Engineering and Innovation:
The Art of Anticipating the Future

COPPE UFRJ 60 anos

DIVERSITY IN CARBON NEUTRALITY
Scientific view bases on IPCC

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WG III – Mitigation of Climate Change

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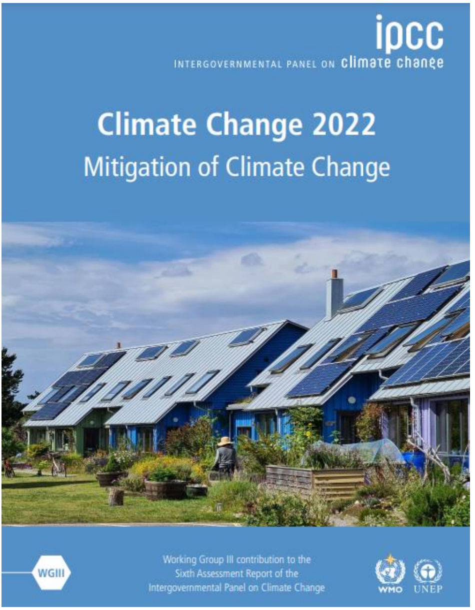

Chapters

10 Transport

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Mitigation Options: LDV

Light duty vehicles (LDVs) represent the main mode of transport for private citizens, and currently represent the largest share of transport emissions globally . Currently, powertrains depending on **gasoline** and **diesel** fuels remain the dominant technology in the LDV segment

Hybrid electric (HEVs) and fully **battery electric vehicles** (BEVs), however, have become increasingly popular in recent years.

Hybrid (HEVs) and **plug-in hybrid electric vehicles** (PHEVs) vary in terms of degree of powertrain electrification. HEVs mainly rely on regenerative braking for charging the battery. On the other hand, PHEVs combine regenerative braking with external power sources for charging the battery.

Fuel cell electric vehicles (FCEVs) have higher production emissions but only water vapor on tail pipe emissions

