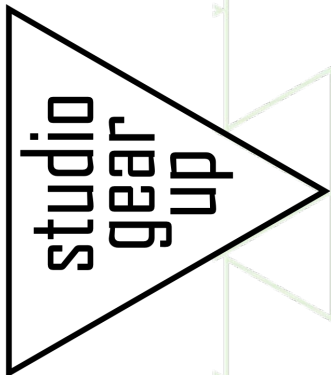


Biodiesel and renewable fuels to achieve climate neutral heavy-duty road transport

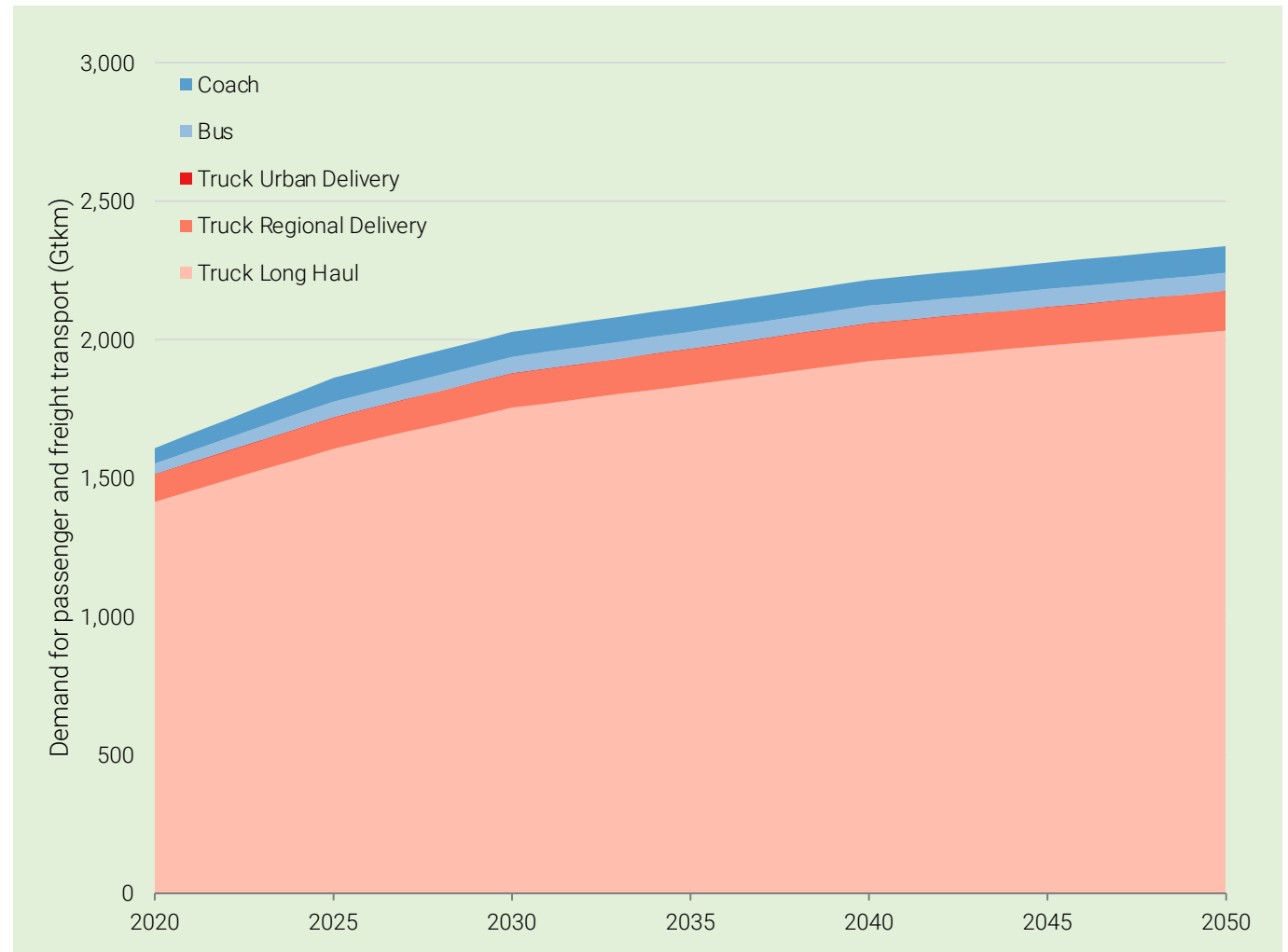


Low Carbon Biofuels Forum
7 July 2023
Carlo Hamelinck

Considering the developments in electrification of the heavy duty road transport segment, what is the role for biodiesel by 2030 and beyond?

EU heavy duty road transport is a hard to abate sector

- Fuel consumption in heavy duty road transport currently represents 20% of the fuel demand in all EU transport
- Demand for heavy duty road transport increases
- Transitioning to battery electric and fuel cell electric vehicles takes time
 - Replacement of fleet
 - Fueling and charging infrastructure
- EU heavy transport today for 99% depends on diesel, of which only 5% is renewable



Demand for transport from EU 2020 Reference Scenarios. To enable mutual comparison, passenger transport is translated to freight transport, proportional to the fuel consumption in 2020.

