ViGo Bioenergy

Birmingham

September 23, 2025

How to think about alternative power trains?

Possible decarbonisation solutions here and now - The misleading question?

CBG	LBG	HVO	FAME biodiesel	BEV
100%[1] (50-180%)	100%[1] (50-180%)	83%[1] (50-90%)	65%[3] (50-95%)	55%[2] (53-99%)

Typical Well-to-wheel CO_2e reduction

1. From Waste-based feedstock
2. From Current EU electricity mix
3. With most common usage

RENEWABLE FUELS AND ELECTRIFICATION

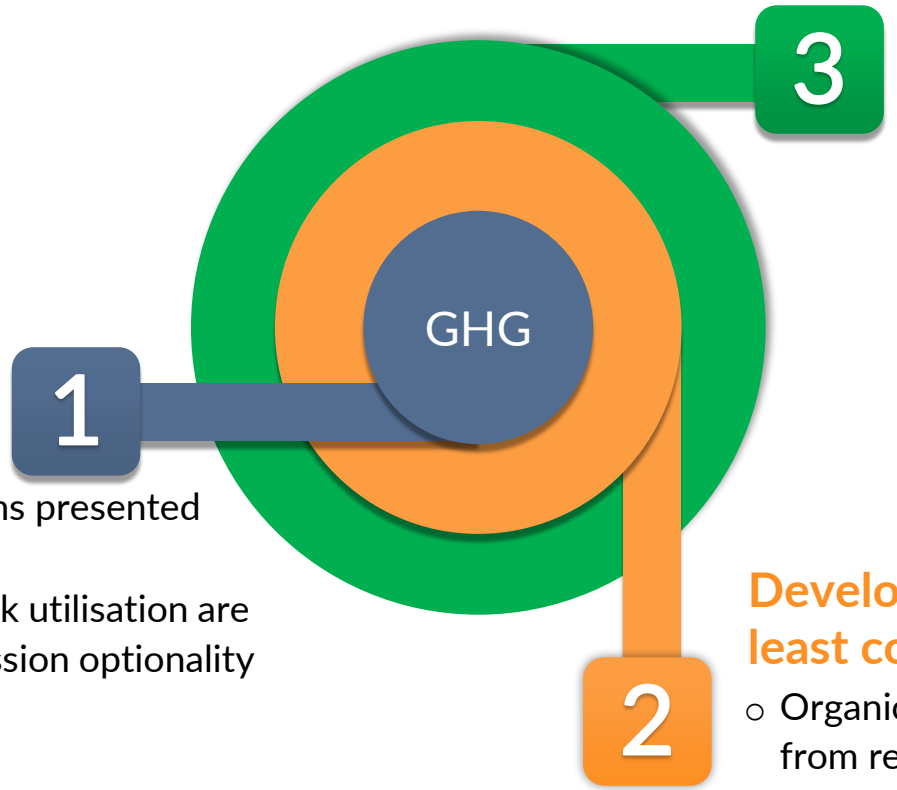
Least cost decarbonisation of heavy duty transport is a three layered question

Perspectives from Vitol

Energy providers need to provide fact-based advice

- Multiple decarbonisation options presented as comparable in feasibility
- But TCO, convenience and truck utilisation are sole arbiters while retaining mission optionality

Gas is the best option



Regulations shall be stable and technology neutral

- Stability, predictability and uniformity compatible with investment at scale
- Clarify objective functions (GHG?) and move from prescriptive to performance based regulations

Tech neutrality, EU+UK-wide approach

Development of energy distribution follow path of least cost / highest convenience

- Organic profitable ("bankable") deployment requires going from return to base to long distance transport
- Ultimate fleet technology mix is decarbonisation path dependent

Organic build-up

Truck customer decarbonisation journey is rather complex

Decarb. options

H_2

BEV

LNG

CNG

HVO

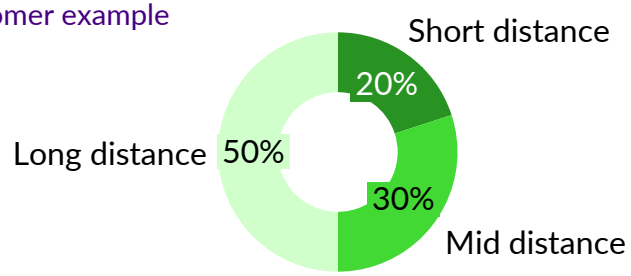
Fleet mix decision tree

Optimal fleet for next 5 years

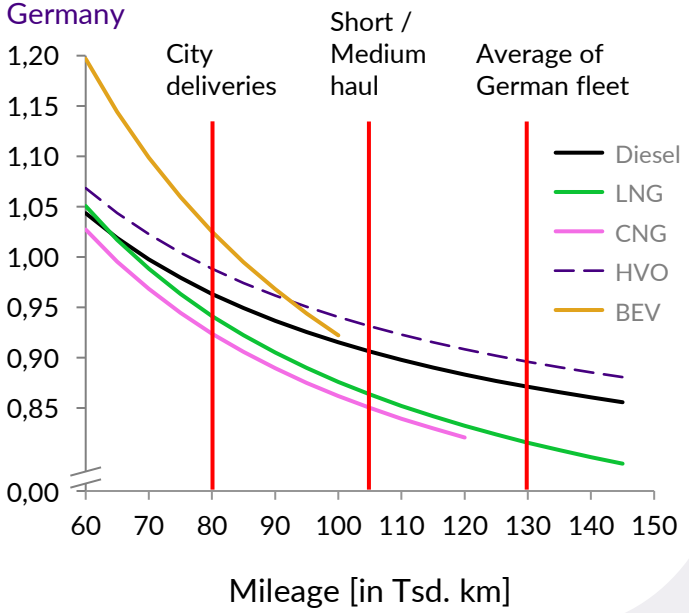
- Route profile
  - Mix of routes
  - Mix stability
- Fleet performance profile
  - Fleet size
  - Truck Performance Range/cost/GHG)
- TCO profile
  - Regulations
  - Commodity price