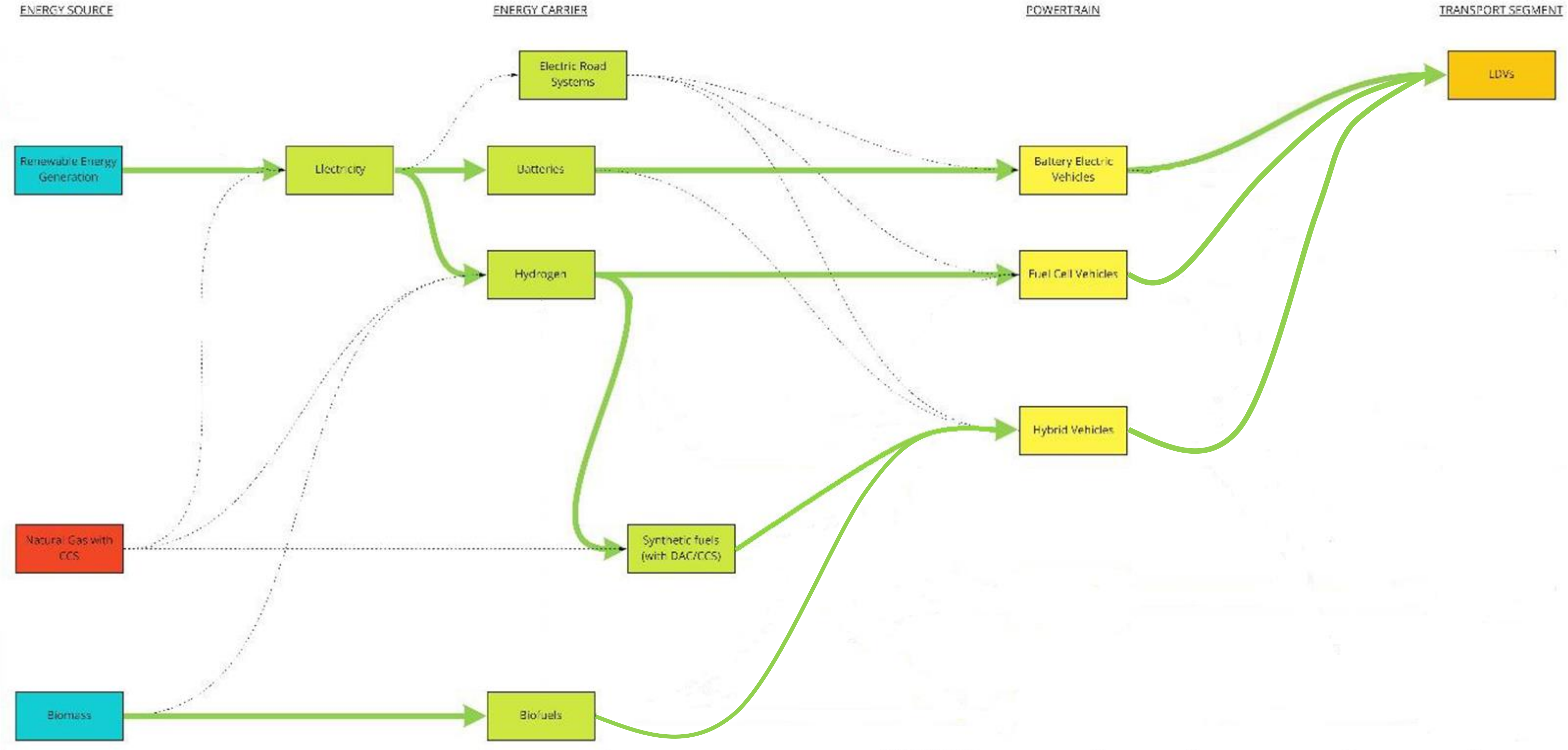
LCA –Life Cycle Analysis

Operating emissions : driving and powertrain efficiency, fuel and electricity mix

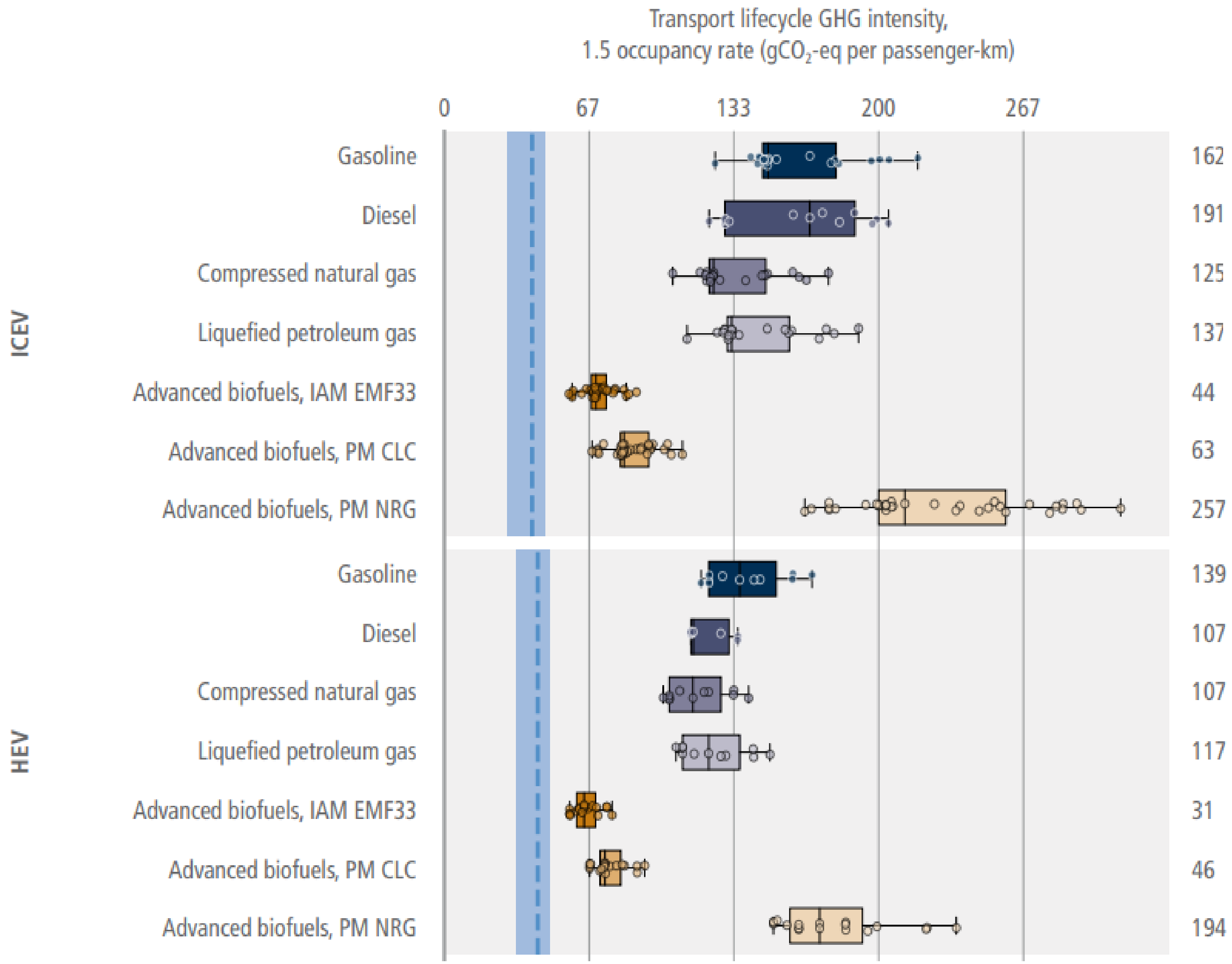
Manufacturing emissions : vehicle (batteries) technology production and energy mix

