International Transport Forum

Decarbonising Transport Initiative

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EXPERT WORKSHOP

Mapping standards for low- and zero-emission electric heavy duty vehicles

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The role of LCA in regulation – application to HDVs

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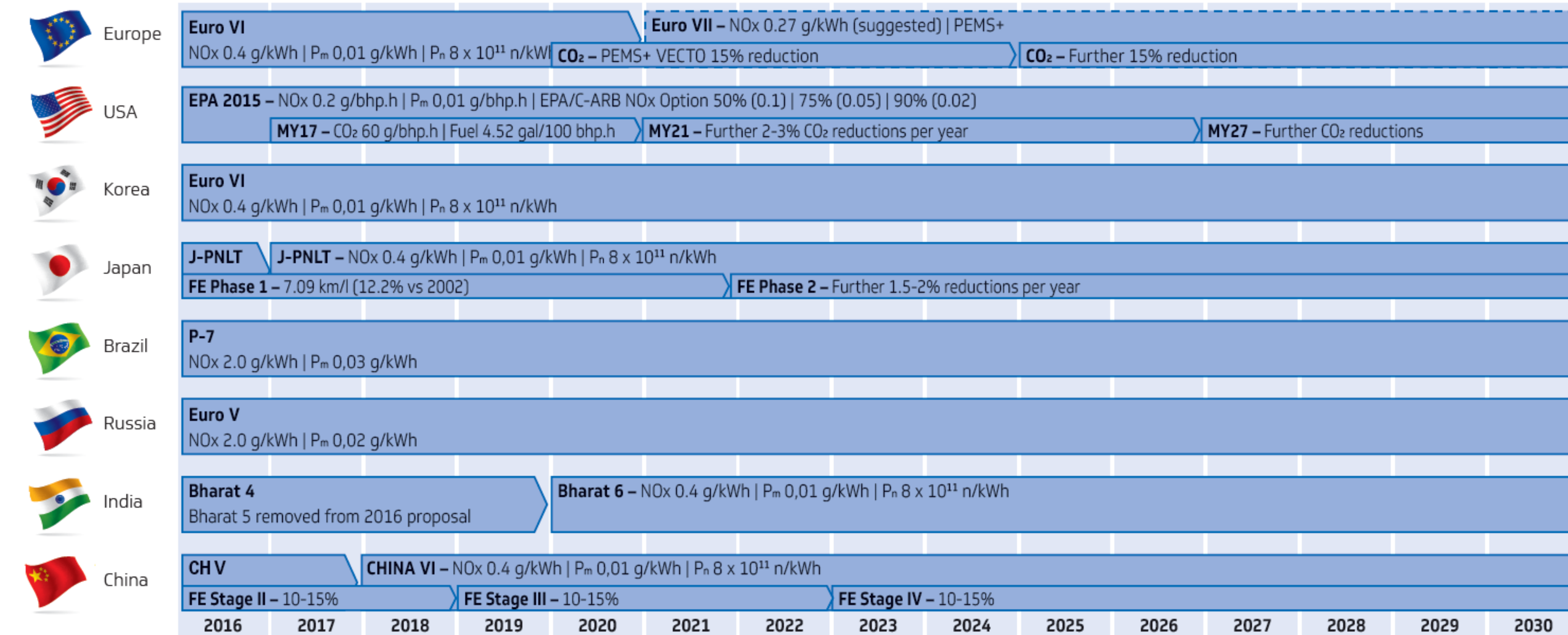
Agenda

1. Brief overview of environmental regulations for HDVs
2. Why add LCA to vehicle regulations?
3. Low carbon fuel as a potential complement to BEV/FCEV for low CO_2 mobility
4. Cradle-to-grave analysis of GWP for HDVs
5. Cradle-to-grave analysis of GWP for e-Diesel vs. GWP of electricity
6. How could LCA be used in regulation?
7. The importance of maintaining technology neutrality – EU RED as an example
8. Potential costs for low carbon fuels
9. Future work

Brief overview of transport regulations - HDVs

ON ROAD – EXHAUST EMISSIONS STANDARDS – ROADMAP



https://d2ou7ivda5raf2.cloudfront.net/sites/default/files/inline-files/booklet%20emission%20heavy%20duty.pdf