Example of supporting analysis
Germany example

Customer example



EUR/km
Germany

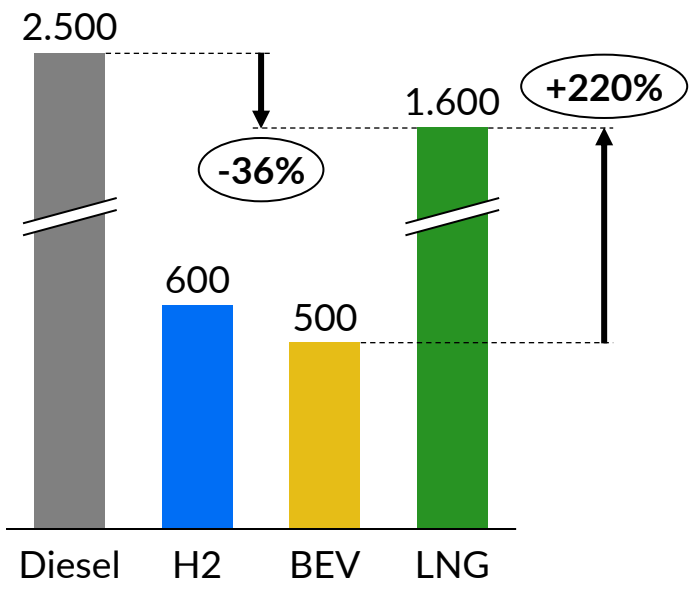


- Only very large fleets can afford to experiment with multiple technologies as they have sufficient stability of route mix
- Technological constraints further limit available options for decarbonisation (BEV not for long distance & weight limits)
- Energy suppliers have a duty to have fact-based, “Assertive impartiality”

Gas offers quick refuelling times and dense network of stations that make it the no-hassle fuel