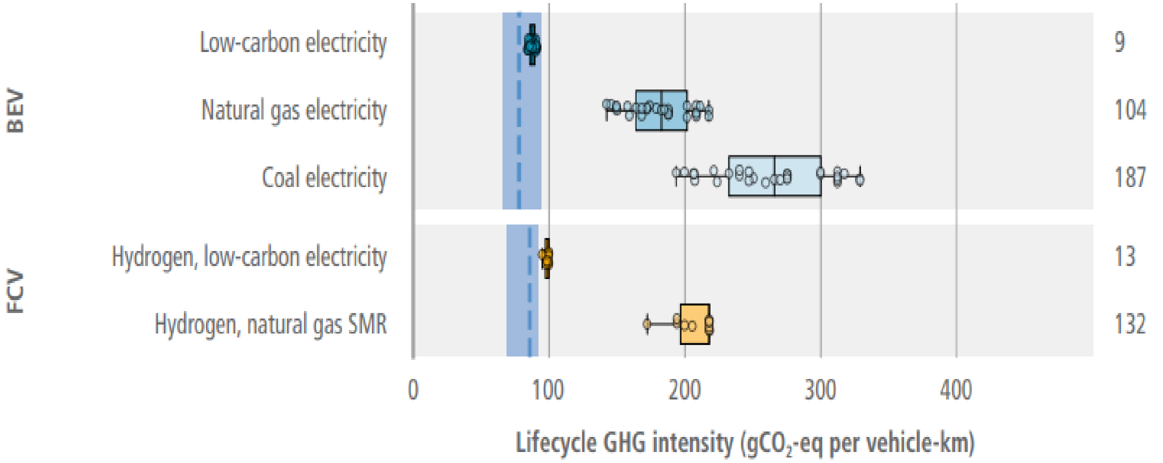
Hydrogen production : dependent on hydrogen fuel chain

Energy systems for different transport modes



Life cycle greenhouse emissions for mid-sized LDVs and fuel technologies.





The primary x-axis reports units in **gCO2-eq/vkm**, assuming a **vehicle life of 180,000 km**. The secondary x-axis uses units of **gCO2eq/passenger-km,** assuming a **1.5 occupancy factor**. Shaded area represents the interquartile range for combined vehicle manufacturing and end-of-life phases. The length of the box and whiskers represent the interquartile range of the operation phase for different fuel chains, while their placement on the x-axis represents the absolute lifecycle climate intensity, i.e., includes manufacturing and end-of-life phases.