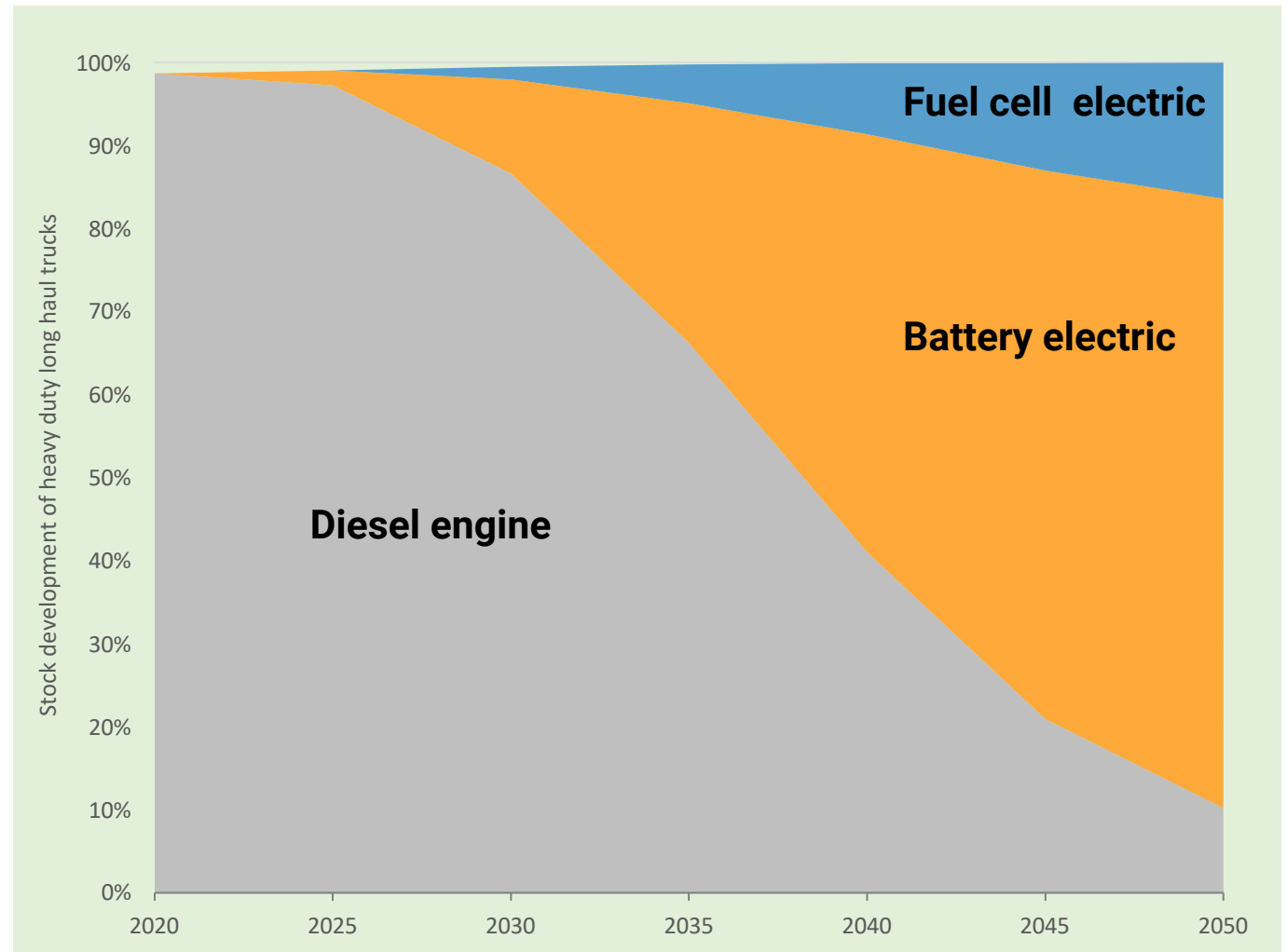
Introduction of battery electric and fuel cell electric trucks takes time

Development of sales share determined by OEMs and policy

- Major OEMs expect that electric trucks will concern 50% of their global truck sales in 2030
- CO₂ emission performance standard will gradually decrease the sales of internal combustion engine vehicles, until a strong limitation or hard stop by 2040
- Introduction of fuel cell electric vehicles less driven by CO₂ emission performance, but rather by opportunity - once infrastructure develops

Development of fleet share

- Fleet development follows sales with 5-10 years
- Average age of fleet is 14 years
 - Typically older vehicles in eastern and southern EU
 - Some vehicles stay in the market for >20 years