- Reflects considerable effort (along with equivalent measures in passenger and LDVs) in a long-term process aimed at curbing tailpipe emissions
- Kept relatively simple in scope and practice
- Shows an increasing focus on fuel economy/greenhouse gas emissions over time but remains focused on tailpipe measurements

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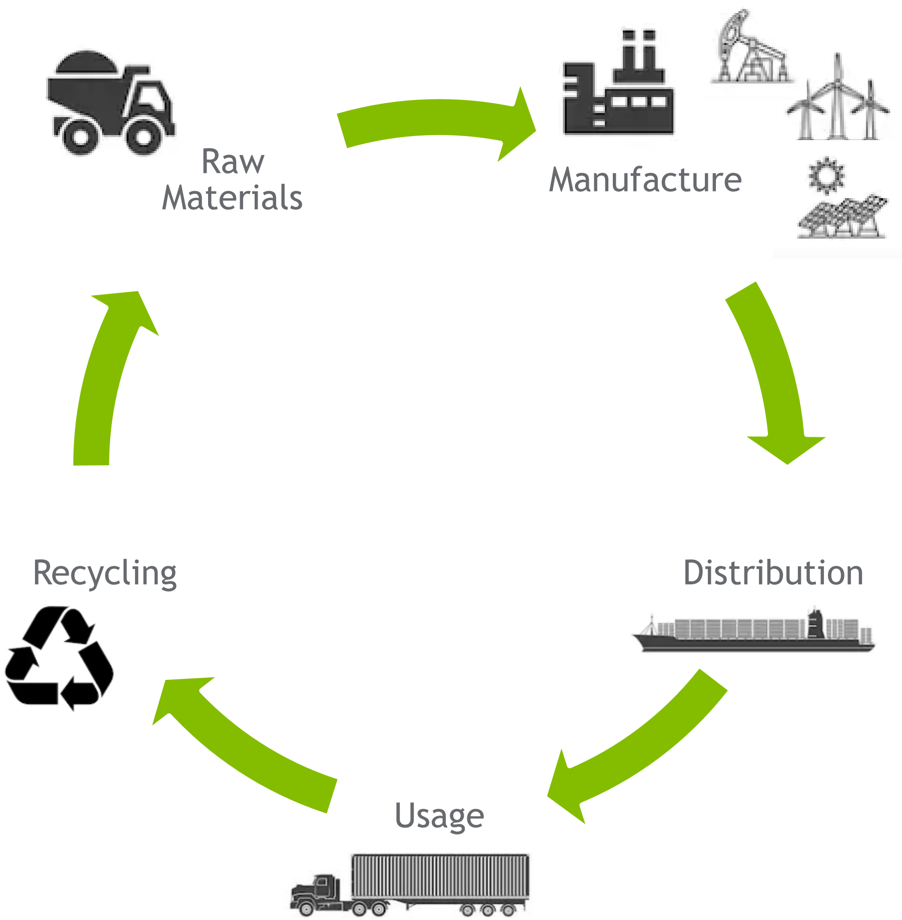
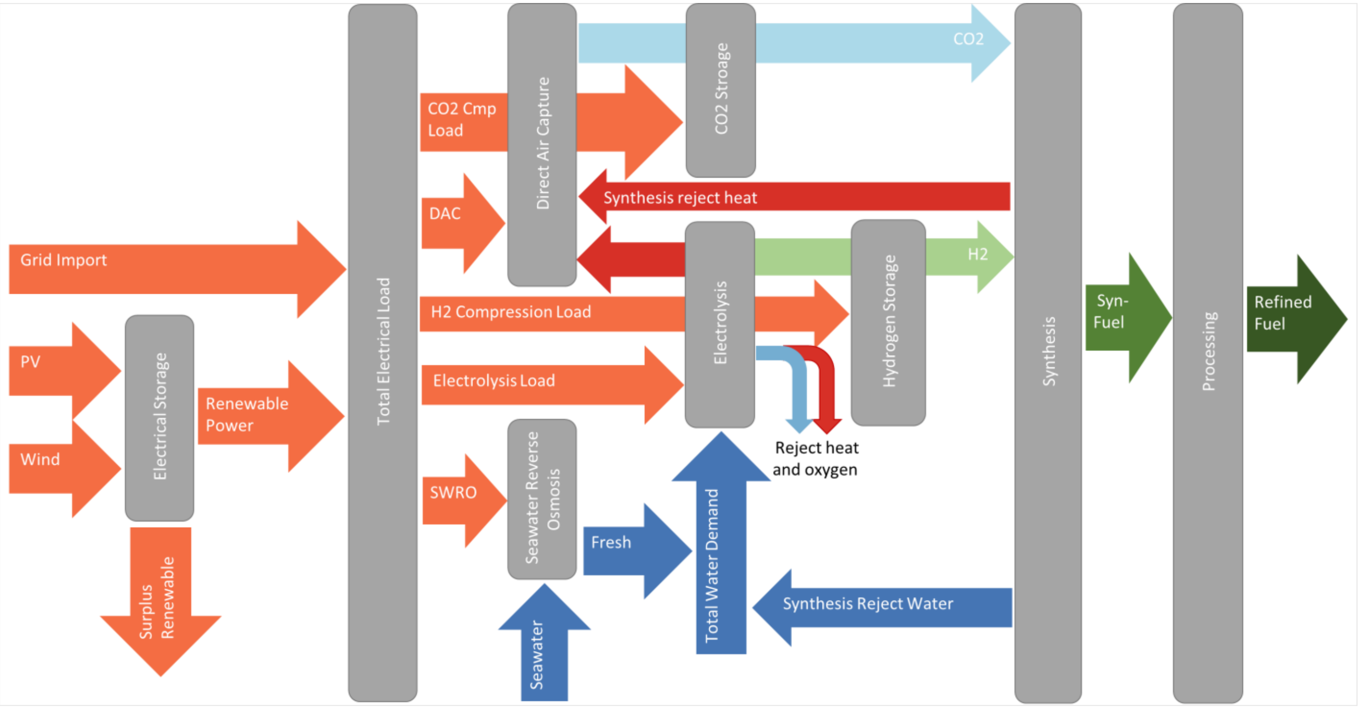
Why add LCA to vehicle regulations?