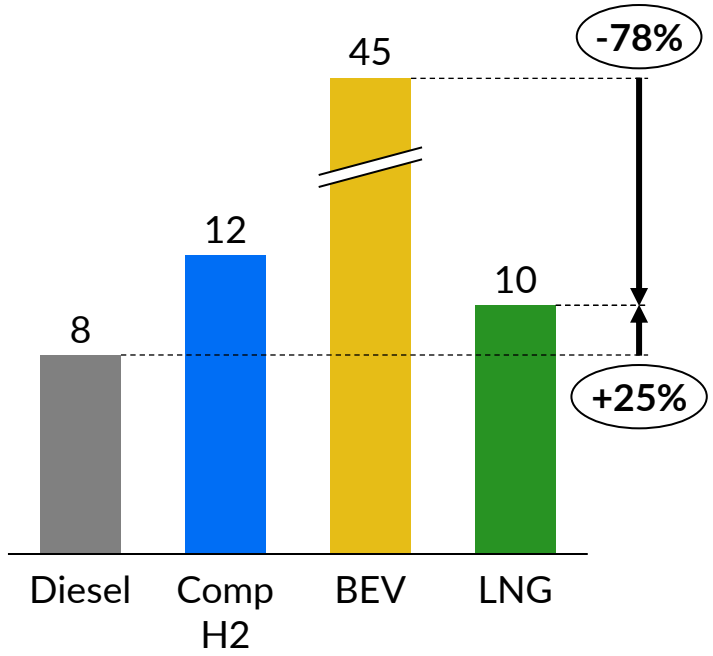
Typical range

Km per tank of fuel



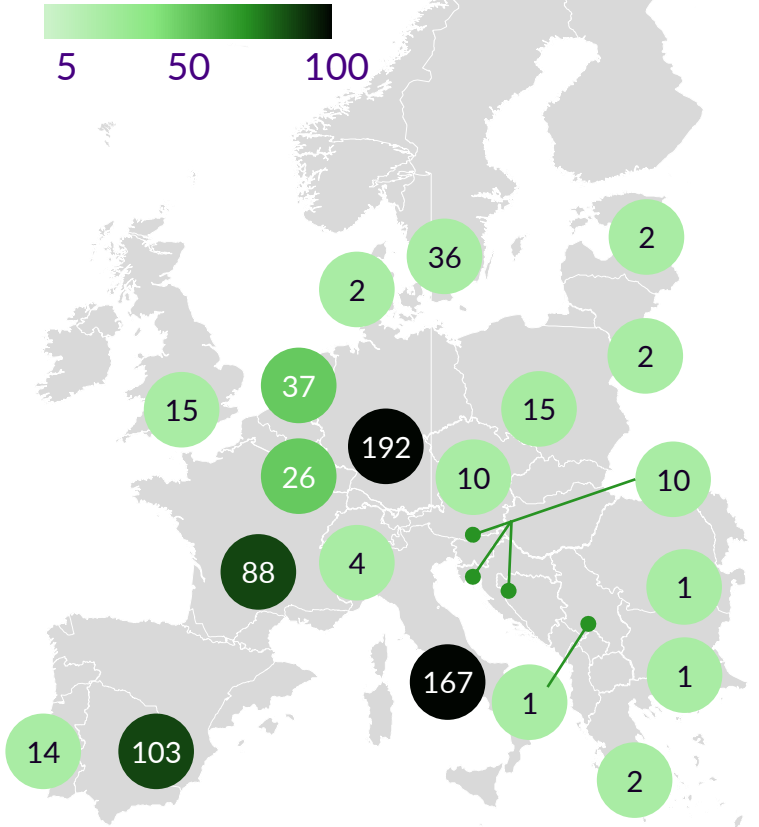
Quick refuelling times

Minutes



Dense network of stations

Number of LNG stations



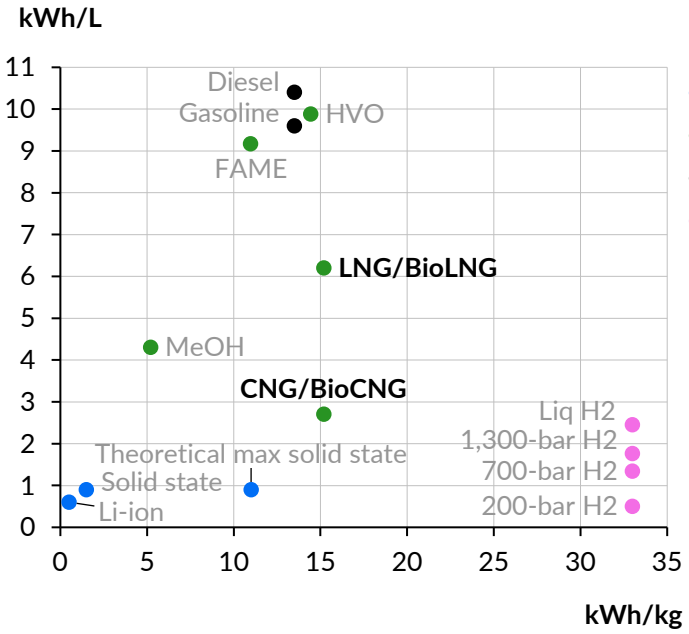
Source: Argus, Eurogas, ViGo analysis

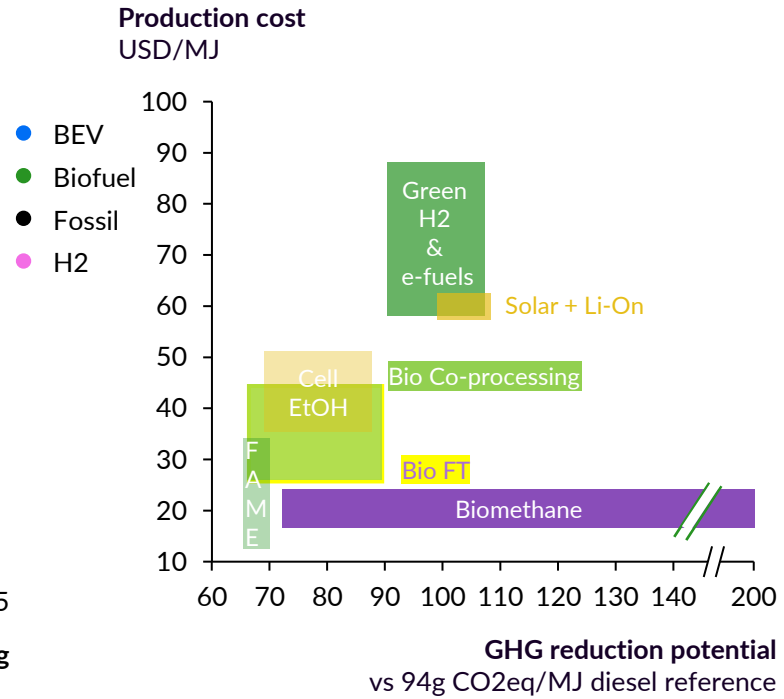
Vitol's core belief: (bio)methane will play a leading role in heavy duty transport for a long time due to technical and cost performance

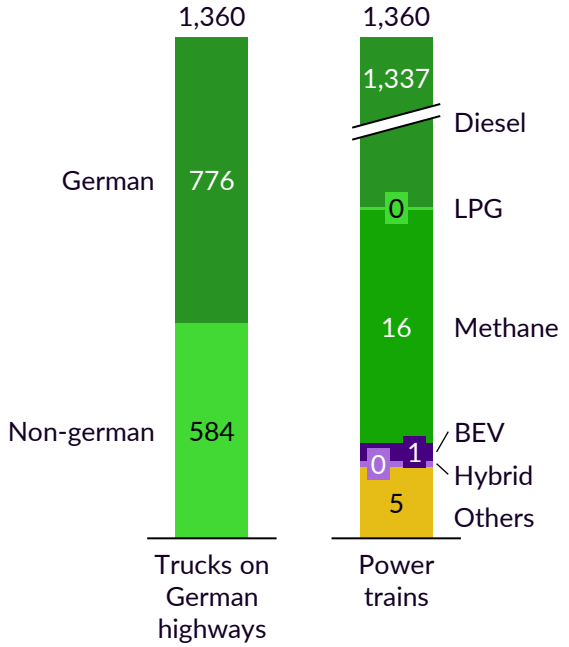
A Natural gas has very high energy density

B Best CO2 performance compared to alternatives

C Cost competitive, no hassle: gas is the dominant debcarb power train for HGVs[1]







Attractive for heavy duty, long range application

The lowest cost to produce, and highest GHG abating fuel

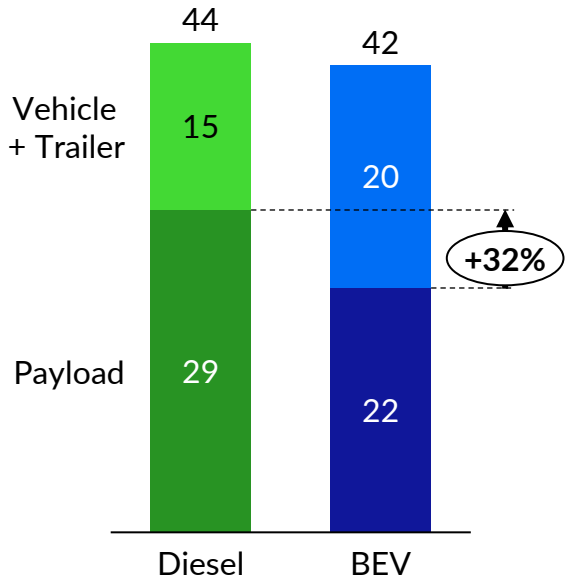
Lower cost than all decarbonization and traditional alternatives

1: Trucks over 12 MT
Source: EU Commission, Nature Energy, Square, Bundesamt für Güterverkehr, Lazard LCOE power analysis

BEVs are penalized on both payload and driving availability

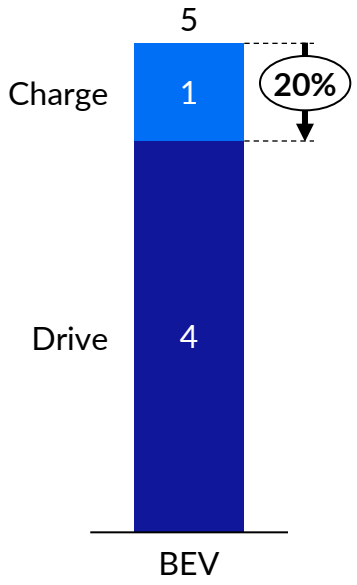
Mass penalty + Time penalty = Operating "cost" penalty of BEV vs diesel due to operational limitations