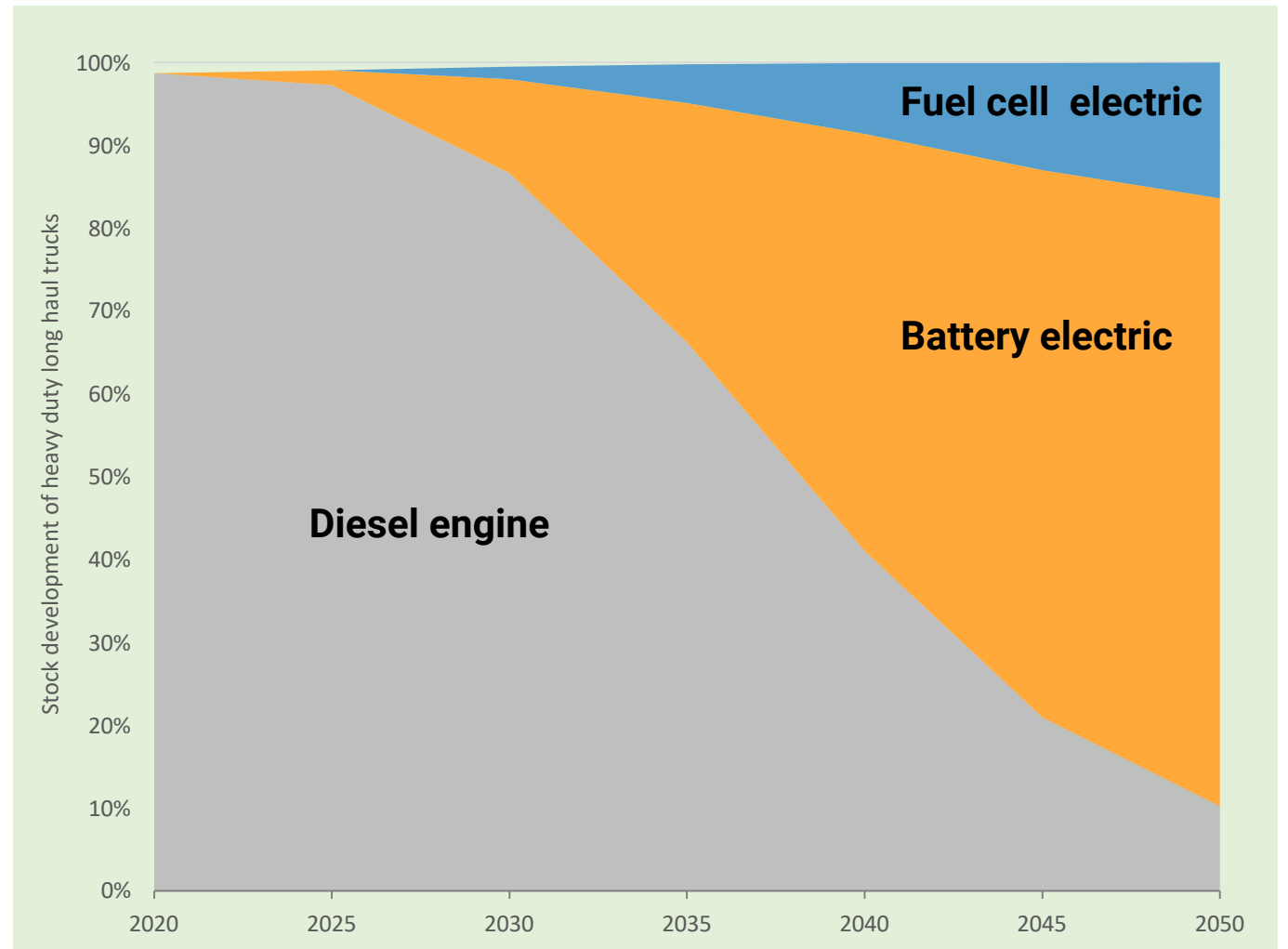


Main assumptions by studio Gear Up: In 2030, 50% of the sales of all trucks is battery electric, first in urban and regional distribution, then in long haul. From 2040 no more sales of internal combustion engine vehicles in the heavy duty road segment

Introduction of battery electric and fuel cell electric trucks takes time

Electrification of subsectors

- Early electrification in urban and regional delivery
 - Shorter daily distances
 - Lower payloads
 - Daily returns to hubs
 - Driven by zero emission zones
- Electrification of long haul trucks slower
 - Charging requires flexibility and planning
 - Infrastructure across EU not ready
 - Much more vehicles
- Similarly, rapid electrification of public buses
- Slower electrification of coaches



Main assumptions by studio Gear Up: In 2030, 50% of the sales of all trucks is battery electric, first in urban and regional distribution, then in long haul. From 2040 no more sales of internal combustion engine vehicles in the heavy duty road segment

Scenarios by European Commission count on electric vehicles cost decrease but developments are uncertain

+ Reasons for cost reduction

- Battery capacity per kg battery material increases
- Battery costs per kg battery may decrease
 - Scale advantages along supply chain
 - Learning and innovation
 - Competition as more suppliers enter the market
- Circular economy principles may spur the development and market appetite of smaller and lighter cars

- Reasons for cost increase

- Battery costs per kg battery may increase
 - Uncertain if the supply can keep up with the strong increase in demand for battery raw materials
 - Production increasingly in EU at higher labour costs
 - Increasing sustainability requirements set to raw materials
- Electric engine costs increase
 - Efficient electric motors have strong permanent magnets made from rare earth metals
 - Heavy duty vehicles require stronger magnets
 - Rare earth metals are abundant, but supply (China mainly) cannot keep pace with surge in demand
 - Increasing sustainability requirements set to raw materials

Electricity required in 2030 for battery electric vehicles and RFNBOs

Demand for battery electric vehicles

- Demand for electricity in all transport increases from 40 TWh in 2020 to 222 TWh in 2030
- Today rail dominates demand
- In 2030 cars and vans dominate demand

