Perspective on biofuel and power demand in the transport sector
Transport sector – current situation

- Around **30% of total final energy consumption**
- 92% from oil products, **3% biofuels**, remainder electricity
- Around **25% of energy-related carbon emissions** (8.5 Gt of CO$_2$ annual emissions)
- **Large source of air pollution**, e.g. nitrogen oxides (NOx), particular matter (PM)
  - Under Remap, transport sector emissions would **decline 75% by 2050**, second largest reduction after the power sector
  - **Renewable electricity and electrification** make up 60% of overall reduction; higher in the transport sector
Transport sector decarbonisation pathways (REmap)

Final energy consumption (EJ/yr)

<table>
<thead>
<tr>
<th>Year</th>
<th>Total Energy Consumption (EJ/yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2016</td>
<td>140</td>
</tr>
<tr>
<td>REmap Case 2050</td>
<td>37% Renewable (incl. electricity)</td>
</tr>
</tbody>
</table>

- **RE-Electrification**: • Battery electric vehicles, • Hydrogen in fuel cells for heavy freight modes.
- **Renewables (direct-uses)**: • Biofuels for road, aviation and marine transport.
- **Energy efficiency**: • Improvements in vehicle fuel economy, • Modal shift to public transport, • Enhanced mobility services.

**Oil** 63%  
**Biofuels** 37%

Liquid fuels
Fossil fuel production must decline

Under the REmap Case, both oil and coal demand decline significantly and continuously, and natural gas demand peaks around 2027. In 2050, natural gas is the largest source of fossil fuel.
Decarbonising and digitalising

**DECARBONISATION**

- **Transport electrification** (i.e. direct electrification) - particularly in cars (batteries), but also public systems (trams, buses)
- **Hydrogen and synthetic fuels, or e-fuels** (i.e. indirect electrification) - produced from electricity (needs to be zero-carbon) and uses hydrogen or other synthetic fuels (ammonia, methanol, etc.)
- **Biofuels** - conventional, advanced, biomethane
- **Others** - energy efficiency (materials, motors, etc.) and modal shift (cars->trains)

**DIGITALISATION**

- **Sharing mobility** - bike/car sharing, carpooling
- **Mobility as a service** - apps and digital platforms that enable combined travel planning, including ride hailing
- **Autonomous vehicles**
- **AI and big data learning** to support optimised planning and operation of transport systems
- **Others** including remote work, e-commerce, etc.
Role of electrification in transport

- Expanding the use of electricity is the main driver for accelerating the energy transformation
- In particular, the electric mobility revolution is gaining pace
  - At the end of 2019, an estimated 7.5 million EVs were on the roads worldwide
  - To reach our climate goals, around 160 million EVs should be on the roads by 2030 and more than 1 billion by 2050
- Globally, by the end of 2019, there were around 880,000 Public Charging Points (PCP)
- The switch to electricity is not just happening with cars
  - Electric buses are making large in-roads, particularly in China
  - Shenzhen has over 16,000 electric buses in operation

Impact of charging EVs on solar PV and wind integration

- Electric vehicles have a small impact on energy demand but larger impact on peak load.
- Different impact of EV charging in a wind or solar PV-dominated power system.
- Smart charging cuts peak load, reduces curtailment and allows higher shares of low-cost PV and wind electricity.
The current energy needs of the shipping sector are mostly met by heavy fuel oil (82%), marine gas and diesel oil (18%).

Global trade volume is estimated to grow at 3.8% per year over the next five years.

Between 2000 and 2017, the CO₂ emissions associated with the shipping sector grew at an average annual rate of 1.87%.
Hydrogen has an important role to play in the transition to zero-emission shipping

Hydrogen product cost projections

- Compared to fossil fuel usage, hydrogen would eliminate direct carbon and SOx emissions while reducing NOx emissions to negligible levels.
- The better solution, though, is green hydrogen from renewable sources, as this is the only source of zero carbon hydrogen.

