Life-cycle greenhouse gas emissions of combustion engine and electric passenger cars and two-wheelers in India

September 21, 2021

Georg Bieker
1. Introduction
2. Methodology
3. Key results
4. Key messages
Introduction
Transport: 80% lower GHG emissions by 2050

- To limit global warming to 1.5 °C, GHG emissions of global transport need to be 80% lower by 2050.

- Which technologies can deliver this deep reduction in the passenger car fleet despite a growing number of vehicles?

Methodology
Scope: Life-cycle GHG emissions

- Life-cycle GHG emissions: CO₂, methane (CH₄), nitrous oxide (N₂O)

  - **Vehicle cycle:**
    - Vehicle and battery production (including raw material)
    - Maintenance
    - End-of-life, recycling

  - **Fuel cycle** (well-to-wheel):
    - Fuel and electricity production
    - Indirect land use change (ILUC)
    - Fuel combustion in vehicle
Methodology: Lifetime average electricity mix

1) Vehicle lifetime average carbon intensity of fuel/electricity mix:

- India average biofuel and biogas blend
- India average electricity mix
- Projected future blend/mix based on current policies
- Compared to Paris Agreement-aligned development

Methodology: Indirect land use change (ILUC)

2) Life-cycle GHG emission of biofuels:
   - **Food-based biofuels:** high ILUC emissions
   - **Residue- and waste-based biofuels:** low ILUC emissions

2) Life-cycle GHG emission of biofuels:
   - Food-based biofuels: high ILUC emissions
   - Residue- and waste-based biofuels: low ILUC emissions

2018 National Policy on Biofuels:
   - Only non-food-based ethanol: Molasses, energy crop, residues
   - Only non-food-based biodiesel: Used cooking oil and waste

Methodology: Battery production

3) Battery production:
   - Most recent data on industrial-scale battery production
   - Market average mix of regional battery production

Battery production GHG emissions

<table>
<thead>
<tr>
<th>kg CO₂ eq./kWh</th>
<th>Europe</th>
<th>United States</th>
<th>China</th>
<th>South Korea</th>
<th>Japan</th>
</tr>
</thead>
<tbody>
<tr>
<td>NMC111-graphite</td>
<td>56</td>
<td>60</td>
<td>77</td>
<td>69</td>
<td>73</td>
</tr>
<tr>
<td>NMC622-graphite</td>
<td>54</td>
<td>57</td>
<td>69</td>
<td>64</td>
<td>68</td>
</tr>
<tr>
<td>NMC811-graphite</td>
<td>53</td>
<td>55</td>
<td>68</td>
<td>63</td>
<td>67</td>
</tr>
<tr>
<td>NCA-graphite</td>
<td>57</td>
<td>59</td>
<td>72</td>
<td>67</td>
<td>70</td>
</tr>
<tr>
<td>LFP-graphite</td>
<td>34-39</td>
<td>37-42</td>
<td>51-56</td>
<td>46-50</td>
<td>50-55</td>
</tr>
</tbody>
</table>

Based on Argonne National Laboratory’s GREET Model (2020 version)

India: 68 kg CO₂ eq./kWh

Methodology: 20-year GWP for methane

4) 20-year global warming potential (GWP) of methane leakage:
   - Methane leakage for natural gas and for grey and blue (CCS) hydrogen

   • 100-year timeframe: 30 times higher global warming potential than CO₂
   • 20-year timeframe: 85 times higher global warming potential than CO₂

CNG cars:
- Natural gas extraction/processing
- Natural gas transport/distribution
- Methane slip from the vehicles

Grey and blue (CCS) hydrogen:
- Natural gas extraction/processing
- Natural gas transport
- Steam reforming
Key results
Global: Battery EVs have lowest emissions

- **Battery EVs** have the lowest emissions for cars registered in 2021 in all four regions

- The GHG emission benefit increases for future BEVs

India: Sedan segment

- **Gasoline cars** include hybrid electric vehicles
- **Diesel and CNG cars:** no GHG emissions benefit
- **Battery EVs:** 19%–34% lower emissions with average grid mix, 79% lower with renewables
- **Fuel cell EVs:** no GHG emission benefit with natural gas hydrogen, 68% lower with renewables

India: SUV segment

- **Gasoline cars** include hybrid electric vehicles
- **Diesel and CNG cars:** no GHG emissions benefit
- **Battery EVs:** 38%–49% lower emissions with average grid mix, 79% lower with renewables
- **Fuel cell EVs:** no GHG emission benefit with natural gas hydrogen, 68% lower with renewables

Hybrid electric vehicles (HEVs)

- **Hybrid electric vehicles:** 23%–27% lower fuel consumption than conventional gasoline cars in lower medium and SUV segment in Europe

  = 20%–23% lower life-cycle GHG emissions

**Life-cycle GHG emissions of average hybrid electric vehicles in Europe**

- **Lower medium segment**
- **SUV segment**

  ![Graph](image)

India: Cars registered in 2030

- **Gasoline cars** include hybrid electric vehicles
- **Diesel and CNG cars:** no GHG emissions benefit
- **Battery EVs:** 30%–56% lower emissions with average grid mix, 79% lower with renewables
- **Fuel cell EVs:** no GHG emission benefit with natural gas hydrogen, 68% lower with renewables

---

India: Cars registered in 2030

- **Gasoline cars** include hybrid electric vehicles

- **Diesel and CNG cars**: no GHG emissions benefit

- **Battery EVs**: 30%–56% lower emissions with average grid mix, 79% lower with renewables

- **Fuel cell EVs**: no GHG emission benefit with natural gas hydrogen, 68% lower with renewables

Electricity, green hydrogen and e-fuels

- Driving on renewable hydrogen is three times more energy intensive than battery EVs.
- Driving on e-fuels is six times more energy-intensive than battery EVs.
- E-fuels are too expensive and too limited to contribute to the decarbonization of road transport.

India: Motorcycles and scooters

• **Battery electric motorcycles:**
  - 33%–45% lower emissions when registered in 2021
  - 45%–66% lower emissions when registered in 2030

• **Battery electric scooters:**
  - 38%–50% lower emissions when registered in 2021
  - 50%–70% lower emissions when registered in 2030

Anup and Deo (2021). Fuel consumption standards for the new two-wheeler fleet in India.
Key messages

• For cars registered today, battery EVs already show the lowest life-cycle GHG emissions of all available options.

• Only battery EVs and hydrogen fuel cell EVs have the potential to be near zero-carbon on a life-cycle basis.

• There is no realistic pathway to decarbonize combustion engine vehicles: the availability of e-fuels and low carbon biofuels is too limited to substantially reduce the emissions of the fuel mix.

• To limit global warming to 1.5 °C, the global passenger car fleet needs to be largely electric by 2050.

• India: With vehicle lifetime of 15 years, this requires that the registration of new combustion engine passenger cars is phased out by 2035–2040.

• For two-wheelers, only electric motorcycles and scooters should be registered after 2035.

• Fuel consumption standards are effective to increase the share of electric two-wheelers.
Thank you!
g.bieker@theicct.org