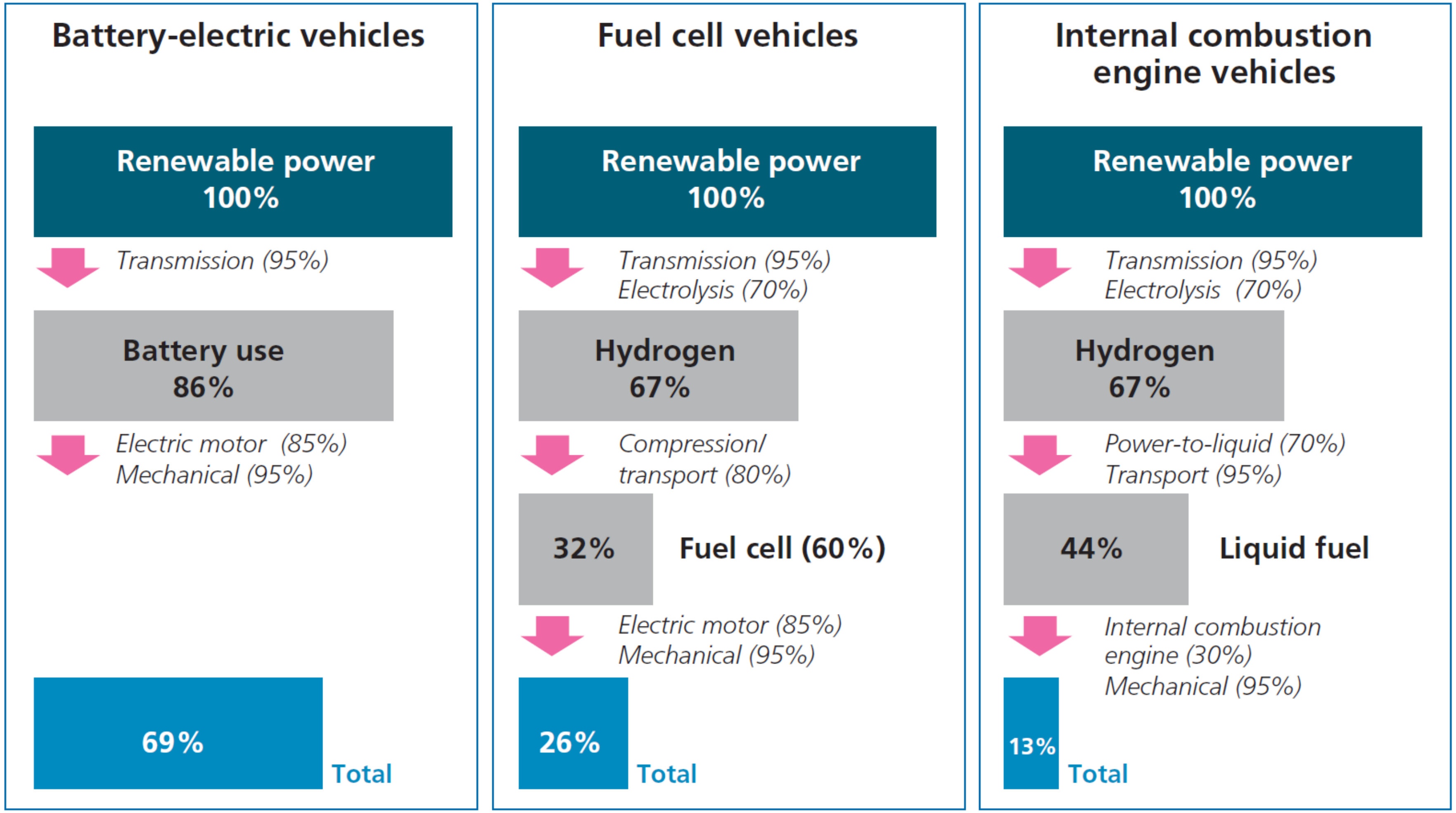
Source: Government.no

Sector Coupling – Energy & Transport Systems



Source: EASAC (2019)