Source: Hydrogen cost projections (IRENA, 2019); fuel cost projections (Lloyd’s Register, 2019; Ship & Bunker, 2019)
The role of hydrogen in the energy transition

- Hydrogen can be used in the industry, transport and buildings sectors for a variety of purposes, i.e. energy vector, feedstock, fuel - Ensuring a low-carbon, clean hydrogen supply is essential!

- It offers a way to recycle assets and potentially transport a renewable, multi-purpose energy carrier and feedstock over long distances

4 TW renewables for hydrogen production
E-fuels

- From H₂ + CO₂
- Synthetic methane and synthetic liquids
- Technically feasible but at high cost
- Not yet applied on a commercial scale
- Existing gas and liquids infrastructure and equipment can be used – avoid asset stranding
- Biofuels constitute a complementary/competing option
- Advanced biofuels are cheaper today than E-fuels

Hydrogen potential in end-use sectors by 2050
The most important group of barriers relates to lack of stable regulation, including mandates and subsidies.

This is followed by the difficulty of financing (availability and cost) and cost competitiveness of advanced biofuels production, including conversion efficiency & CAPEX.
Summary of key points

• Transport sector emissions need to **decline by 75%**, despite almost a **doubling of passenger and freight activity by 2050**

• Sector’s growth shifting from OECD to **non-OECD countries**

• **Energy sector and transport sector transformation** are two sides of the same coin

• **Decarbonisation and digitalisation** are disrupting the transport sector

• Options for decarbonization include **direct and indirect electrification**, **biofuels**, and **efficiency**

• Electrification increases to **43% of total final energy consumption, USD 13 trillion investment** to 2050
Disaggregation of global energy consumption on the transport sector

- International shipping alone accounts for around 9% of global emissions associated with the transport sector.
- The current energy needs of the shipping sector are mostly met by heavy fuel oil (82%), marine gas and diesel oil (18%).
- Global trade volume is estimated to grow at 3.8% per year over the next five years.
- Between 2000 and 2017, the CO₂ emissions associated with the shipping sector grew at an average annual rate of 1.87%.

Global international bunkering for shipping accounts for 8.9 exajoules, this resulted in 677 megatons of CO₂ (2017)

Source: EIA (2016)
Conversion of electricity to synthetic methane

Source: Agora (2017)
Conversion of electricity to synthetic liquid fuels

Source: Agora (2017)
• **Passenger transport activity will increase 75%** even in a climate friendly scenario (REmap), more according to current and planned policies (Reference Case)

• Today’s split is **45% OECD, and 55% non-OECD**; by **2050 28% OECD and 72% non-OECD**

• **Freight tonnage will more than double**; shipping will continue to dominate with 75% of tonne/km

• **Energy intensity** differs by mode:
  - Cars 1.0-3.5 MJ/p-km (average 2.1), aviation 1.0-2.9 (average 1.75), bus 0.6, two-three wheeler 0.5, rail 0.3
  - Trucks 0.7-2.0 MJ/t-km, rail 0.4, shipping 0.3
Increasing electrification in the transport sector

- Electricity providing 43% of total transport energy consumption, and due to higher efficiency, covering 60% of the overall transport activity.

- Renewables increase to provide 57% of transport TFEC by 2050.

- Overall passenger and freight activity almost doubles (but less than under the Reference Case); but due to energy efficiency and electrification, TFEC in transport declines.
Today:
About 14 EJ hydrogen produced mainly from fossil source - green and blue hydrogen production is negligible

2050:
Two-thirds of hydrogen produced could come from green hydrogen

Demonstration projects with electrolysis – with increasingly bigger sizes (> 50 MW)

Source: IRENA (2019)
Energy transition has made progress but acceleration is needed – transport is key

• **Energy transition:**
  - **Costs of renewable energy continue** to decline rapidly with wind and solar leading capacity expansion: 84% of new renewable power capacity added in 2018;
  - **Power is becoming distributed and renewable**; flexibility is key (storage, demand, grids)
  - **Key technologies** with falling costs include PV, wind, batteries, electrolysers

