Impacts of monetary incentives and non-monetary policy measures on transport decarbonization in Ireland

Vahid Aryanpur
PhD student | Energy Policy & Modelling Group, MaREI Center for Energy, Climate and Marine | School of Engineering, UCC | vahid.aryanpur@ucc.ie | IEA ETSAP Workshop | June 17, 2021
Content

- Background
- Purpose of the study
- Methodology and model specifications
- Scenario assumptions and Results
- Conclusions
Transport Sector in Ireland (SEAI, 2020)
- Transport is the largest energy-consuming sector in Ireland (42% of total final energy consumption in 2018)
- This sector significantly relies on fossil fuels and is responsible for 40% of energy-related CO2 emissions
- Private cars are responsible for the largest share of transport emissions at 40%

Key solutions (Climate Action Plan, 2019)
- Private cars: 840,000 EVs on the road by 2030
- Remote and home-working
- Modal shift to public transport
- Renewable biofuel
- Zero carbon public transport fleets

Ambitious targets (Climate Action Bill, 2021)
- Target 2030: 51% reduction compared to 2018
- Target 2050: Carbon-neutral transport

Approach (Joint Committee on Environment & Climate Action, 2021)
- avoid-shift-improve approach into the transport and mobility infrastructure planning
Focus and Purpose

▪ Focus
  ✓ Sector: Private cars in Ireland
  ✓ Target: 51% reduction in CO₂ emissions
  ✓ Year: 2030

▪ Research Questions
  ✓ How different measures impacts on CO₂ emissions from private cars
  ✓ Solutions to reach the mitigation target in 2030
  ✓ The appropriate time to remove the purchase grant while meeting EV adoption target
How policy measures impact decarbonization pathways in transport sector?

**Supply-side Modules**
- **Resources and Potentials**
  - Fossil fuel: Oil, Gas, Coal
  - Renewable: Wind, Hydro, Solar, Biomass
- **Power**
  - Fossil-Fired
  - Biogas-Fired
  - CCS (Gas/Biomass)
  - Renewable
- **Fuel Supply**
  - Oil products
  - NG/Biogas
  - Liquid Biofuels
  - Hydrogen
- **Distribution**
  - Electricity
  - Oil products
  - Biofuels
  - Natural gas
- **Imports**
  - Electricity
  - Oil products
  - Biofuels
  - Natural gas

**Demand-side Modules**
- **End-use Technologies**
  - Residential
    - Appliances
    - Boiler
    - Heat pumps
  - Other sectors
    - Industry
    - Service
    - Agriculture
- **Energy Service Demands**
  - Residential & Service
    - Space heating
    - Hot water
    - Electricity
    - Others
  - Industrial
    - Chemicals
    - Machinery
    - Metals
    - Food & beverage
    - Others

**Transport Technologies**
- **Inland Freight**
  - Light Goods Trucks
    - ICEs, HEVs
    - FCVs
    - PHEVs, BEVS
  - Medium & Heavy Goods Trucks
    - ICEs & HEVs
    - FCVs
    - BEVs
  - Trains
    - ICEs, BEVs, FCVs
- **Inland Passenger**
  - Light-Duty Vehicles
    - Cars & Taxis
      - ICEs & HEVs
      - FCVs
      - BEVs, PHEVs
    - 2-Wheelers
      - ICEs, BEVs
  - Heavy-Duty Vehicles
    - Trains
      - ICEs (Train)
      - BEVs (Light rail)
      - BEVs (Train)
    - Buses
      - ICEs
      - FCVs
      - BEVs
- **Other transport**
  - Tourism, Navigation, Aviation, Unspecified

**Main Scenarios**
- BAU Scenario
- Low Demand Scenario

**Policy Measures**
- Biofuel obligation
- Monetary incentives
- Banning ICEs

**Transport Demand**
- Passenger (pkm)
  - Short-range (<5km)
  - Medium-range (5-30km)
  - Long-range (>30km)
- Freight (ton.km)
- Others (PJ)

**Carbon Constraint (kt CO₂)**

**Method**
- Energy flow
- Scenario assumption
- CO₂ flow
- End-use Demand
- Hurdle rates
Model Specifications

❑ General
  ▪ Model horizon: 2018 – 2050
  ▪ Periods: 18 Periods (yearly/multi-years)
  ▪ Social discount rate: 4%
  ▪ Flexible Spatio-temporal resolution: 26 sub-regions, 40 time-slices
  ▪ Model details: >60 Attributes; >150 User Constraints; >300 Commodities; >2000 Technologies

❑ Transport
  ▪ Region specific characteristics: vehicle fleet, infrastructure, fuel consumption, mileage, occupancy rate, and load factor
  ▪ Historic scrappage profiles for existing vehicles
  ▪ Retirement profile for new vehicles
Vehicle Purchase Decision

- **Hurdle rates** are used to capture the consumer behaviour when purchasing a transport technology.
- Consumer-specific Hurdle Rate: TAM\(^1\), PRIMES\(^2\)

**Relationship between individual discount rates and income in PRIMES**

<table>
<thead>
<tr>
<th>Income class</th>
<th>Discount rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low-income (39%)</td>
<td>30.8%</td>
</tr>
<tr>
<td>Medium-income (17-27%)</td>
<td>49.6%</td>
</tr>
<tr>
<td>High-income (5-9%)</td>
<td>19.6%</td>
</tr>
</tbody>
</table>

**Sub-regions in TIM**

Household median gross income by county:

- €66,203
- €32,259

**Individual discount rates in TIM (region-specific discount rate)**

<table>
<thead>
<tr>
<th>Income class</th>
<th>Frequency</th>
</tr>
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<tbody>
<tr>
<td>Low-income</td>
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<td>High-income</td>
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</tbody>
</table>