Demand for hydrogen

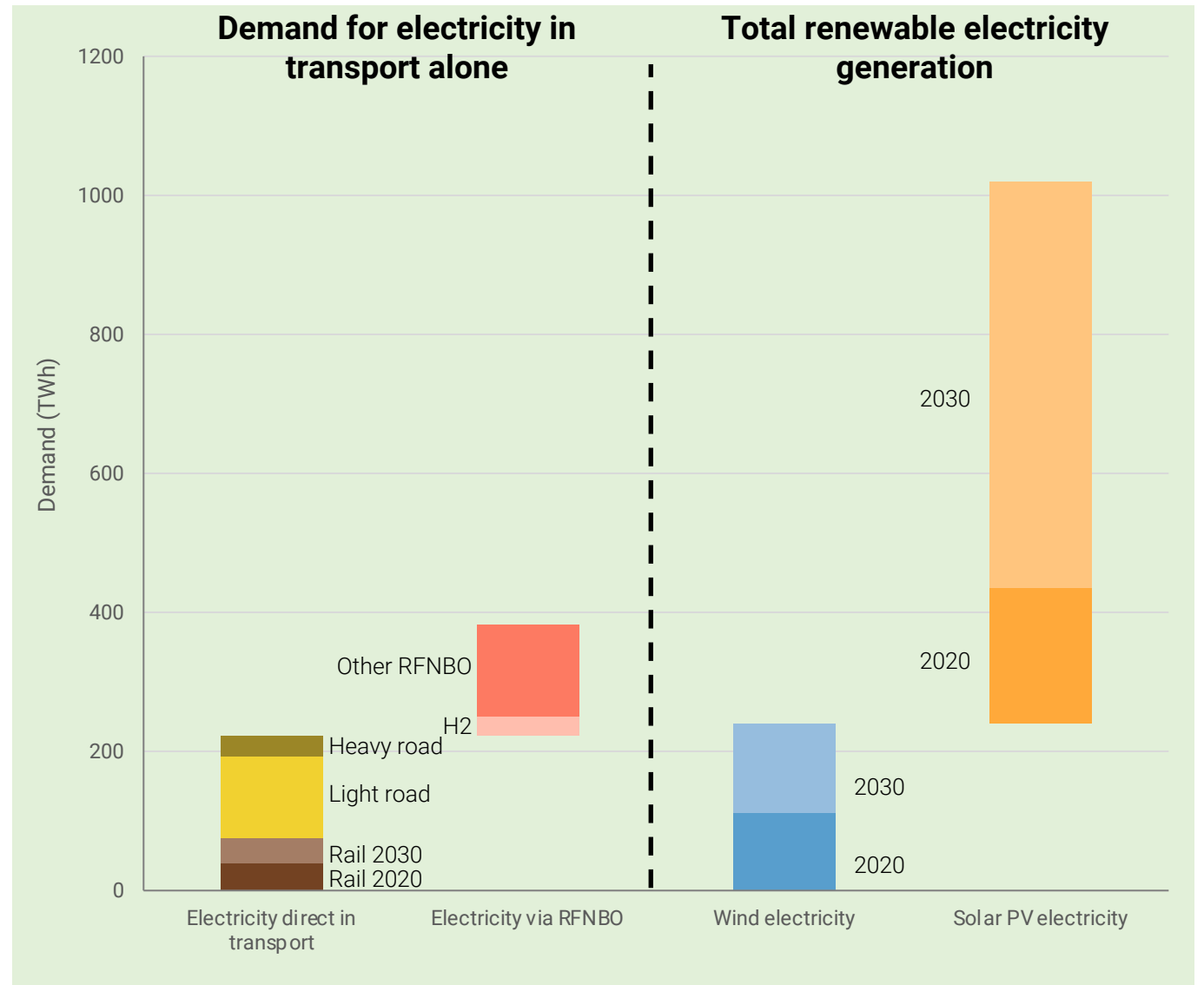
- AFIR requires hydrogen supply network
- Results in 800 stations of > 2 ton/day supply

Demand for all RFNBOs

- Model assumed 2.6% RFNBO
→ based on RED III final text this will be less
- RFNBOs are ultimately produced from hydrogen

Additional renewable electricity generation

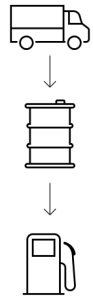
- According to REPowerEU



Organisation of the hydrogen supply depends on circumstances

①

Gaseous delivery,
gaseous
consumption



Pros

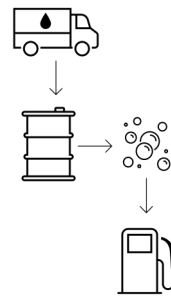
- Simplicity for delivery and service station
- Cheap for small volumes

Cons

- Small amount of hydrogen per delivery
- Expensive for large volumes

②

Liquid delivery,
gaseous
consumption



Pros

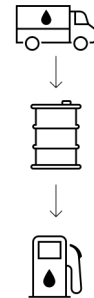
- Cheaper delivery for large volumes

Cons

- Liquid storage handling is difficult
- More equipment needed at the service station

③

Liquid delivery,
liquid consumption



Pros

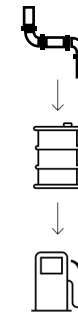
- Cheaper delivery for larger volumes
- Simplicity for service station

Cons

- Difficult handling of liquid hydrogen
- Likely a small market in the near future

④

Pipeline delivery



Pros

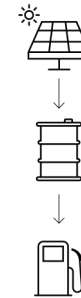
- If pipeline is available, this is the cheapest and simplest form of delivery

Cons

- Hydrogen pipelines are scarce and expensive to build up
- Natural gas pipelines can only transport limited amounts of hydrogen