Energy Conversion Efficiency



Source: EASAC (2019)

Sector Coupling – Energy & Transport Systems

Example 1 – Battery Electric Vehicles (EU)

- 250 million passenger BEVs (100%) → 0.9 TW*

  *EU maximum power capacity = 1 TW (0.5 TW peak demand)

Example 2 – Hydrogen Fuel Cell Trucks & Buses (EU)

- 1 million FCETs (15%) + 0.25 million FCEBs (25%)

  → 50 000 tpd of hydrogen*

  *50 000 H2 Refueling Stations (each 1 tpd)

Source Ø. Ulleberg, IFE (2019)

Sector Coupling – Energy & Transport Systems

- **Example 3 – Electricity & Hydrogen for Maritime Transport (Norway)**

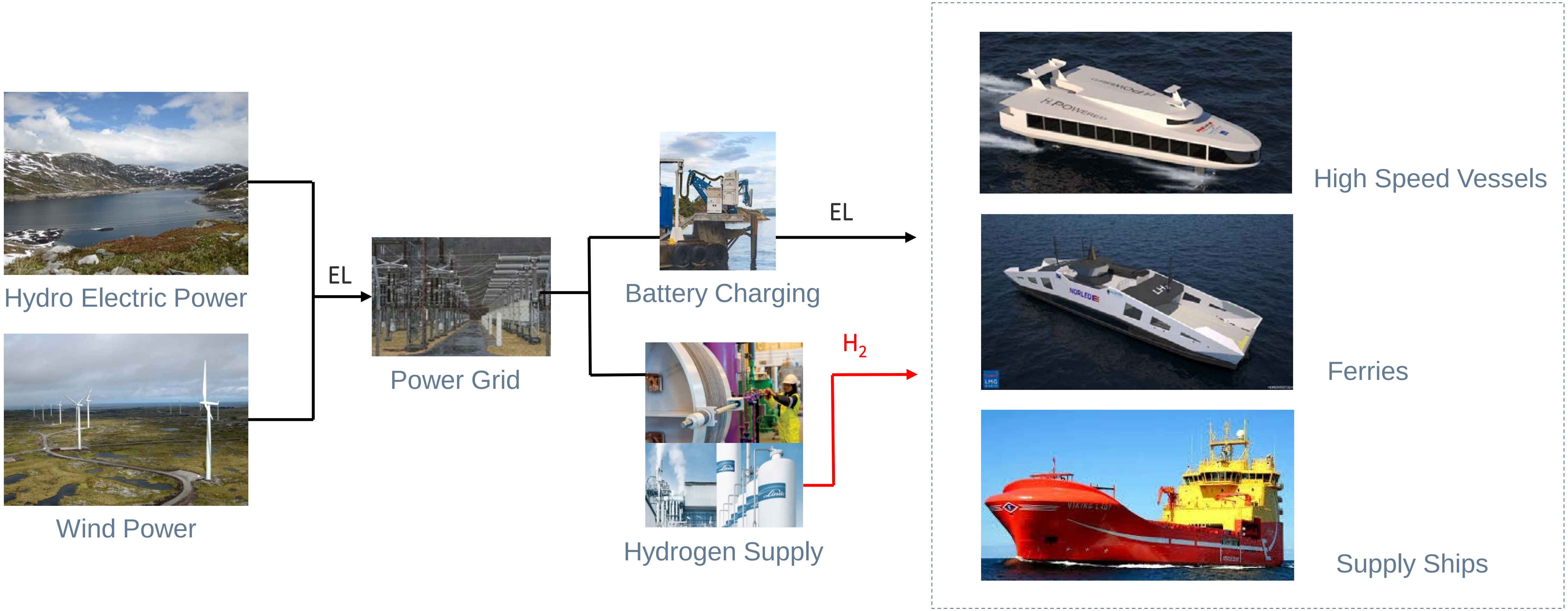


Illustration: Ø. Ulleberg, IFE (2019)