MT per vehicle



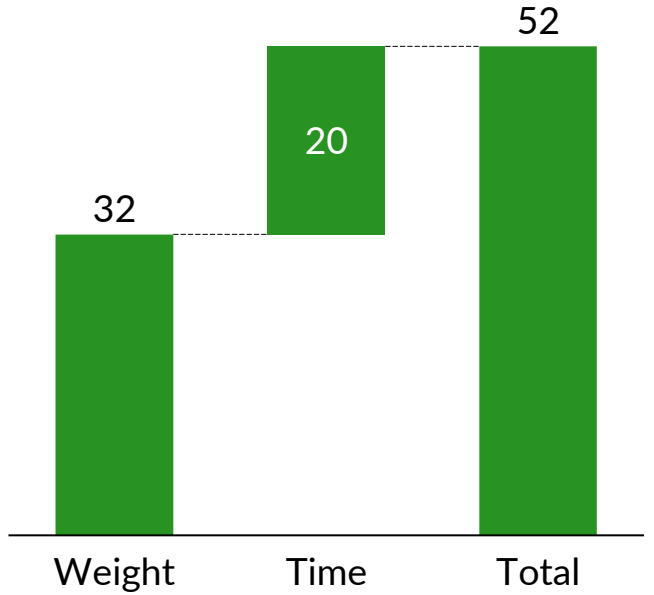
- Payload loss is 7/29 = 24%
- 4 BEVs to move same freight as 3 Diesels…
- **Outcome**: 32% extra cost

Hours



- BEV can drive for ~4 hours (320km) between charges
- Charge for ~1 hour out of 5 hours…. 20% of the time
- **Outcome**: take an extra stop at a public charging point… 20% additional cost.

%



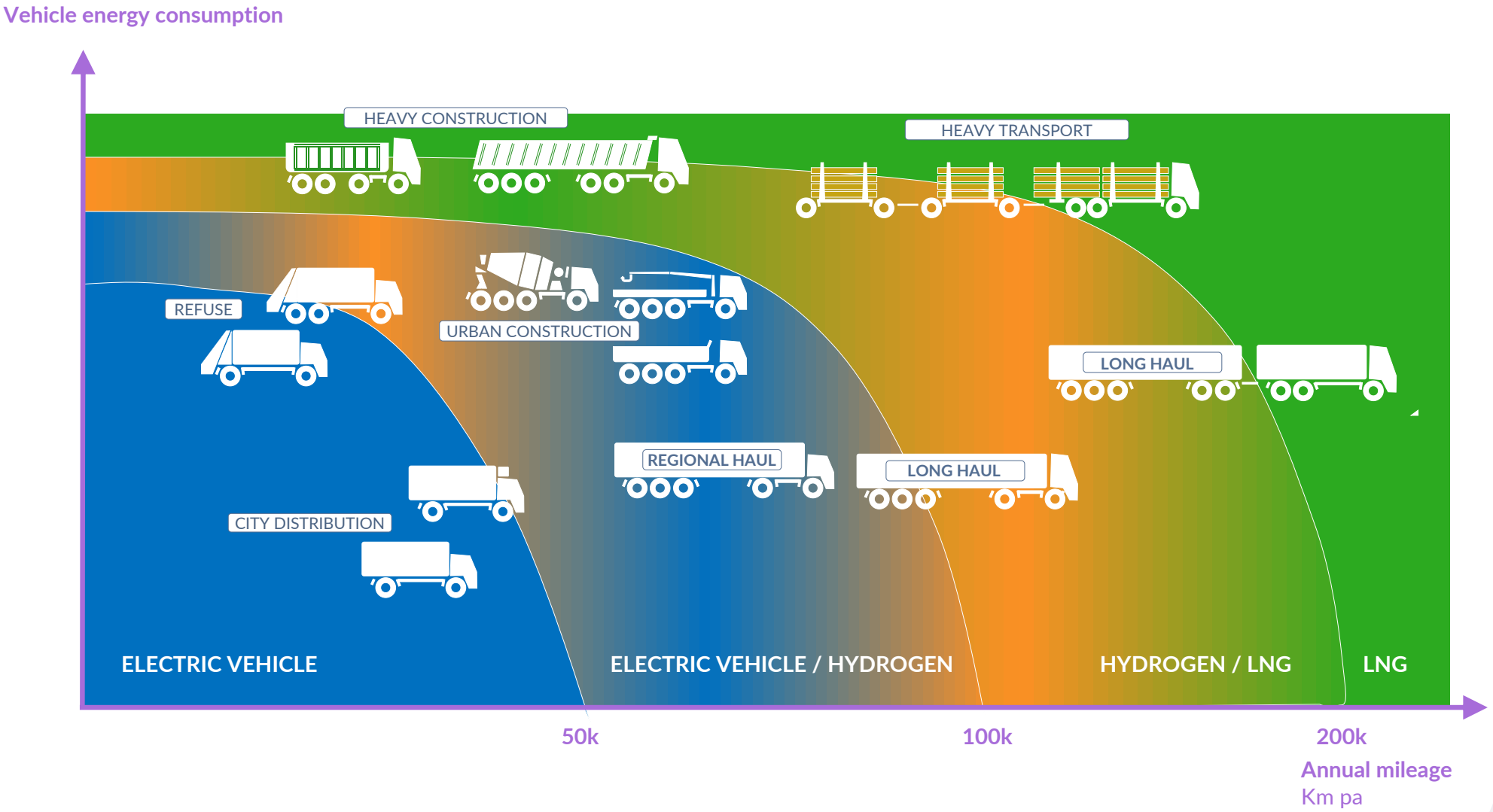
Low payload capacity

High offroad immobilization

High operational constraints to overcome for BEVs

1: Trucks over 12 MT
Source: EU Commission, Nature Energy, Square, Bundesamt für Güterverkehr, Lazard LCOE power analysis

Horses for courses: diesel and LNG are fuels of choice for a number of “difficult to abate” applications