⑤

On-site generation



Pros

- No delivery required
- More control over supply chain
- Green image

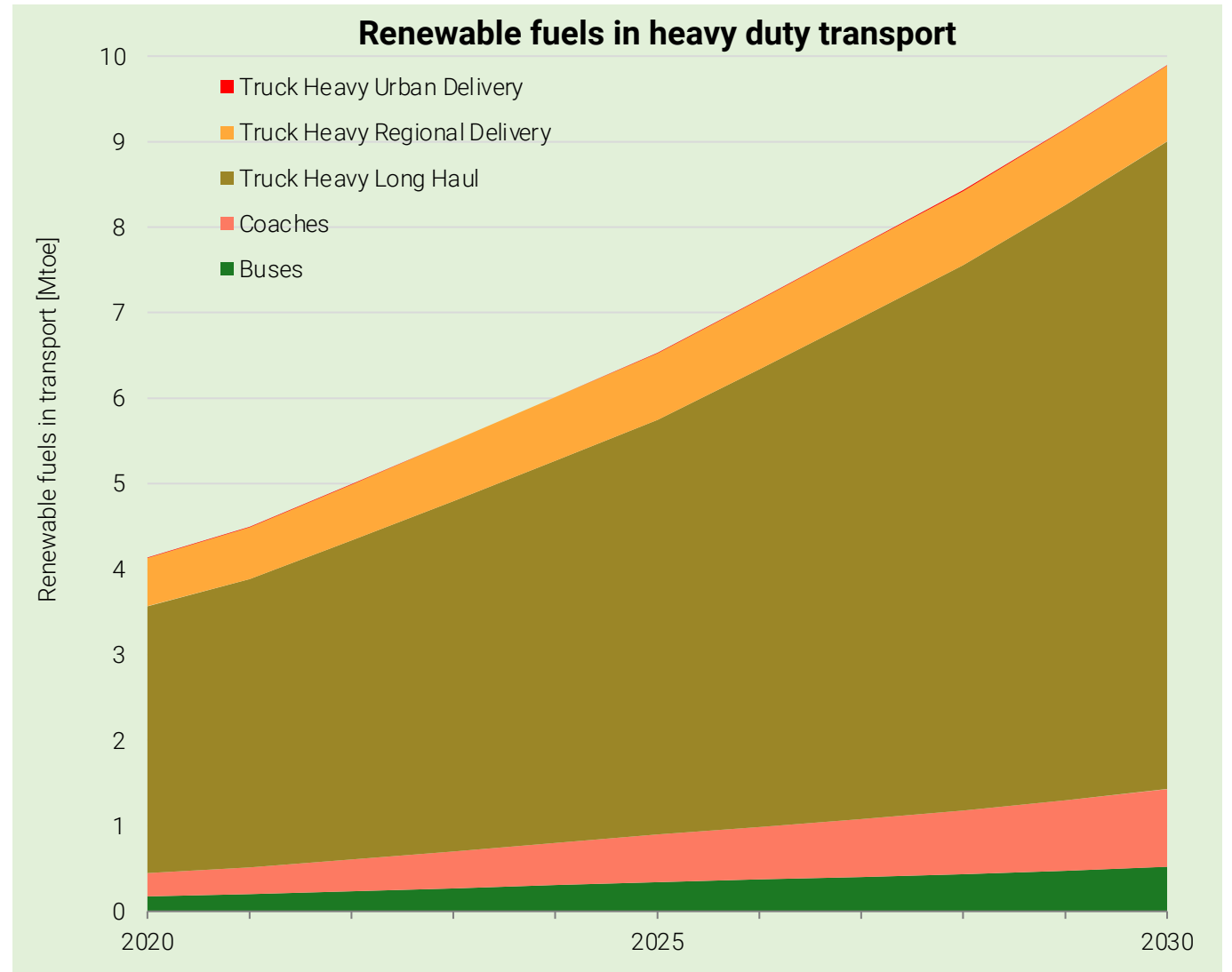
Cons

- Highest equipment requirements and technical risks
- May be outcompeted by increasingly competitive hydrogen market

Resulting demand for fuels

Renewable fuel in heavy-duty road more than doubles

- By far most demand is in long-haul trucks



Demand resulting from Fit-for-55 policy package proposed by European Commission in 2021, assuming that obligations in aviation and maritime are first fulfilled, after which the remainder of RED III is achieved in road transport.

Resulting demand for fuels

Renewable fuel in heavy-duty road more than doubles

- By far most demand is in long-haul trucks

Demand food/feed crops diesel increases

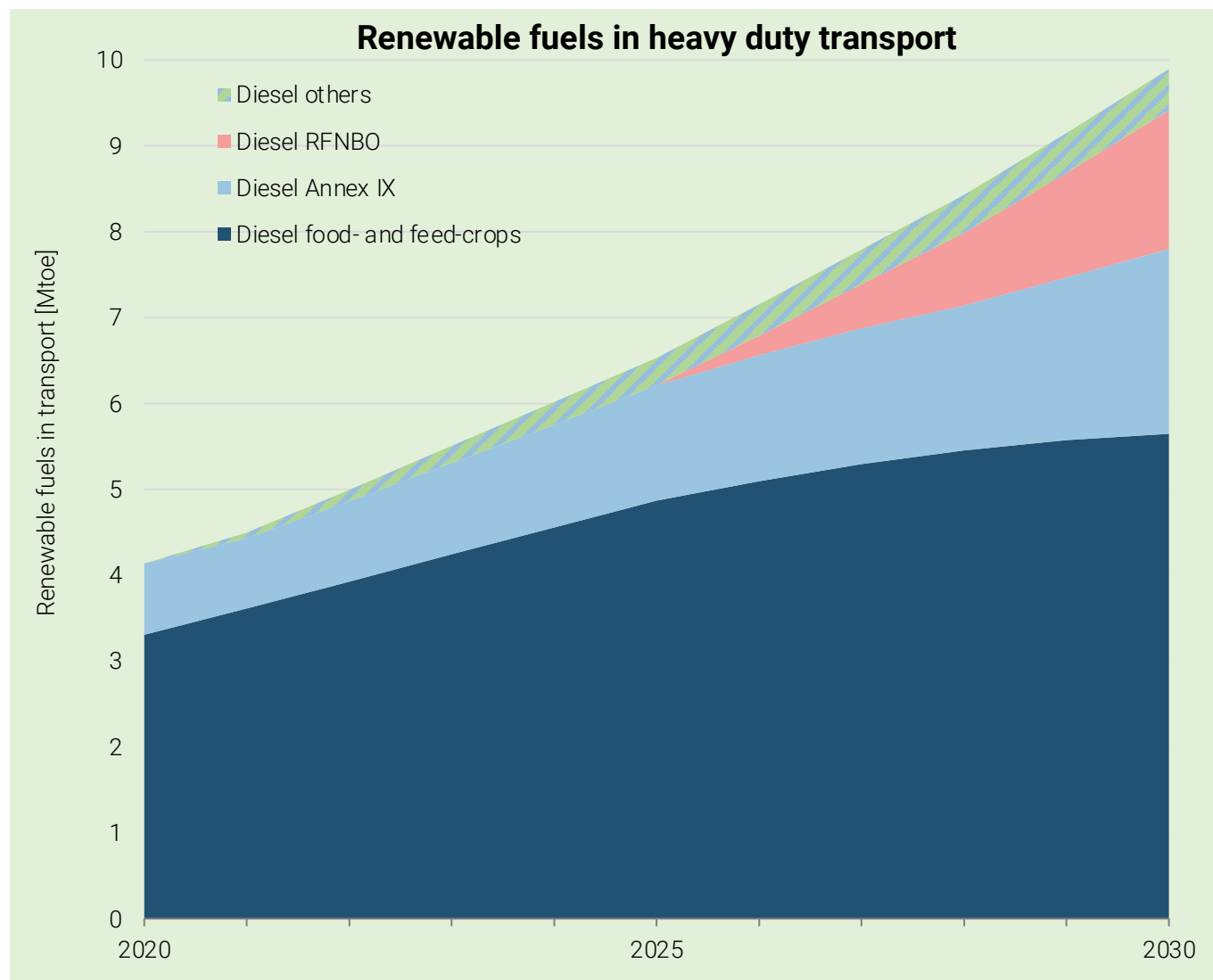
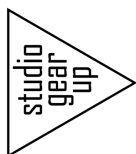
- Large increase in demand for transport
- Demand 2020 was below trend
- 2030 target is +1% share above 2020
- Long haul is by far largest of all heavy duty

Renewable diesel from Annex IX feedstocks

- Annex IX B until the 1.7% limit
- Annex IX A has options for renewable diesel
 - FT-diesel co-produced with FT-jet
 - Pyrolysis oil, POME, tall oil

Sudden rise of RFNBOs from 2025 onwards?