## BAU Scenario

<table>
<thead>
<tr>
<th>Scenarios</th>
<th>Demand</th>
<th>Modal share</th>
<th>Biofuel</th>
<th>Policy measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Business as usual (BAU)</td>
<td>Increase</td>
<td>Fixed</td>
<td>No obligation</td>
<td>No action</td>
</tr>
<tr>
<td>1.1. Modal shift</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.2. Biofuel Obligation Scheme (BOS1)</td>
<td></td>
<td></td>
<td>B12 and E10</td>
<td></td>
</tr>
<tr>
<td>1.3. Biofuel Obligation Scheme (BOS2)</td>
<td></td>
<td></td>
<td>B20 and E10</td>
<td></td>
</tr>
<tr>
<td>1.4. Occupancy rate</td>
<td></td>
<td></td>
<td></td>
<td>Occupancy rate (5-50%)</td>
</tr>
<tr>
<td>1.5. Monetary incentives</td>
<td></td>
<td></td>
<td></td>
<td>Grants &amp; tax relief</td>
</tr>
</tbody>
</table>

Region-specific hurdle rates are incorporated in all scenarios
Low Demand Scenario

<table>
<thead>
<tr>
<th>Scenarios</th>
<th>Demand*</th>
<th>Modal share</th>
<th>Biofuel</th>
<th>Policy measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>2. Low Energy Demand (LED)</td>
<td>Decreasing</td>
<td>Fixed</td>
<td>No obligation</td>
<td>No action</td>
</tr>
<tr>
<td>2.1. Modal shift</td>
<td></td>
<td></td>
<td></td>
<td>Modal shift</td>
</tr>
<tr>
<td>2.2. Biofuel Obligation Scheme (BOS1)</td>
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<td></td>
<td></td>
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</tbody>
</table>

* pkms/capita will decrease from 17,000 in 2018 to 12,000 in 2050
Results: CO₂ emissions in BAU Scenario (Mt)

<table>
<thead>
<tr>
<th></th>
<th>Actual 2018</th>
<th>Growth in activity</th>
<th>LDI improvements</th>
<th>Biofuel Obligation</th>
<th>Radical Biofuel Obligation</th>
<th>Active modes</th>
<th>Emission level 2030</th>
<th>Target 2030</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>6.07</td>
<td>1.17</td>
<td>-0.88</td>
<td>-0.64</td>
<td>-0.24</td>
<td>-0.41</td>
<td>5.05</td>
<td>2.97</td>
</tr>
</tbody>
</table>

Sensitivity Analysis

✓ Monetary and non-monetary measures

Solutions to fill the gap:

✓ EV adoption: 1.1 million EVs are required. Monetary incentives (Purchase grants + VRT Relief) should be kept until the end of year 2027.

✓ Occupancy rate: Increasing the average occupancy rate by 35% (from 1.49 to at least 2.0)

✓ Hybrid solution: Increasing the average Occupancy Rate (OR) by 10% and 700k EVs.
Results: CO₂ emissions in LED Scenario (Mt)

Sensitivity Analysis
✓ Monetary and non-monetary measures

Solutions to fill the gap:
✓ EV adoption: 600k EVs are required, Monetary incentives (Purchase grants+VRT Relief) should be kept until the middle of year 2023.

✓ Occupancy rate: Increasing the average occupancy rate by 25% (from 1.49 to at least 1.86)

✓ Hybrid solution: Increasing the average occupancy rate by 15% and 450k EVs.
Results: Monetary incentives in BAU scenario

<table>
<thead>
<tr>
<th>Vehicle type</th>
<th>Private cars</th>
<th>Vans</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>BEV</td>
<td>PHEV</td>
</tr>
<tr>
<td>Purchase grant</td>
<td>€5000</td>
<td>€2500</td>
</tr>
<tr>
<td>VRT relief</td>
<td>€5000</td>
<td>€2500</td>
</tr>
</tbody>
</table>

Monetary Incentive Removal (MIR)

VRT relief for BEVs is in place until the end of 2021 and for PHEVs until end of 2020

EV Cars (1000 Vehicle)

2030 target: 840k EVs

CO2 emissions (MT)

2030 target: 2.97 MT CO₂

Purchase price proportion in 2024 (EV/ICE): 1.41
Conclusions

Impact of measures on decarbonization

- Individual measures (even a radical action) cannot meet the ambitious targets

- Avoid (reduce the travel need) can deliver far better outcome than the adoption of zero-carbon vehicles

- To achieve the mitigation target in BAU:
  - 700k BEVs, combined with radical increase in OR are required
  - Monetary incentives should be kept until 2027

- To achieve the mitigation target in LED:
  - LED scenario: 450k BEVs, combined with moderate increase in OR are required
  - Monetary incentives can be removed from 2023
Insights and future works

Modelling insights (spatially-resolved model)

- Better capture region-specific characteristics
- Higher spatial resolution can be used as a mean to incorporate consumer heterogeneity
- Solution time for a multi-region model is ~30 mins and for a single-region is ~6 mins on a laptop

Future works

- Region-specific policy measures (such as banning single passenger cars in urban areas, phase out ICEs from some regions)
- More targeted monetary incentives (allocating purchase grants to low-income vehicle buyers/regions)
- Incorporation of disposable income instead of median household income
Further details and results in: https://tim-review1.netlify.app/about
In terms of BEV adoption, single-region model differs from multi-region (30 percent less than multi-region case).

Same demand, but an average data is used for national-scale hurdle rates.

Average national (homogeneous consumers) hurdle rate makes BEVs (technologies with higher upfront cost) less competitive than the other options.