Sector Coupling – Energy & Transport Systems

- **Example 3 – Electricity & Hydrogen for Maritime Transport (Norway)**

Possible hydrogen marked in 2030: 60 tpd*

*3 GW water electrolysis, 1 TWh/year

High Speed Vessels

Ferries

Supply Ships

Source: Norwegian Center of Excellence Maritime Clean Tech (2019)

MoZEES – A Research Center on Zero Emission Transport

Battery & Hydrogen
– Technology Value Chains

***Heavy Duty* Transport: Road, Rail, Sea**
– Areas for Innovation & New Business

Materials → **Components** → **Systems**

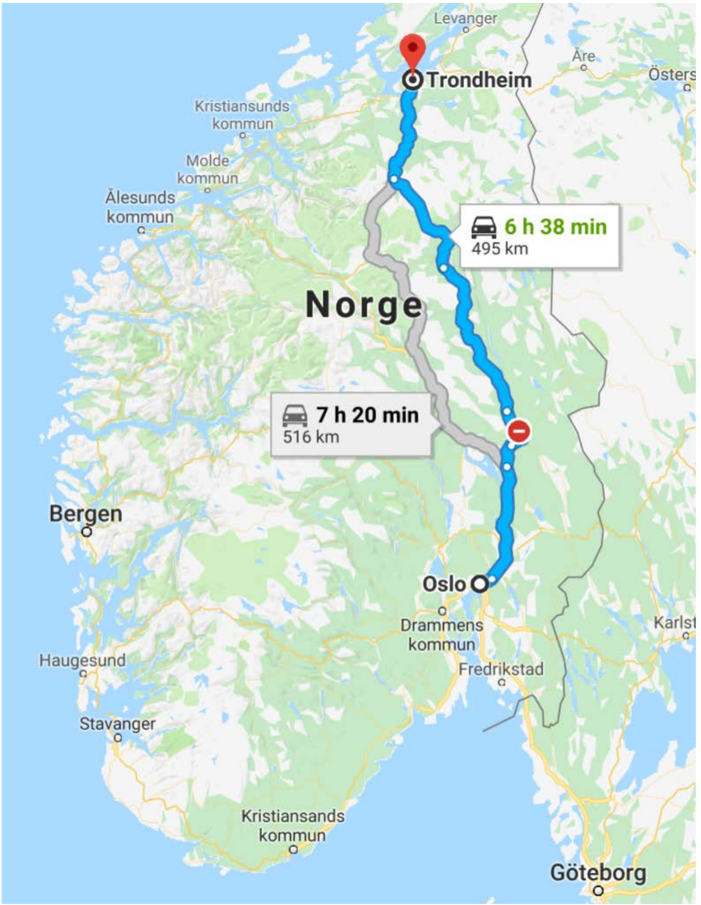
260 MNOK (2017-2024)