- Policy and regulation are increasingly driven by global and cross-sectoral goals particularly GHG reduction
- LCA ensures **total** environmental outcomes are accounted
- LCA is technology agnostic and ensures all stakeholders/processes are captured
- LCA limits unintended consequences by:
  - Identifying impact shifts, e.g., land-use impacts, increased ecotoxicity etc.
  - Identifying potential leakage, e.g., moving impacts to countries with less stringent environmental conditions
- LCA can provide a framework for policy/regulatory practices, e.g., eco-labeling
- LCA is widely used by OEMs in existing business practices

Low carbon fuel as a potential complement to BEV/FCEV for low CO_2 mobility

- Uses a combination of existing technologies with room for improvement in terms of efficiency and cost
- Can be supplemented with storage (feedstock or electric) to improve operation
- Can create fuels for **all transport modes**
- Can range from low carbon (e.g., SMR with CCS for hydrogen and industrial CO_2) to fully renewable (e.g., electrolysis and DAC) and as such can be economically tailored to long-term CO_2 reduction goals and technology development



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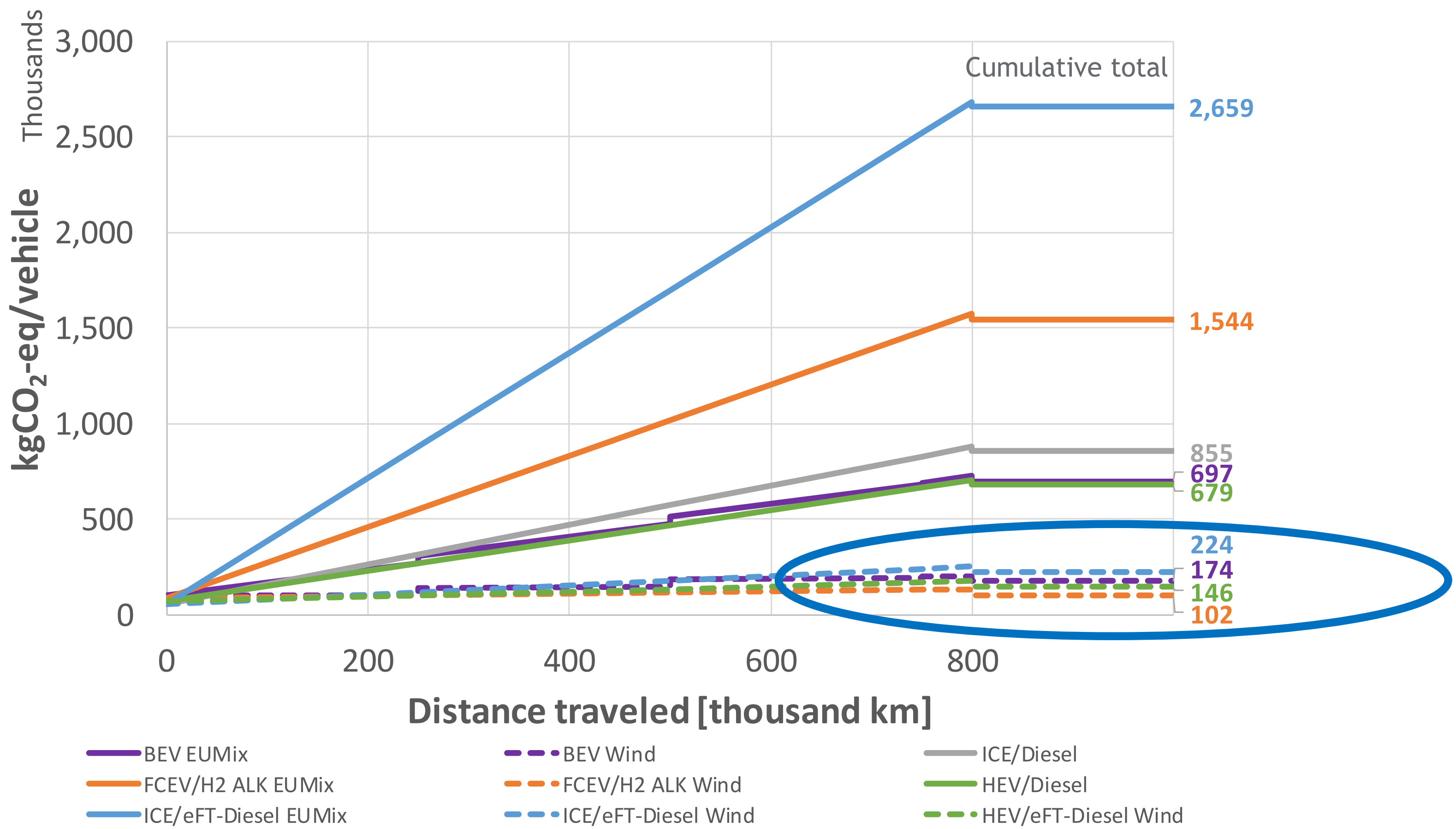
Cradle-to-grave analysis of GWP for HDVs



Conventional/ electro-Fischer-Tropsch (e-FT) diesel ICE: 14.6 t, 33.1 l/100 km
Hybrid EV (HEV): 14.8 t, 30 kWh battery, 28.1 l/100 km
Battery EV (BEV): 16.3 t, 5 batteries × 100 kWh, 160 kWh/100 km
Fuel Cell EV (FCEV): 15.0 t, 30 kWh battery, 300 kW cell, 75 g Pt load, 60 kg H_2 tank, 8 kg/100 km
GWP calculated as **IPCC AR5 GWP100**, incl. biogenic carbon
End-of-life includes depollution, shredding, recycling & disposal of materials, material & energy credits