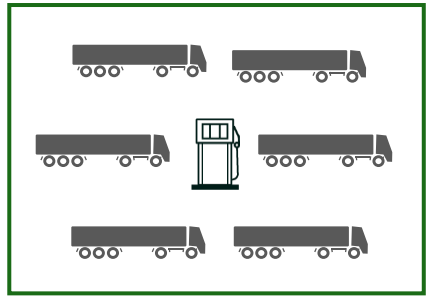


- A large number of applications representing a small portion of overall demand will not be able to electrify their power trains
- Counter-intuitively, they become the starting point for the decarbonisation journey as small operators cannot afford multiple technologies / performance profiles

Energy systems grow organically from local usage, they grow by accretion of economic individual, profitable, fuelling points

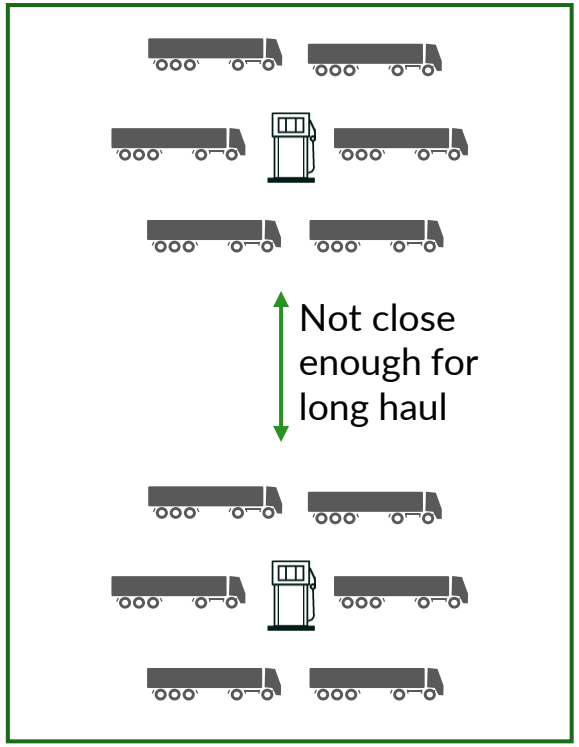
BEV H2 UK → Germany

Early market



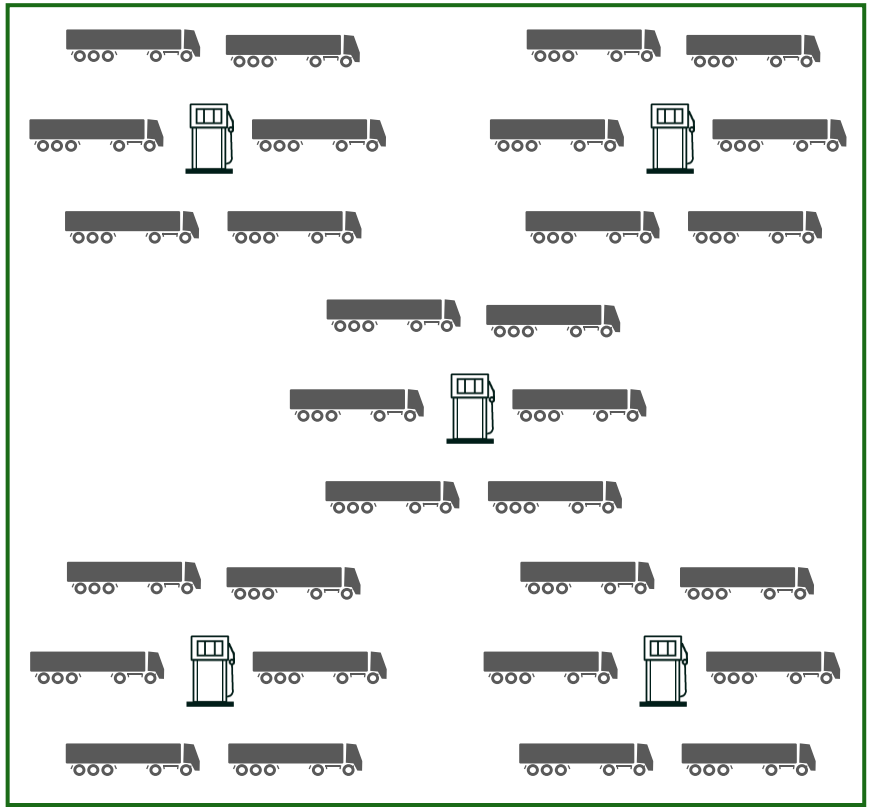
- Each fuelling station focuses on anchor, return to base vehicles
- They have an attractive business case, or do not get built
- Infrastructure for more expensive fuels typically attracts support at this stage

Growth phase



- Open access fuelling points
- Spread of new fuel supported by economics, performance & convenience