• **Transport transformation:**
  - **Renewable share** remains largely unchanged, efficiency has improved
  - **Expanding electricity use** (direct and indirect) can be a main driver: e.g. EV sales surpassed 2 million units in 2018
  - **Digital platforms** allowing for mobility sharing and multimodality
  - **Sector coupling**, power to vehicle, power to gas, power to grid

→ Two main themes: **Decarbonisation and Digitalisation**
Electrification paired with renewables is a major solution for decarbonisation

- By 2050, electricity will provide around 50% of the global final energy mix
  - Electricity consumption in end-use sectors will more than double from today's level - Electricity consumption includes both direct (e.g. EVs) and indirect (e.g. hydrogen or other e-fuels)
- 86% of electricity generation will come from renewables in 2050
- The share of electricity consumed in TFEC in transport will increase from 1% today to 43% by 2050
Smart charging makes EVs a source of flexibility for power systems - facilitating integration of VRE

Source: IRENA (2019) Innovation Outlook: Smart charging for Electric Vehicles
Cumulative investment of USD 110 trillion must be made between 2016-2050 predominantly in low-carbon technologies, averaging around 2% of global GDP per year over the period.

- Shifting investments into electrification, renewable energy and energy efficiency technologies, which together, would make up four-fifths of the cumulative energy sector investments over the period to 2050:
  - USD 12.7 trillion in electrification technologies in end-uses
Countries with biofuel obligations for transport, 2016

New policies since 2017
- Brazil – RenovaBio
- China – Nationwide E10 by 2020
- Canada – Federal Clean Fuel Standard; Some provinces boost blending
- India – National Biofuel Policy 2018
- Bolivia E25 by 2025

Global biofuel investments are on a declining trend

The industry has reached and even exceeded the USD 20 billion level in the past, which is needed for biofuels in the low-carbon transport sector pathway.

- To achieve the 5-fold increase goal, more than 100 refineries should be developed annually at an investment cost of USD 20+ billion.
- More than 10% of bioliquids should be allocated for aviation but the buildout of biojet refineries is slow.
Bridging the gap: A pathway for a well-below 2°C climate target, towards 1.5°C

- Energy-related CO2 emissions have grown by around 1% annually over the last five years.
- The global carbon budget is set to run out by 2030 based on current and planned policies.
- Energy-related emissions would need to fall by 3.5% per year to the world to meet the aims of the Paris Climate Agreement.
## Electrification of the transport sector

### RENEWABLE ENERGY AND ELECTRIFICATION

<table>
<thead>
<tr>
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<th>2016</th>
<th>REmap Case 2050</th>
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<tbody>
<tr>
<td>Renewable share in final energy use in transport</td>
<td>3%</td>
<td>56%</td>
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<td>Electricity share in final energy use in transport</td>
<td>1%</td>
<td>43%</td>
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</table>

### ELECTRIFICATION

<table>
<thead>
<tr>
<th>Type</th>
<th>2016 units</th>
<th>REmap Case 2050 units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electric passenger cars</td>
<td>1.2 million</td>
<td>1109 million</td>
</tr>
<tr>
<td>Electric buses and light duty vehicles</td>
<td>0.02 million</td>
<td>58 million</td>
</tr>
<tr>
<td>Electric 2/3 wheelers</td>
<td>200 million</td>
<td>2402 million</td>
</tr>
<tr>
<td>Battery Storage available to grid from EVs</td>
<td>0.5 GWh</td>
<td>14065 GWh</td>
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</table>
Innovations to integrate solar PV and Wind - EVs smart charging is one of those

Free download of report at: https://www.irena.org/publications/2019/Feb/Innovation-landscape-for-a-renewable-powered-future

<table>
<thead>
<tr>
<th>ENABLING TECHNOLOGIES</th>
<th>BUSINESS MODELS</th>
<th>MARKET DESIGN</th>
<th>SYSTEM OPERATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>7. Artificial intelligence and big data</td>
<td></td>
<td>23. Market integration of distributed energy resources</td>
<td></td>
</tr>
<tr>
<td>8. Blockchain</td>
<td></td>
<td>24. Net billing schemes</td>
<td></td>
</tr>
<tr>
<td>9. Renewable mini-grids</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10. Supergrids</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11. Flexibility in conventional power plants</td>
<td></td>
<td></td>
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</tbody>
</table>
Indirect electrification
Accelerate the uptake of electric mobility by:

- Establishing minimum standards for vehicle emissions
  - Give EVs priority for city access
- Incentivising charging infrastructure rollout
- Strengthening link between the power and transport sectors for integrated planning and policy designs (vehicle-to-grid services)
- Deploy low-emissions city trucks

All sectors need to reduce carbon intensity over time

Renewable energy, energy efficiency and electrification can reduce the carbon intensity of the energy system by 70% by 2050
Transport sector key indicators infographic

### Renewable Energy and Electrification

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### Electrification

- **Electric passenger cars**: 1.2 million units vs. 1,109 million units
- **Electric buses and light duty vehicles**: 0.02 million units vs. 58 million units
- **Electric 2/3 wheelers**: 200 million units vs. 2,402 million units
- **Battery Storage available to grid from EVs**: 0.5 GWh vs. 14,065 GWh

### Energy Related CO₂ Emissions

- **8.5 Gt CO₂/yr**
- **2.4 Gt CO₂/yr**

### Investment

- **Total investments for decarbonisation over the period 2016-2050**: 6.1 USD trillion
- **14 USD trillion**

Note: Considering 50% grid connected electric passenger cars and 75% grid connected electric 2/3 wheelers by 2050.
Renewable energy shares increase in all end-use sectors

- By 2050, renewables could dominate the transport and buildings sectors reaching 57% and 81% of the sectors’ final energy consumption.

- Electricity would account for the largest share of renewable energy use, with over one third of transport final energy source from renewable power
Uptake of EVs - the battery bank of the future

Growth in EV deployment between 2010 and 2050 in a Paris Agreement-aligned scenario

<table>
<thead>
<tr>
<th>Year</th>
<th>Passenger electric cars on the road</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010</td>
<td>&lt;0.5 mil</td>
</tr>
<tr>
<td>TODAY (2017/2018)</td>
<td>6 mil</td>
</tr>
<tr>
<td>2030</td>
<td>157 mil</td>
</tr>
<tr>
<td>2040</td>
<td>745 mil</td>
</tr>
<tr>
<td>2050</td>
<td>1,166 mil</td>
</tr>
</tbody>
</table>

By 2050, potential storage capacity to provide grid services:

~ 14 TWh EV batteries vs ~ 9 TWh stationary batteries

(including second use)

Source: IRENA (2019) Innovation Outlook: Smart charging for Electric Vehicles
Increasing electrification in the transport sector

• Electricity providing 43% of total transport energy consumption, and due to higher efficiency, covering 60% of the overall transport activity

• Overall passenger and freight activity almost doubles (but less than under the Reference Case); but due to energy efficiency and electrification, TFEC in transport declines
Transport solutions

**REDUCE THE ENERGY NEED FOR TRANSPORT:**

- Deploy advanced digital communication technologies to reduce the transport needs (eg. teleconferencing over travelling) and to improve efficiency of transport by better utilizing the assets (eg. re-routing due to traffic).
- Promote mobility services: Promote vehicle sharing and autonomous driving.
- Accelerate modal shift from passenger cars to public transport (electric railways or trams or electric buses).

**ACCELERATE THE UPTAKE OF ELECTRIC MOBILITY:**

- Establish minimum standards for vehicle emissions. Give the priority for electric vehicles for city access.
- Incentivise charging infrastructure rollout.
- Strengthen link between the power and transport sectors for integrated planning and policy designs (vehicle-to-grid services).
- Deploy low-emissions city trucks.

**FOSTER BIOFUELS IN ROAD, AVIATION AND SHIPPING:**

- Eliminate fossil fuel subsidies and implement carbon pricing to increase the competitiveness of renewable fuels in the shipping and aviation.
- Adopt supporting policies to scale up sustainable production of first- and second-generation biofuels. Introduce specific mandates for advanced biofuels and put in place direct financial incentives along with financial de-risking measures.