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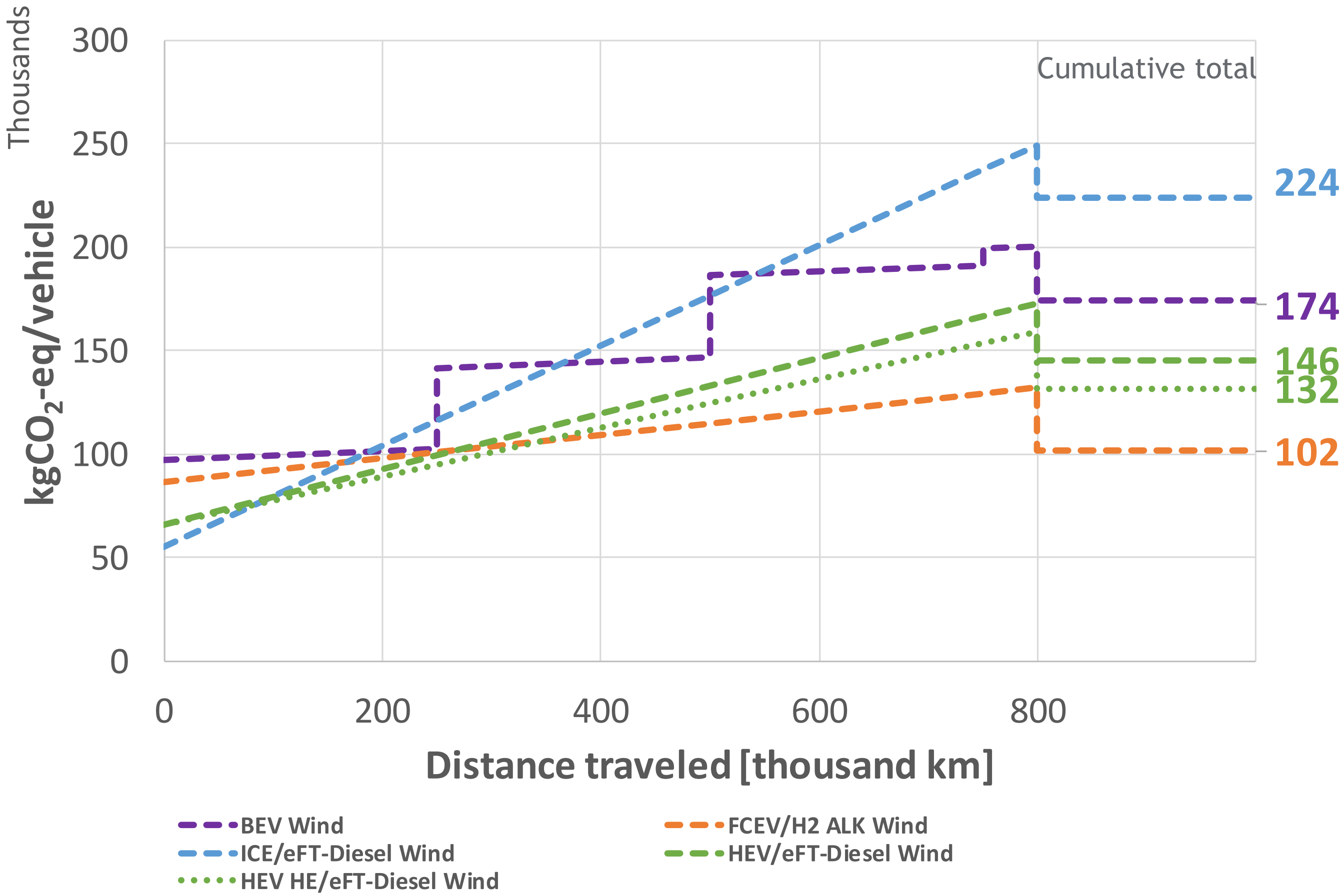
Cradle-to-grave analysis of GWP for HDVs