38 Partners

MoZEES
Mobility Zero Emission Energy Systems
FME

Case Study – Hydrogen Refueling & Fuel Cell Trucks

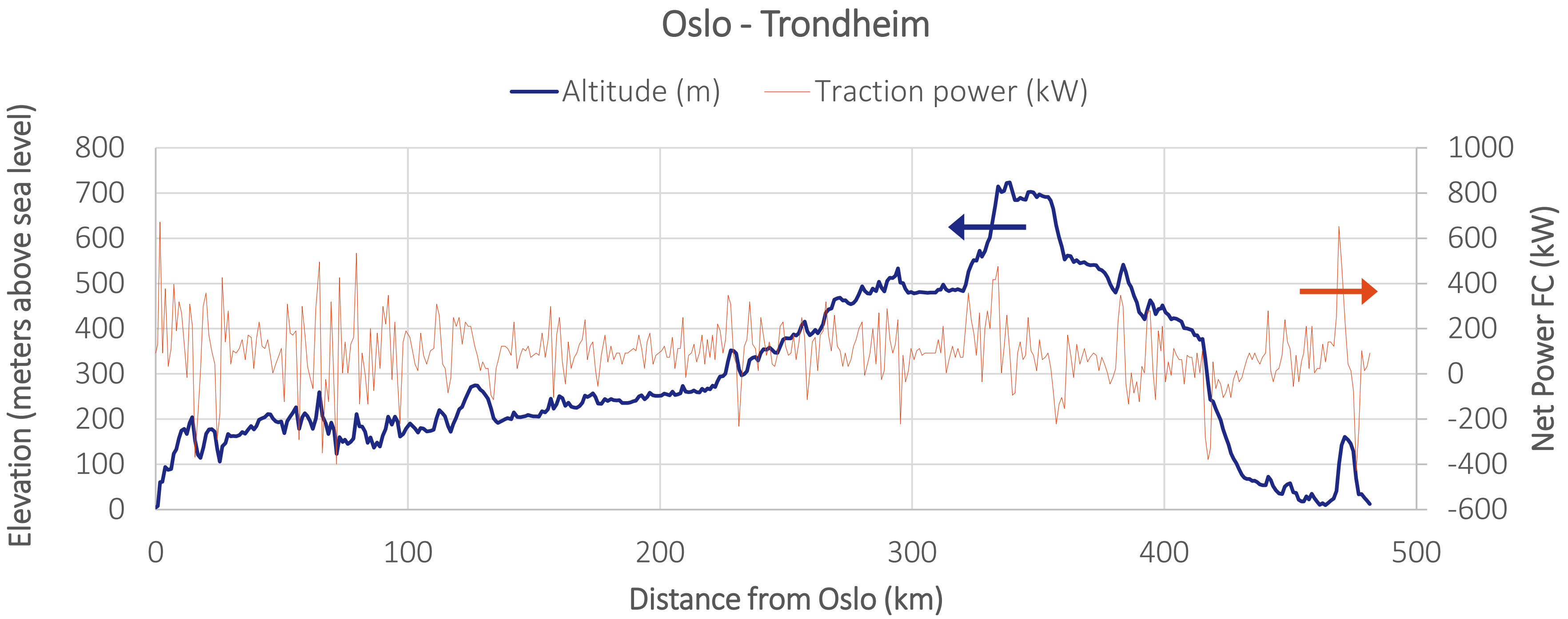
Oslo - Trondheim

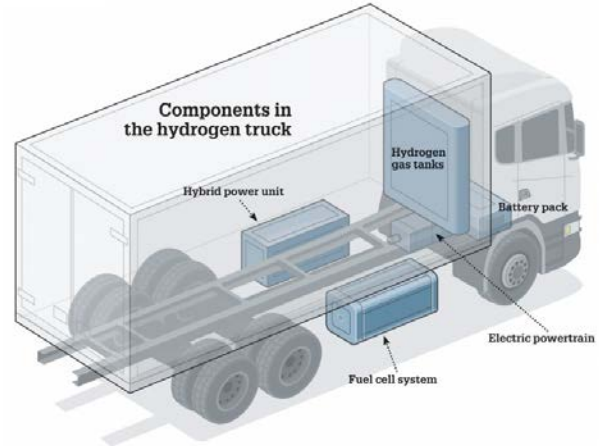


	Today	2030
Annual transport of cargo	930 000 tons (average last 10 years)	1 150 000
Trips per working day	260	330
Zero emission trucks	0	100

Source: Janis Danebergs (2019), Techno-economic study of hydrogen as a heavy-duty truck fuel, Master Thesis, KTH/IFE

Case Study – Hydrogen Fuel Cell Electric Truck (FCET)