Maturity



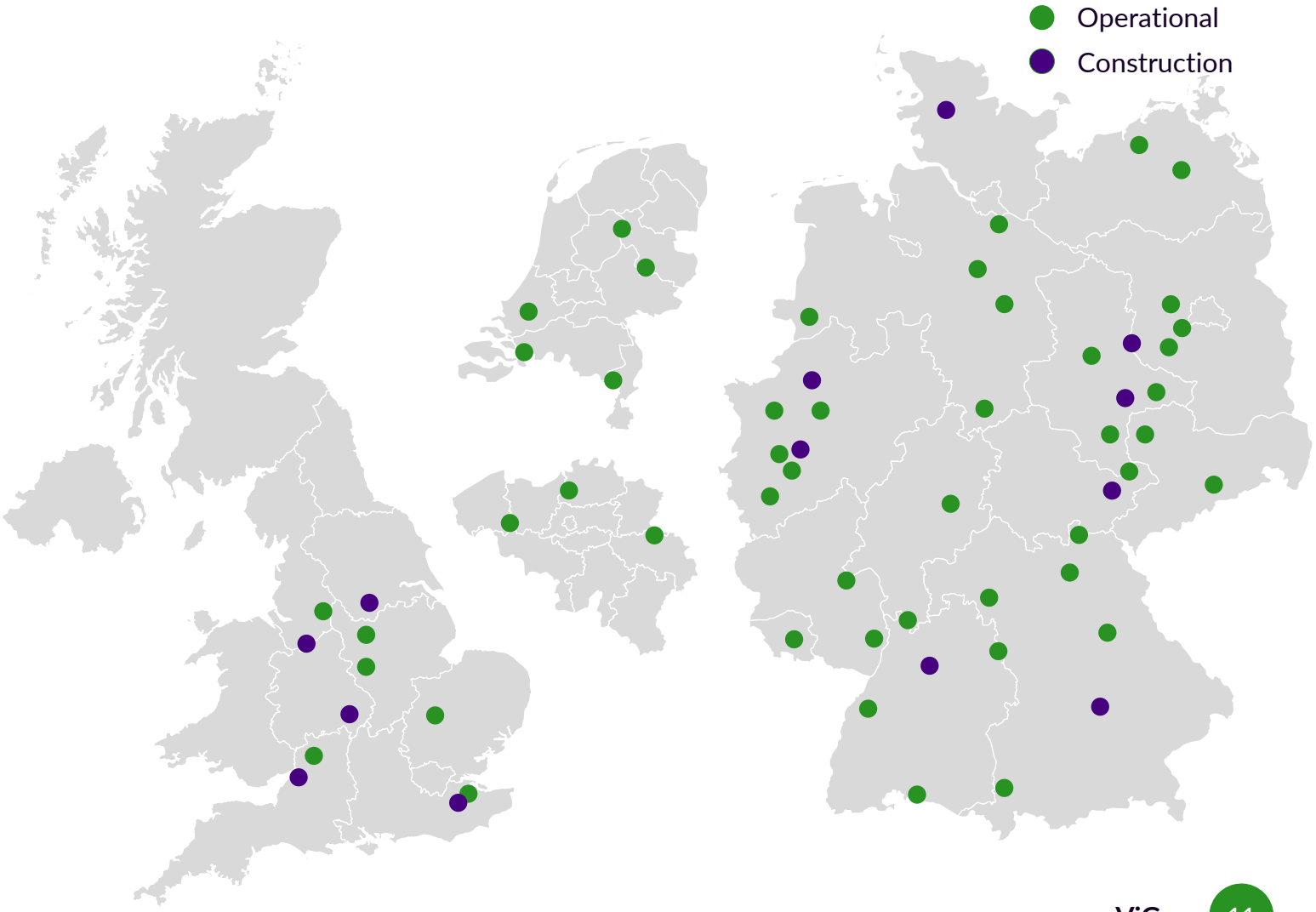
- Density of mesh creates network continuity
- Long distance usage can switch to new fuels

- Energy distribution systems are built on individual, profitable, fuelling points servicing return to base operations
- As density increases and these points are open access, longer haul routes can switch to the new fuel
- Investing in “corridors” is likely to lead to low asset utilisation for a long time, especially if the new option is less convenient / more costly for return to base work

Downstream

A leading bioLNG-to-truck distributor in Germany, Netherlands, Belgium and the UK…

47 stations in operations



Contact Us to Get Started

Germany

Kurfürstendamm 136
D – 10711 Berlin
Germany

T +49 (0) 30 43 97 167 0

United Kingdom

Nova South, 160 Victoria St.
London SW1E 5LB
United Kingdom

T +44 (0) 7868 135887

The Netherlands

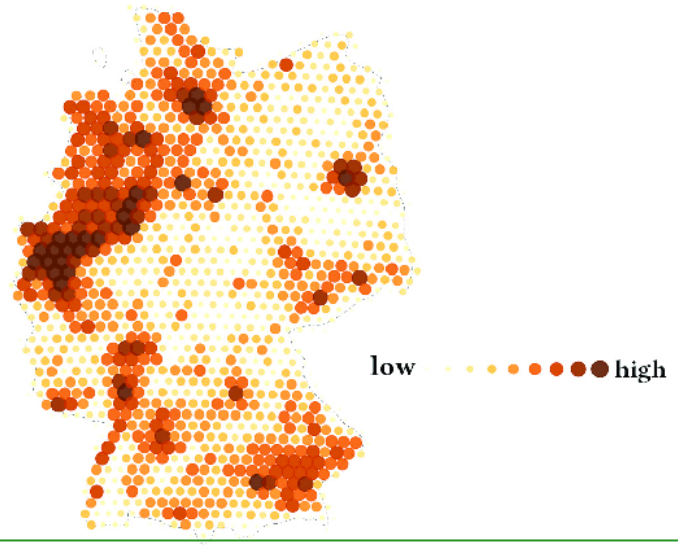
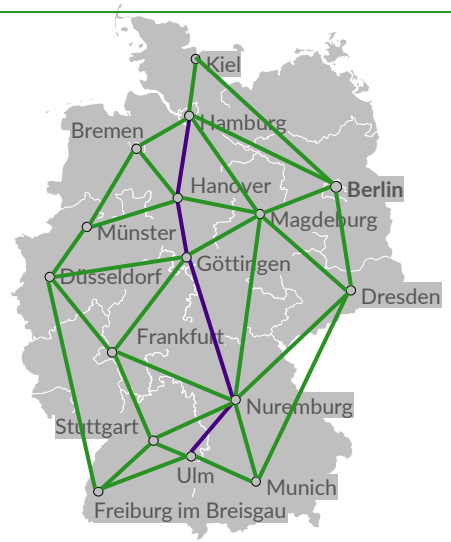
Euclideslaan 265
3584 BV Utrecht
The Netherlands