- Hydrogen as a pure fuel in fuel cell vehicles
- Hydrogen via fossil oil refineries
- e-methanol, e-dme



Demand resulting from Fit-for-55 policy package proposed by European Commission in 2021, assuming that obligations in aviation and maritime are first fulfilled, after which the remainder of RED III is achieved in road transport.

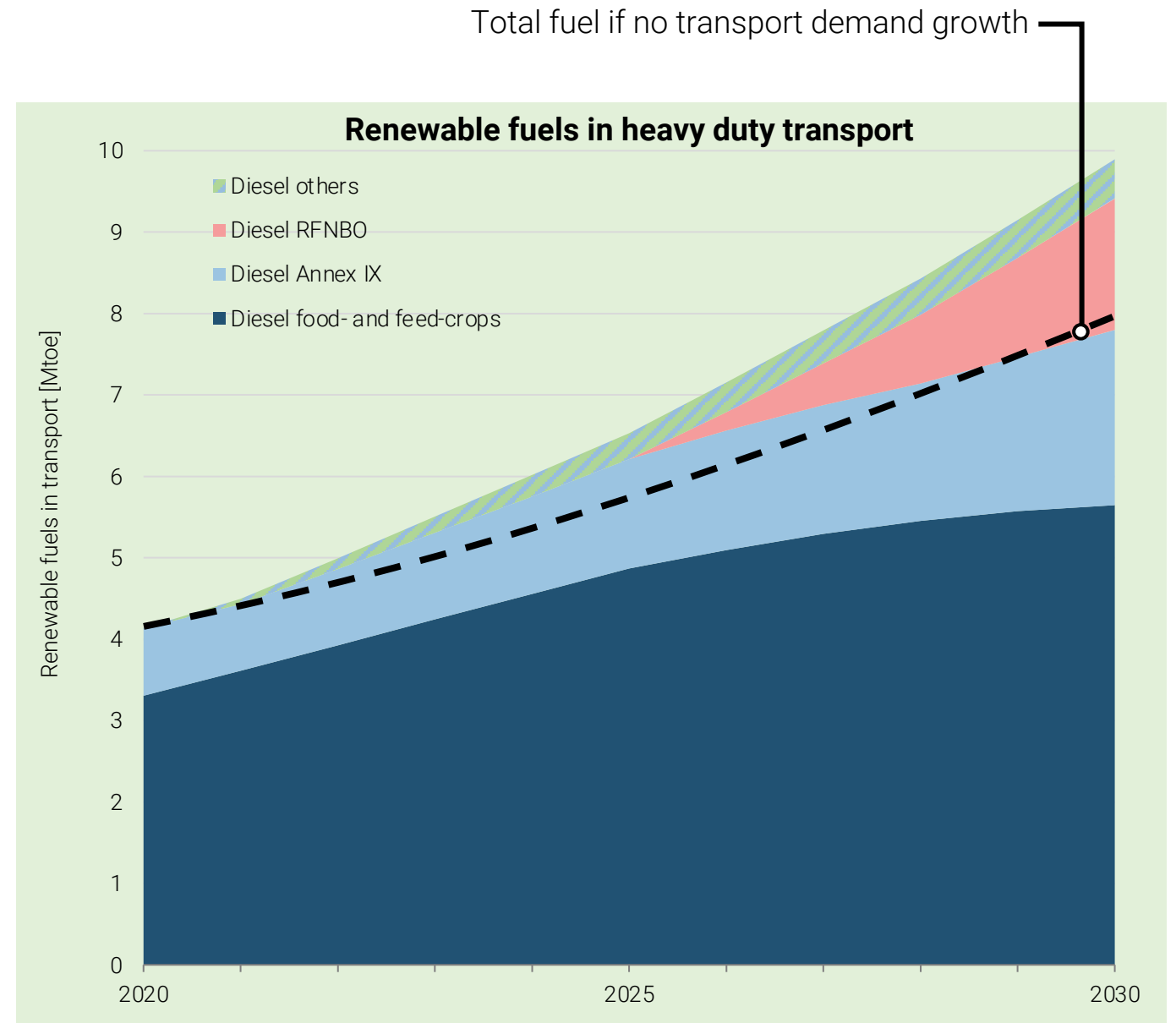
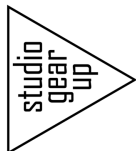
Resulting demand for fuels

Uncertainties

- Demand growth follows EC Reference scenarios, but energy crisis/recession could decrease demand

Model based on provisional agreement RED III

- Final text approved by Council 16 June
- Notable changes compared to 2021 proposal
- Overall target proposed was -13%
→ becomes -14.5%
→ top of the curve will likely increase
- Proposed target for RFNBOs was 2.6%
→ becomes at least 1%
but after double counting \cong 0.5% effectively
- Proposed target for Annex IX A was 2.2%
→ becomes up to 4.5%
but after double counting \cong 2.25% effectively



Demand resulting from Fit-for-55 policy package proposed by European Commission in 2021, assuming that obligations in aviation and maritime are first fulfilled, after which the remainder of RED III is achieved in road transport.