Conventional/electro-Fischer-Tropsch (e-FT) diesel ICE: 14.6 t, 33.1 l/100 km
Hybrid EV (HEV): 14.8 t, 30 kWh battery, 28.1 l/100 km (24 l/100km **High Efficiency HEV**)
Battery EV (BEV): 16.3 t, 5 batteries × 100 kWh, 160 kWh/100 km
Fuel Cell EV (FECV): 15.0 t, 30 kWh battery, 300 kW cell, 75 g Pt load, 60 kg H_2 tank, 8 kg/100 km
GWP calculated as **IPCC AR5 GWP100**, incl. biogenic carbon
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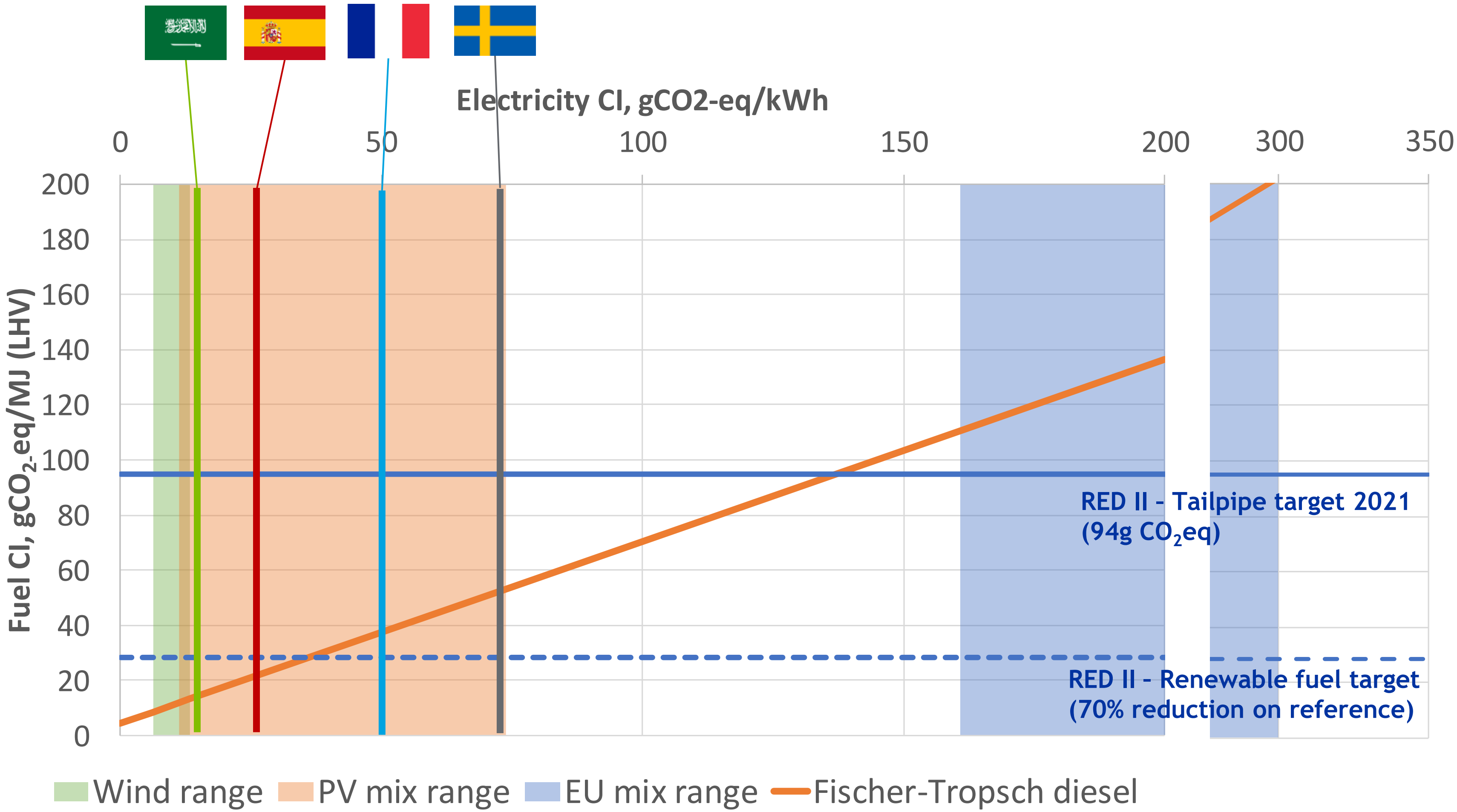
Cradle-to-grave analysis of GWP for e-Diesel vs. GWP of electricity



Hydrogen source: Alkaline electrolysis
Carbon source: Atmosphere
Heat integration: On
Heat source: Electricity
GWP calculated as **IPCC AR5 GWP100**, incl. biogenic carbon

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How could LCA be used in regulation?

- Could be limited to one factor to simplify broader LCA adoption
  - CO_2 (GWP) would be a logical option given its prominence in recent policy/regulation, its global nature and the potential for burden shifts to other regions or life-cycle phases.
  - Is in keeping with existing protocols, for example the Renewable Energy Directive (RED) in Europe and the Renewable Fuel Standard (RFS) could be considered as single-criteria LCAs in their treatment of alternate fuels
- Could augment existing regulation
  - Add production and EOL emission factors to form a new total emission rate that better reflects **total** impacts
- Or, alternatively it could be used for new policy measures (has existing precedence)
  - For example as an emission credit for reductions in production, use-phase or EOL
- But this would require:
  - Developing consensus on methodologies, data, models, etc.
  - Ensuring impacts aren't simply shifted from GWP to another LC factor

The importance of maintaining technology neutrality – EU RED as an example

In crafting the EU RED regulations, there are aspects* that do not adequately ensure the best total outcome due to a lack of equal treatment for all options.