T +31 (0) 30 307 84 84

Modelling / simulation approach

Modelled scenario

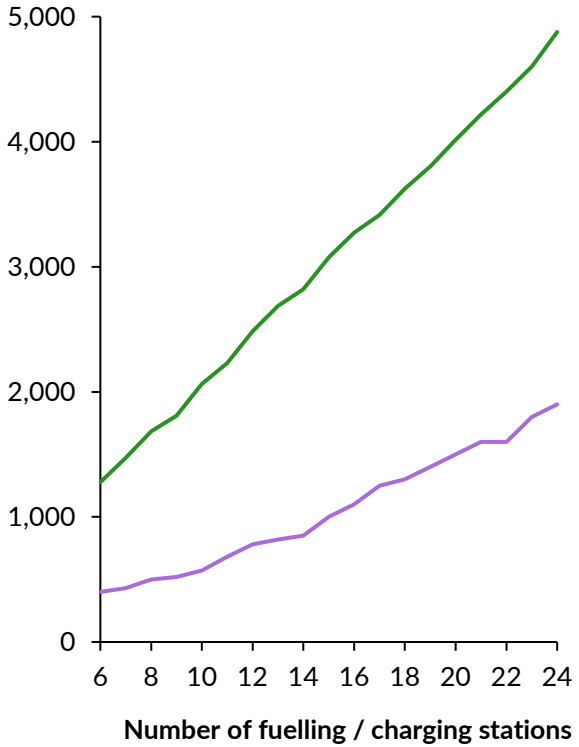
Modelling complexity +

	Traffic density based on population density	Lattice	Single route
Routes			
Description / rationale	• Logistics companies operate across countries on wide varieties of route lengths • They use a variety of truck sizes with different levels of electrification potential • Ton Miles are correlated with population density and hubs specialisation • Highly computational to model optimal road transport energy distribution infrastructure	• Lattice structure preserves the overall structure of the route patterns • Still very computationally heavy given the number of potential routes	• Single route infrastructure sizing creates a valid comparison point between gas and BEV technologies • It allows to incorporate all major design constraints (energy delivery speed, legal constraints on drivers) and explores BEV constraints on more challenging medium to long distance routes • It provides a best case estimate of the infrastructure requirements for BEV to compete against gas / diesel on medium / long distance routes

Source: ViGo analysis

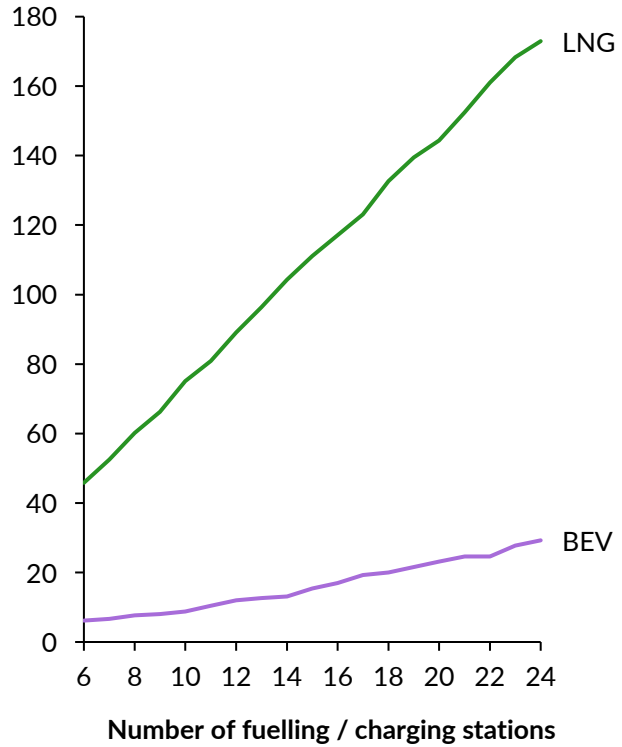
The BioLNG system solution is much less capital intensive than the BEV solution

Trucks capacity as a function of number of stations



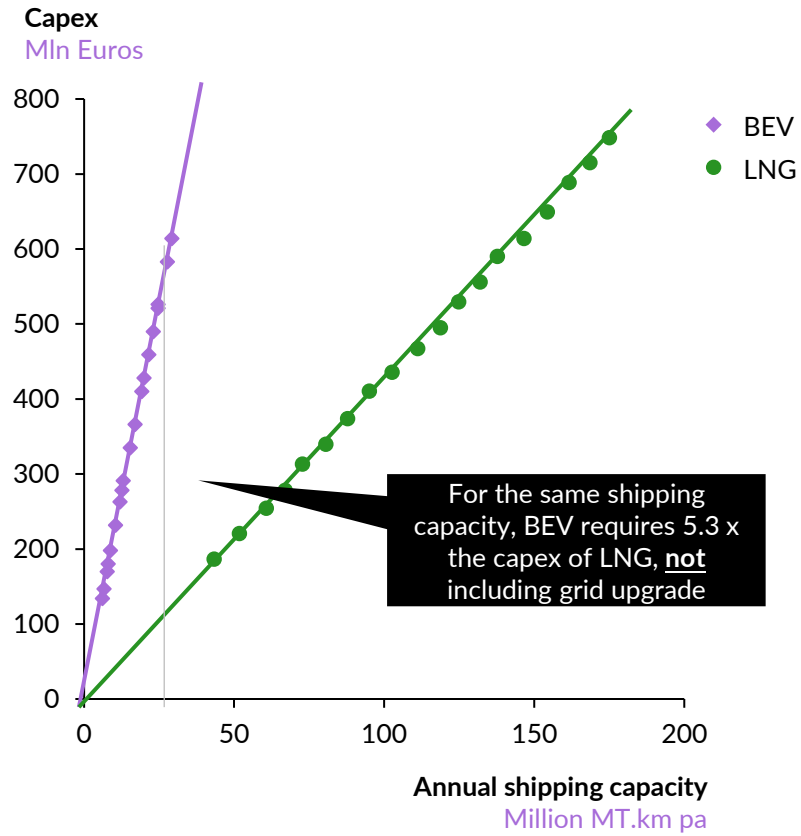
- Given their short range, BEVs require many more fuelling points than LNG

Shipping capacity
Million MT.km pa



- BEVs are penalised by their short range and load penalty (10%)