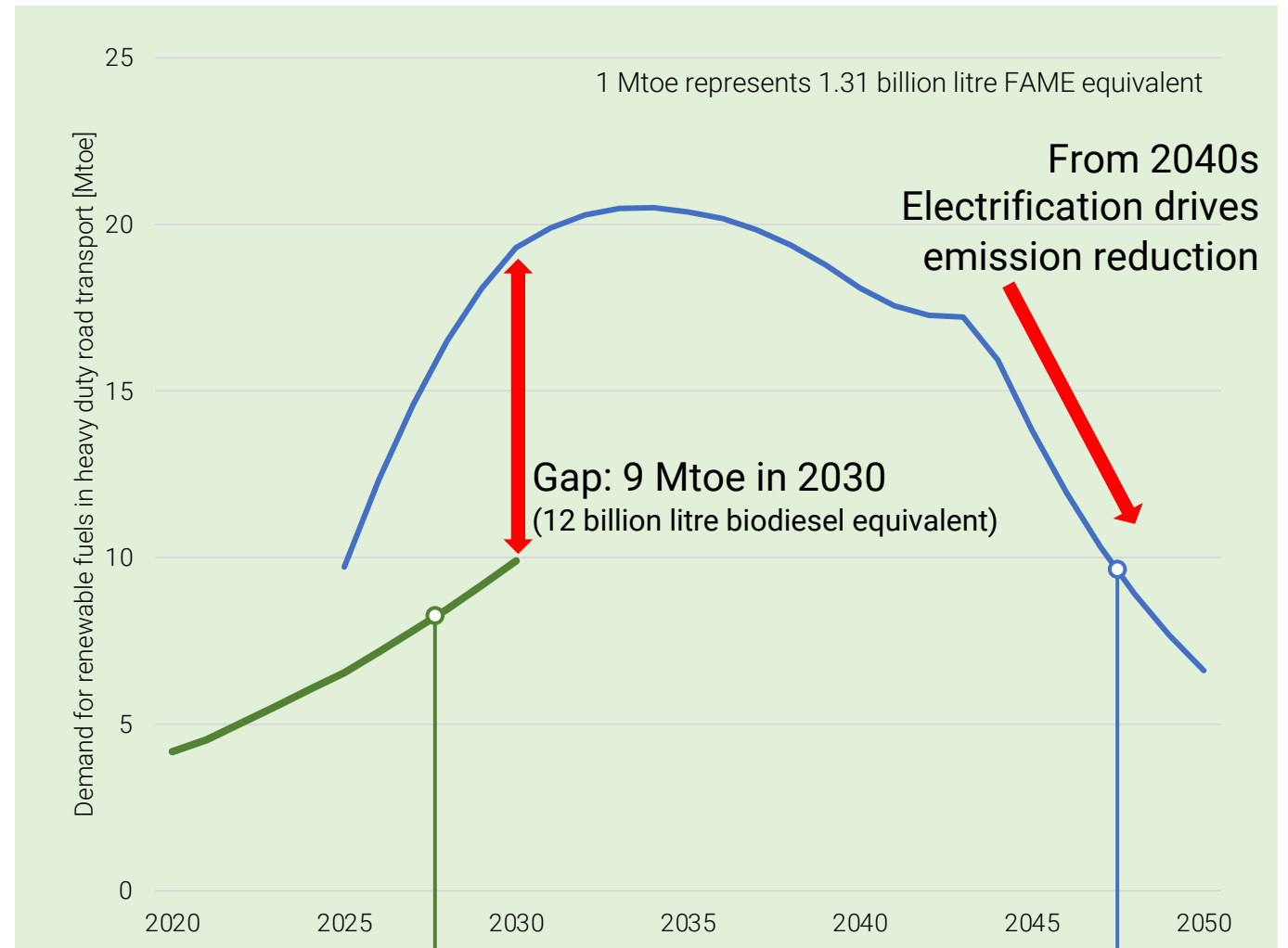
Climate action requires an increased contribution of renewable fuels until a sharp drop from 2043 onwards

Demand for renewable fuels in heavy duty road transport, on path to zero emissions in 2043

- New Emission Trading System ETS II requires linear reduction in emissions from road transport + buildings + small industry
- Sectors must reach zero emissions around 2043
- EVs limit role of ICEVs after 2043
- Still, in 2030 more renewable fuels will be needed than what is mandated by Fit-for-55
- Plateau between 2030 and 2043 because electrification balances the demand increase

Main assumptions and uncertainties

- Demand increase as in EU2020 reference scenario, but energy crisis may slow demand growth, and may slow down fleet replacement
- Proportional role heavy duty road in achieving ETS II, but could be smaller when more is achieved in buildings and small industry



Amount of renewable fuels in heavy duty road transport required:

as a consequence of RED III, FuelEU Maritime, ReFuelEU Aviation combined

by ETS

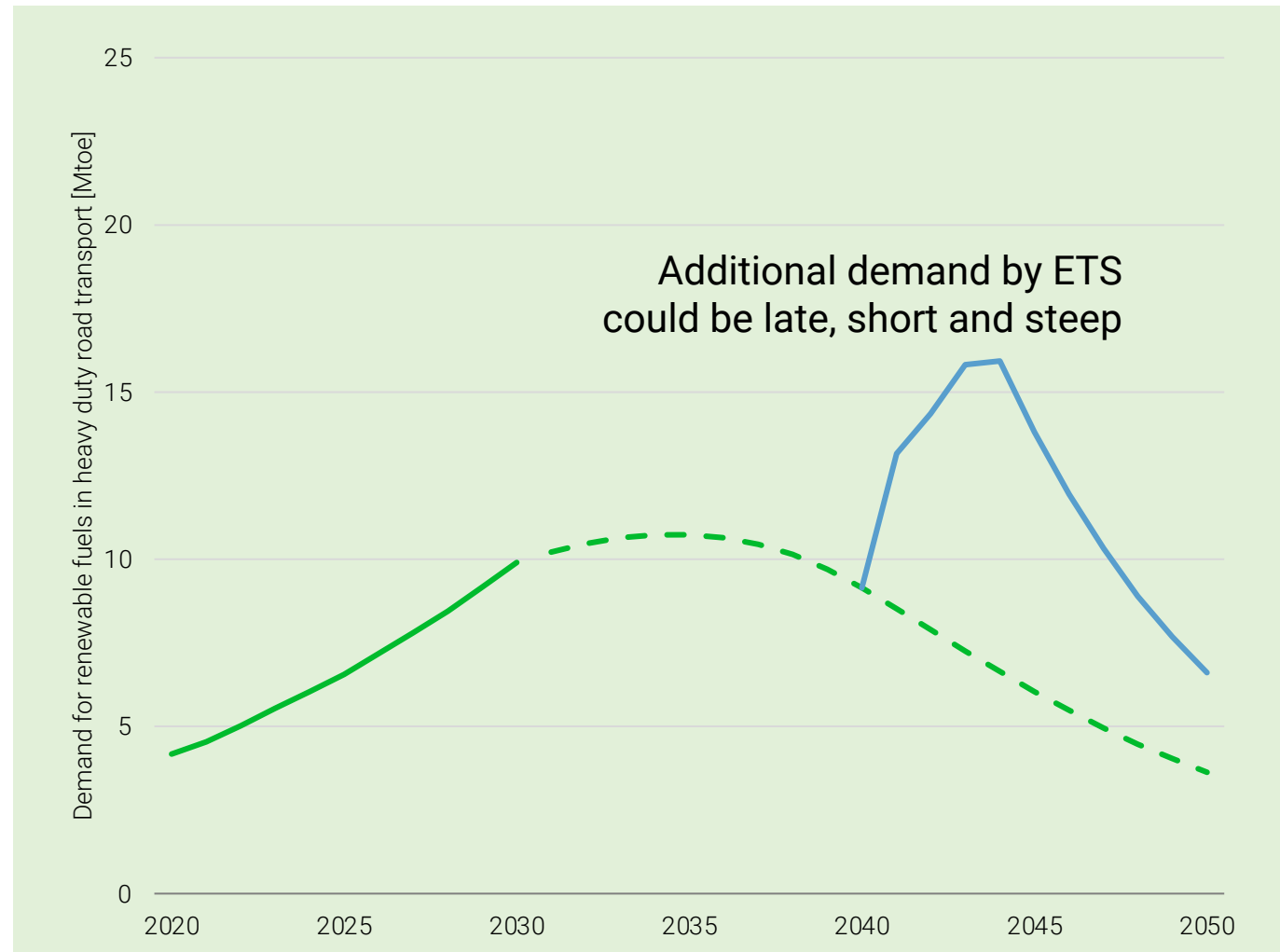
Market stability measures and climate action in buildings could postpone pressure on road transport

The additional demand to achieve the ETS II targets could come late

- Frontloading with 130% of required allowances at start ETS II in 2027
- 600 million additional allowances in the Market stability reserve (MSR) can be released if prices increase to sharp or above 45€/tonne
- Emission reduction could be achieved earlier (at less costs) in buildings

End of curve remains the same

- When the MSR is depleted and buildings have zero emissions, the remaining emissions from transport still have to be addressed
- From 2043 onwards zero emissions in both sectors requires renewable fuels for the remaining ICEVs
- Demand for renewable fuels could be short and steep



Summary

Battery (and fuel cell) electrification challenging but happening

- Development of infrastructure and introduction of vehicles takes time
- Fleets lag behind sales

Until 2030, the demand for renewable diesel from Fit-for-55 grows significantly

- Demand for food and feed crop based biodiesel stabilises
- Demand for Annex IX based biodiesel strongly increases, especially IX A
- Demand for RFNBOs in the diesel segment increases

ETS can further increase the demand for renewable diesel replacements until 2043

- Driven by a required linear reduction of CO₂ emissions
- If battery and fuel cell electric would develop faster, the peak would be earlier and lower
- If emission reduction occurs first in buildings, and if carbon abatement cost in road is too high, demand could be late, short and steep

Demand for renewable diesel drops sharply after 2043

- Liquid fuels will first exit short haul (urban and regional) sectors, later long haul
- The current volume may then be concentrated in a smaller region, where transition to electric is slower
 - This requires the application of higher blends of renewable diesel above B7
- While another part of renewable diesel will find use in marine and aviation

Perspectives for renewable diesel: blurry or booming?

A large volume of renewable fuels will be needed in heavy-duty road transport

- RED III will more than triple the volume of renewable energy in all transport in 2030 compared to 2020
- Renewable fuel in transport will more than double – also in heavy-duty road transport

But options are restricted

- Options for expanding crop-based are limited (marginal land only)
- Options for expanding Annex IX B are also limited (floating cap & scramble for residues)
- Therefore, the expansion should be sought mainly in Annex IX A and RFNBOs

Around 2040, a much higher volume of renewable fuels is likely needed in heavy duty road transport

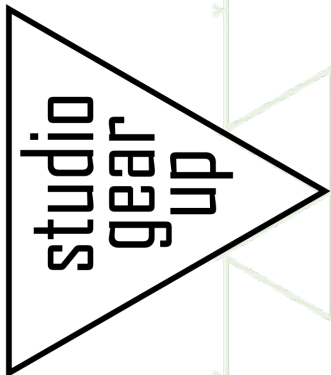
- By then the emission ceiling of ETS II becomes close to zero
- But EU fleets may not be fully electrified and still require fuels, which must be close to 100% renewable

A late, short and steep additional demand should be avoided

- Increase renewable fuels supply early and deliver cost attractive
- Requires exit strategy – for instance flexibility to supply wider biobased economy

The industry can shape the development

- This requires that you tackle challenges with regard to feedstocks, technology, investment
- How are you going to do this?



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