- For example for e-fuels it forces temporal and geographical correlation of supply and demand and excludes renewable contribution when grid constraints exist. These constraints do not exist for EVs which instead are given an incentive multiplier

	Utilizes existing supply infrastructure	Allows use of existing vehicles	Covers all transport modes	Encourages renewable generation	Given preferential policy
Electric Vehicle	◔	○	◑	◕	●
Low Carbon Fuel	●	●	●	◕	◔

This simple example highlights that unintended consequences are easily created, in this case they could:

- Limit renewable production for the same desired outcome (noting LCF requires more RES input but it may be better utilized)
- Require significantly greater infrastructure costs with associated technical risks (i.e. requirement for smart-grid, V2G etc.)
- Exacerbate social inequity by limiting solutions

* Sections 87 and 90 of Directive 2018/2001

● Full effect ○ No effect

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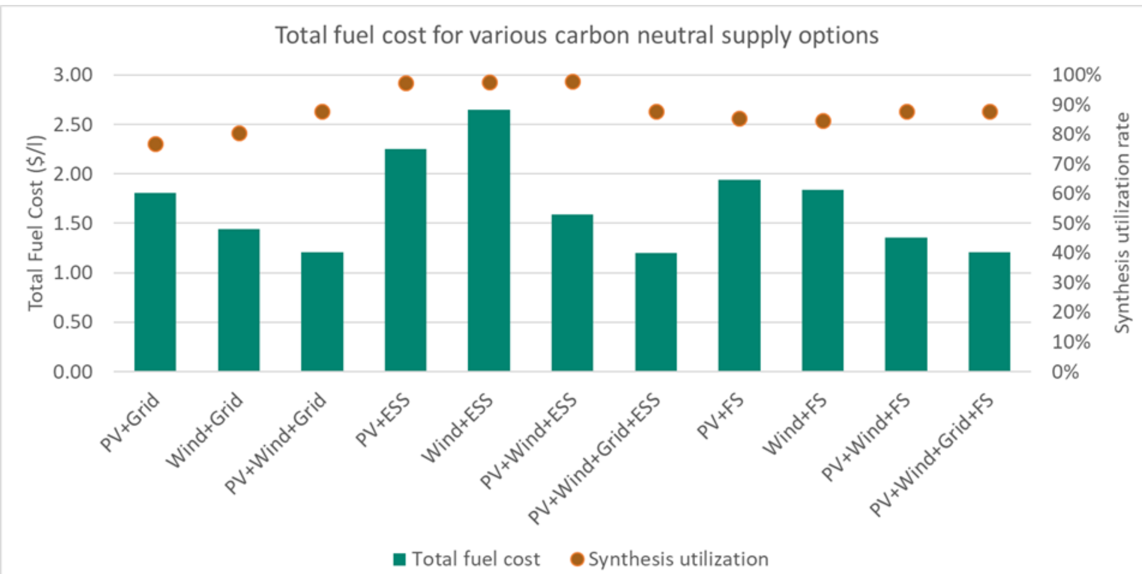
Potential costs for low carbon fuels

- Preliminary work to identify optimal technology mixes shows e-fuels could be created for similar prices to current prices including taxes.
- These fuels can be synthesized for use in all forms of transport, e.g., e-gasoline, e-petrol and e-jet.
- This reduces risk, enhances supply optionality and utilizes existing infrastructure.



- E-fuels created in KSA in 2030
- Grid import (where assumed) limited to maintain carbon neutrality based on published Saudi 2030 mix
- Spill rates at half LCOE
- Based on detailed hourly dispatch modeling to maintain minimum synthesis utilization rates
- Includes optionality to store electricity and/or feedstock to maintain high plant utilization rates

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Future work

LCA shows that similar GWPs can be achieved for BEV and e-fuels

Issues that require further work to enhance policy/regulation include:

- Quantifying implications for mass EV adoption
  - Increased T&D costs including smart-grid architecture
  - Impacts on dispatch of electrical generation
  - Policy/regulatory changes to allow V2G
  - Risk mitigation for carbon reductions
- Quantifying the cost reductions and performance improvements for e-fuels
  - Direct air-capture and/or fugitive emissions
  - Hydrogen production (SMR-CCS, electrolysis, etc.)
  - Synthesis improvements

* Sections 87 and 90 of Directive 2018/2001

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