Capex[1] vs shipping capacity



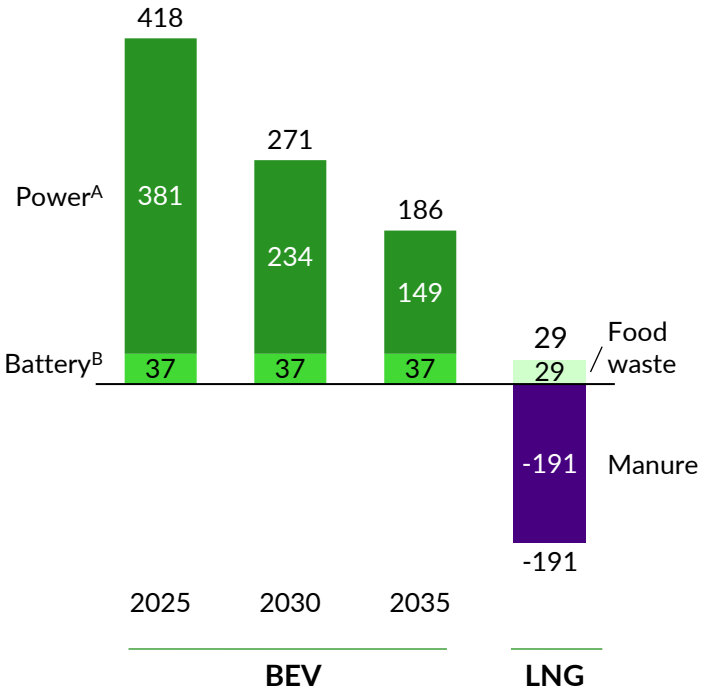
- To match the performance of LNG, battery energy density would have to improve by a factor 5

Source: ViGo analysis

BEVs compare unfavourably to LNG on multiple dimensions

GHG emissions

MT of CO2eq over the life of an HGV (1 Million km)



Even accounting for the forecasted spectacular greening of the German grid, BEHGVs emit considerably more than LNG HGVs

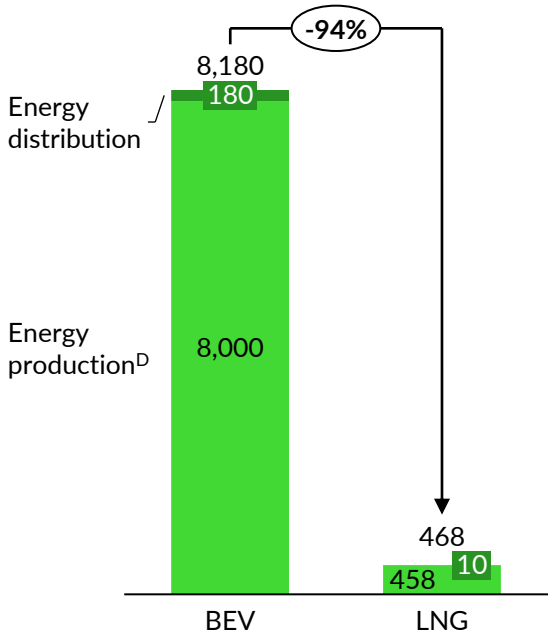
A; 381 g/KWh in 2024, 1 kwh per km, 1 Million km

B; assumes 73 kg / kwh

Source: BNEF, Journal Pone, German Ministry of Environment

Land use (distribution and production)

M² per HGV



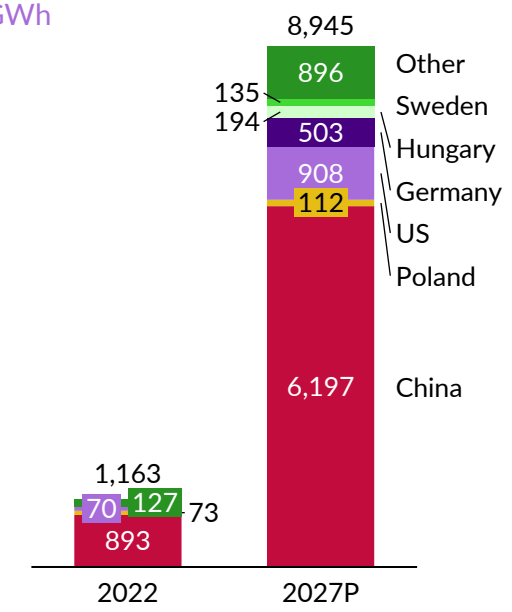
BEVs consume much more land than LNG due to the low energy density of renewable power production and the low density of energy delivered per m^{2n}

D; Average of 100 m2/MWH for wind and 20 m2/MWh for solar (McKinsey), BEV running on 100% green power, 6,000 m2 per High capacity BEV station
10,000 m2/100 GWh of biogas production and 2000 m2 per LNG station

Manufacturing base

Lithium battery manufacturing capacity

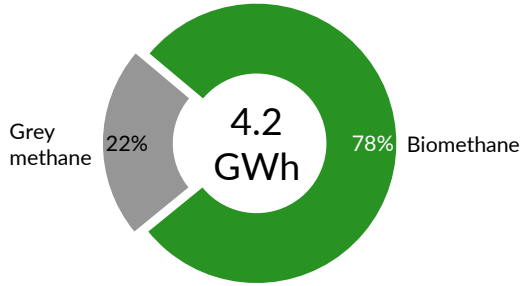
GWh



- 6 of the top 10 battery manufacturers are headquartered in China
- China controls cathode, anode and refined battery material production
- Even battery manufacturing / final assembly in countries other than China relies on Chinese supply chains

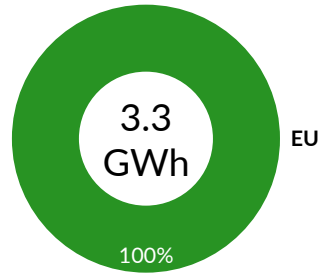
Nature of methane in transport in Germany

%, GWh, 2024



BioLNG/CNG

GWh



- 100% of biogas into transport in Germany is of EU origin

How can regulations simplify, accelerate and lower the cost of compliance for road transport decarbonisation?

EU 28

Technology neutrality to simplify

- Focus on GHG performance of fuels
- Conduct cost-benefit analysis to discard high cost marginal gains regulations

EU-wide uniform rules to accelerate

- Implementation of directives vary in time, ever changing local preferences and tinkering
- Move to a “regulation” equivalent framework

Deepen the regulatory market to lower compliance costs

- Accept all forms of decarbonized energies from all Member States to lower cost of compliance – no energy movement restrictions
- Single regulatory compliance instrument valid in all EU (GHG tickets)
- Support market infrastructure (Exchange) to improve price discovery, provide risk management tools and lower cost of transaction