Insights from Irish Energy Systems Modelling on Decarbonising Road Freight and the Impact of Intangible Costs

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Trucks: Emissions & Demand

- CO\(_2\) emissions during 1990 to 2021 have risen by 115%.
- Transport sector is responsible for 34% of energy-related CO\(_2\) emissions.
- Trucks generate 20% of transport emissions.
- Trucks make up 5% of total road vehicle stock.
- The overall freight demand is expected to double by 2050.

meet increasing demand while minimising environmental impacts.
Decarbonising trucks

Barriers
- Alternative fuel availability
- Recharging/refuelling time
- Decreased cargo capacity
- Capital-intensive infrastructures
- Well-to-wheel emissions
- Less commercialised technologies
- Hesitancy to invest in a less mature technology

Need for a comprehensive Energy System Analysis
Freight sector and main input

Techno-economic parameters
- Existing trucks
  - Fleet composition
  - Fuel economy
  - Retirement profile
  - Activities
- New trucks
  - Drivetrain capital costs
  - O&M costs
  - Load factor
  - Lifetime
  - Annual mileage
  - Retirement profile

Supply-side Module
Emission Control Module
Rest of Demand-side Module

Road Freight Sector

Transport Fuels
- Diesel
- Bio-diesel
- CNG
- Bio-CNG
- Hydrogen
- Electricity

Demand (PJ)

Goods Vehicles

Existing fleet
- Light Trucks (2-5 t)
  - ICEs
- Medium Trucks (5-10 t)
  - ICEs
- Heavy Trucks (>10 t)
  - ICEs

Alternative options
- Light Trucks (2-5 t)
  - ICEs, HEVs, PHEVs, BEVs, FCVs
- Medium Trucks (5-10 t)
  - ICEs, HEVs, BEVs, FCVs
- Heavy Trucks (>10 t)
  - ICEs, HEVs, BEVs, FCVs

Intangible costs
- Recharging time
- Cargo capacity
- Hurdle rates

Demand (tkm)
## Cargo capacity and refuelling time

<table>
<thead>
<tr>
<th>Technology</th>
<th>Cargo capacity relative to diesel ICE</th>
<th>2020</th>
<th>2050</th>
</tr>
</thead>
<tbody>
<tr>
<td>ICEs (CNG)</td>
<td></td>
<td>0.99</td>
<td>0.99</td>
</tr>
<tr>
<td>BEVs</td>
<td></td>
<td>0.67</td>
<td>0.89</td>
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<tr>
<td>FCVs</td>
<td></td>
<td>0.9</td>
<td>0.96</td>
</tr>
</tbody>
</table>

8 ton to 5.4 ton

Discount rate

- **Social DR**: 4%
- **EU Range**: 10-12%
- **Ireland**: 12%
  - High levels of competition
  - Low profit margins
  - Volatile fuel prices
  - Suggest a higher rate of return for investors
Scenario definition

- Reference
- Net zero by 2050
- Net zero + Intangible costs

<table>
<thead>
<tr>
<th>Scenarios</th>
<th>BAU</th>
<th>Carbon budget constraint</th>
<th>Intangible costs</th>
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</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Recharging time</td>
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<tr>
<td>Reference</td>
<td>✓</td>
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<tr>
<td>Mitigation</td>
<td>✓</td>
<td>✓</td>
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<tr>
<td>Mitigation+ Intangible</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
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</tbody>
</table>
Results: Vehicle stock

Heavy Trucks (over 10 tonne)

<table>
<thead>
<tr>
<th>Year</th>
<th>ICEs</th>
<th>HEVs</th>
<th>PHEVs</th>
<th>BEVs</th>
<th>FCVs</th>
<th>ZEVs (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2020</td>
<td></td>
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<tr>
<td>2025</td>
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<td>2030</td>
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<td>2035</td>
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<td>2040</td>
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<td>2045</td>
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<tr>
<td>2050</td>
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</table>

Stock (kVehicles)

Reference

ZEVs (%)

[Graph showing the percentage of Zero Emission Vehicles (ZEVs) for Heavy Trucks (over 10 tonne) from 2020 to 2050, with columns for ICEs, HEVs, PHEVs, BEVs, FCVs, and ZEVs (%).]
Fuel consumption

![Graph showing fuel consumption over time for different energy sources.](image-url)

- **Diesel**
- **Biodiesel**
- **Gas**
- **Electricity**
- **Hydrogen**

**Graph Details:**
- **X-axis:** Years (2020 to 2050)
- **Y-axis:** Fuel consumption (PJ)
- **Legend:**
  - Diesel
  - Biodiesel
  - Gas
  - Electricity
  - Hydrogen
  - ZEF (%)

**Notes:**
- The graph illustrates the projected fuel consumption for each energy source from 2020 to 2050, with a focus on ZEF (Zero Emission Fuel) percentage.

**Legend:**
- **ZEF (%):** Represents the percentage of zero emission fuel consumption.
- **Fuel consumption (PJ):** Projected fuel consumption in petajoules (PJ).

**Key Observations:**
- The usage of zero emission fuels like electricity and hydrogen shows a significant increase over the years.
- Diesel consumption shows a gradual decrease.
- Biodiesel and gas consumption remain relatively constant.

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**Average fuel economy (tkm/lde):**
- 2020: 9
- 2025: 11.1
- 2030: 12.1
- 2035: 14.0
- 2040: 9.0
- 2045: 8.6
- 2050: 20

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**Current value:**
- 2020: Reference
- 2025: Reference
- 2030: Reference
- 2035: Reference
- 2040: Reference
- 2045: Reference
- 2050: Reference

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**Net zero+Intangible:**
- 2020: 0
- 2025: 5
- 2030: 10
- 2035: 15
- 2040: 20
Key takeaways

- **Cargo capacity, refuelling time, and hurdle rates** can significantly change the results between electrification & hydrogen FCV

- **Intangible costs impact preference**
  - Hydrogen FCV may be favoured for medium and heavy trucks
  - BEVs are preferred without considering intangible costs

- **Importance of holistic evaluation**: Policy makers and stakeholders should consider both tangible & intangible factors for effective decarbonisation strategies
Future research

- Sensitivity analysis to further refine results
- The impact of driving range
- Infrastructure considerations (H2, EVSE)
- Technology readiness of zero emission trucks
- Series-production (manufacturing readiness)
Thanks for listening!