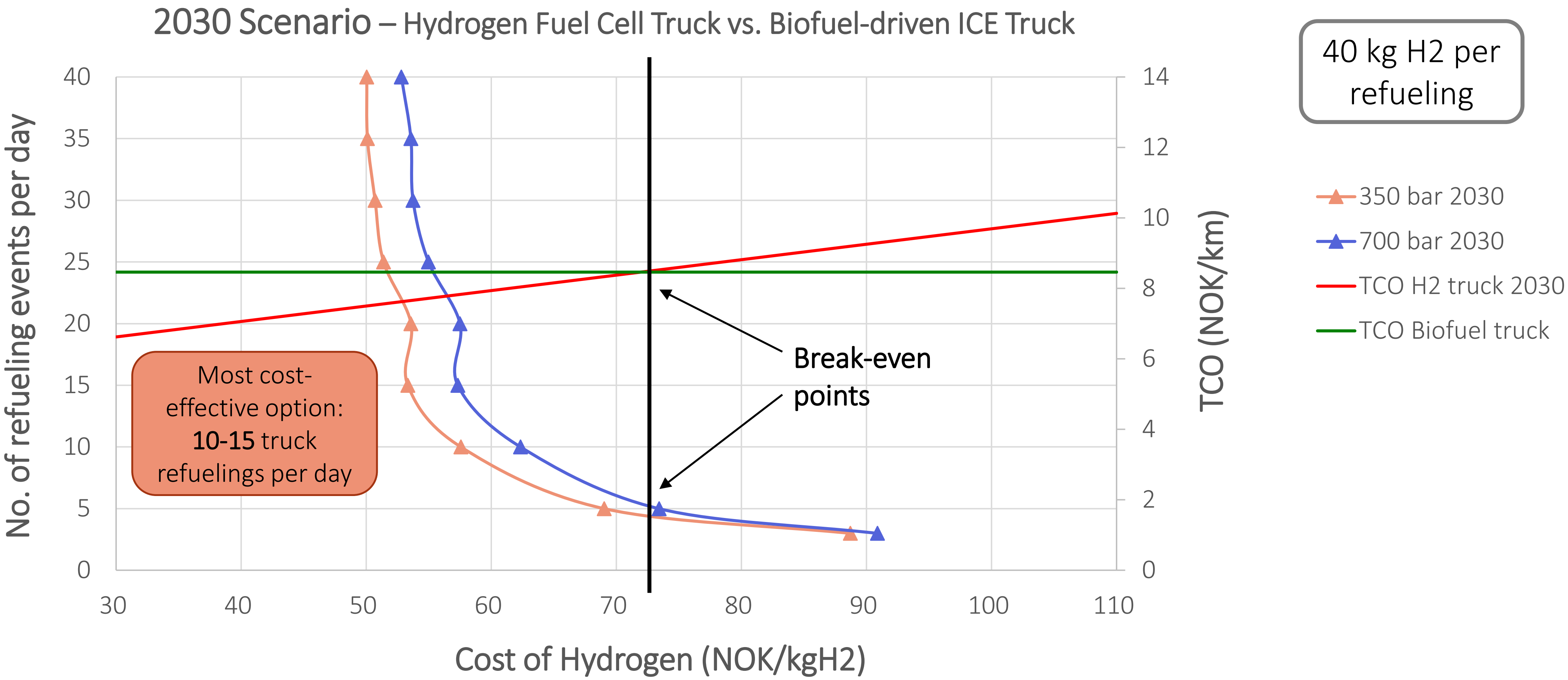


Fuel	Energy Demand per trip	Efficiency of Fuel Cell / Engine	Fuel Demand
Hydrogen	729 kWh	55%	40 kg
Biodiesel	850 kWh	43%	208 l

Batteries for regenerative power increase overall efficiency by **> 10%**

Source: Janis Danebergs (2019), Techno-economic study of hydrogen as a heavy-duty truck fuel, Master Thesis, KTH/IFE

Case Study – H2 Refueling Stations & Fuel Cell Trucks



Source: Janis Danebergs (2019), Techno-economic study of hydrogen as a heavy-duty truck fuel, Master Thesis, KTH/IFE

Conclusions

- Both passenger and freight **transport demand** expected to **increase towards 2050**
- **Battery Electric** most suitable and competitive option for **light-duty vehicles**, due to high efficiency
- **Hydrogen** and **Fuel Cell Electric** most promising option for **heavy-duty vehicles**, due to high energy storage density
- **Zero-emission transport** will require huge investments in new **renewable power** production & charging/refueling **infrastructure**

IFE Hynor Hydrogen Technology Center

Thank you for your attention!

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