Internal Combustion Engine Performance Improvement

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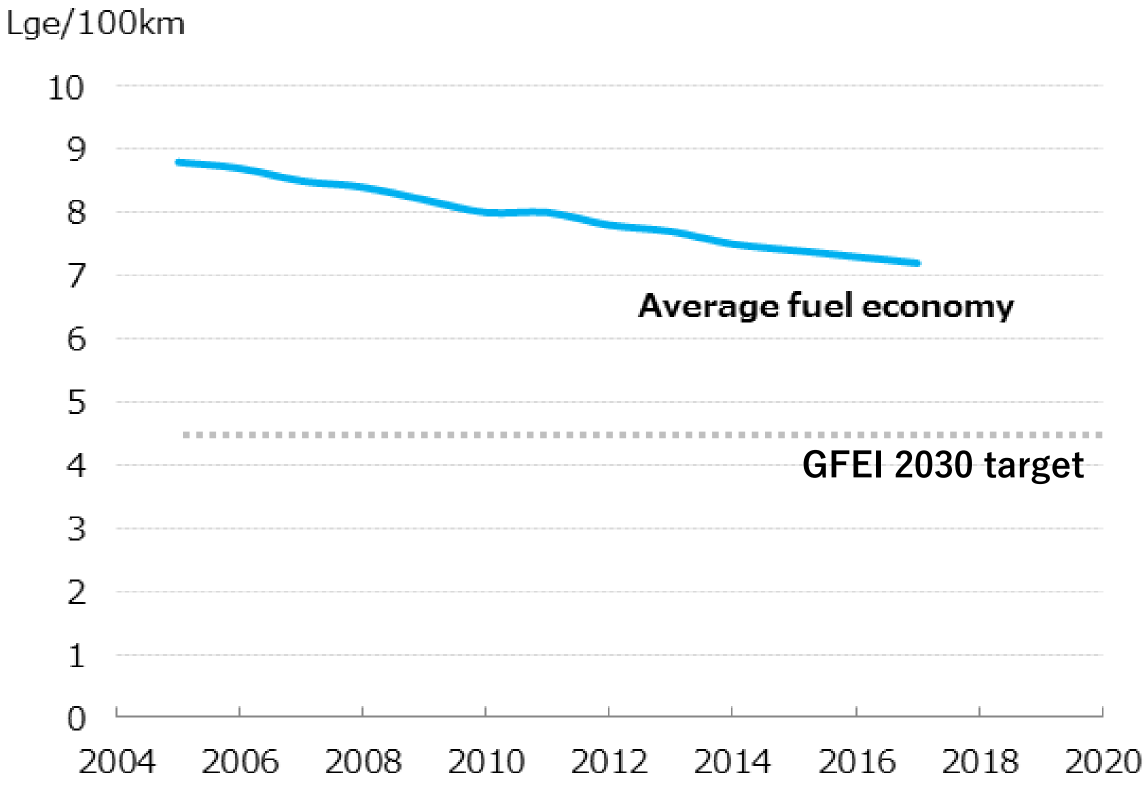
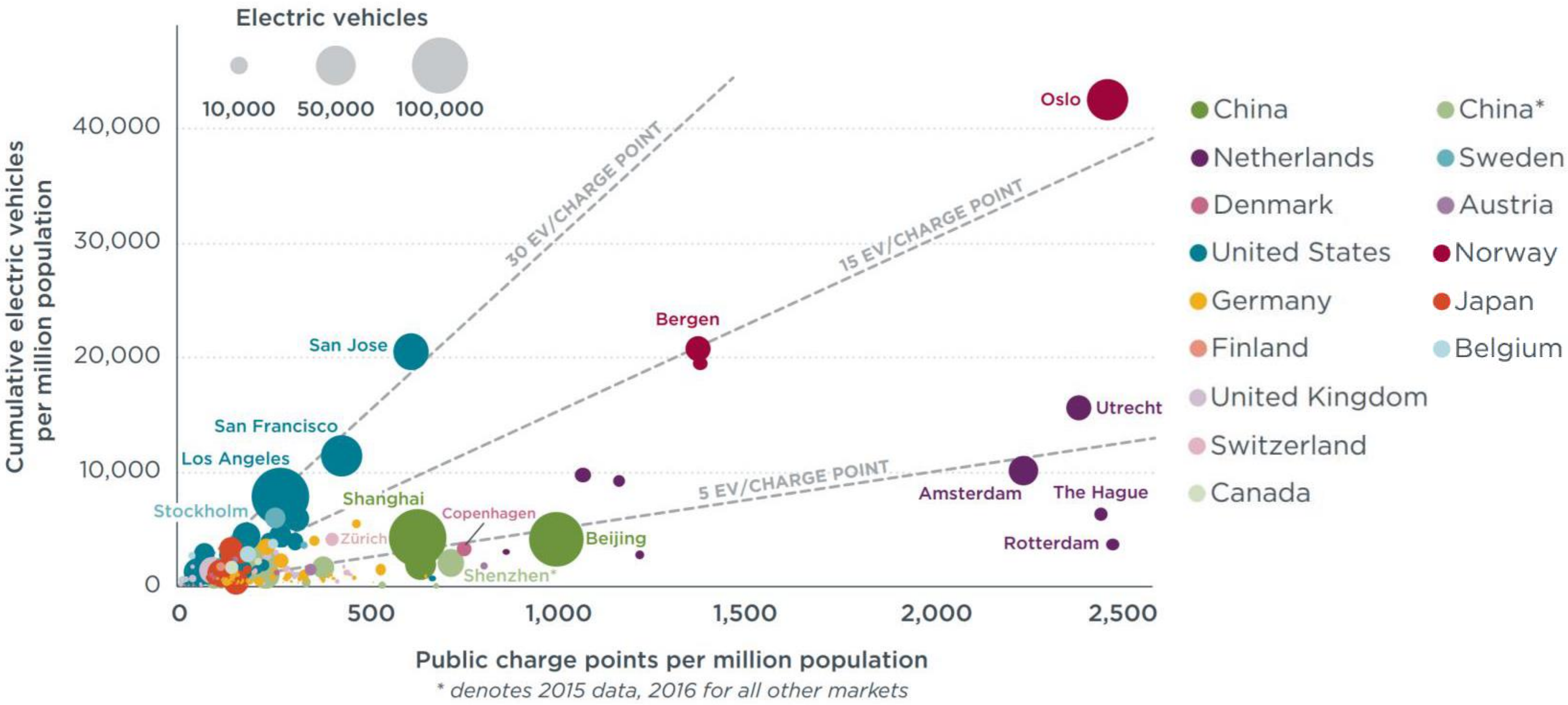
The average fuel consumption of new vehicles has improved significantly in recent years, due to more stringent emission regulations and the test cycle following real-world driving conditions; however, improvements are now slowing down.

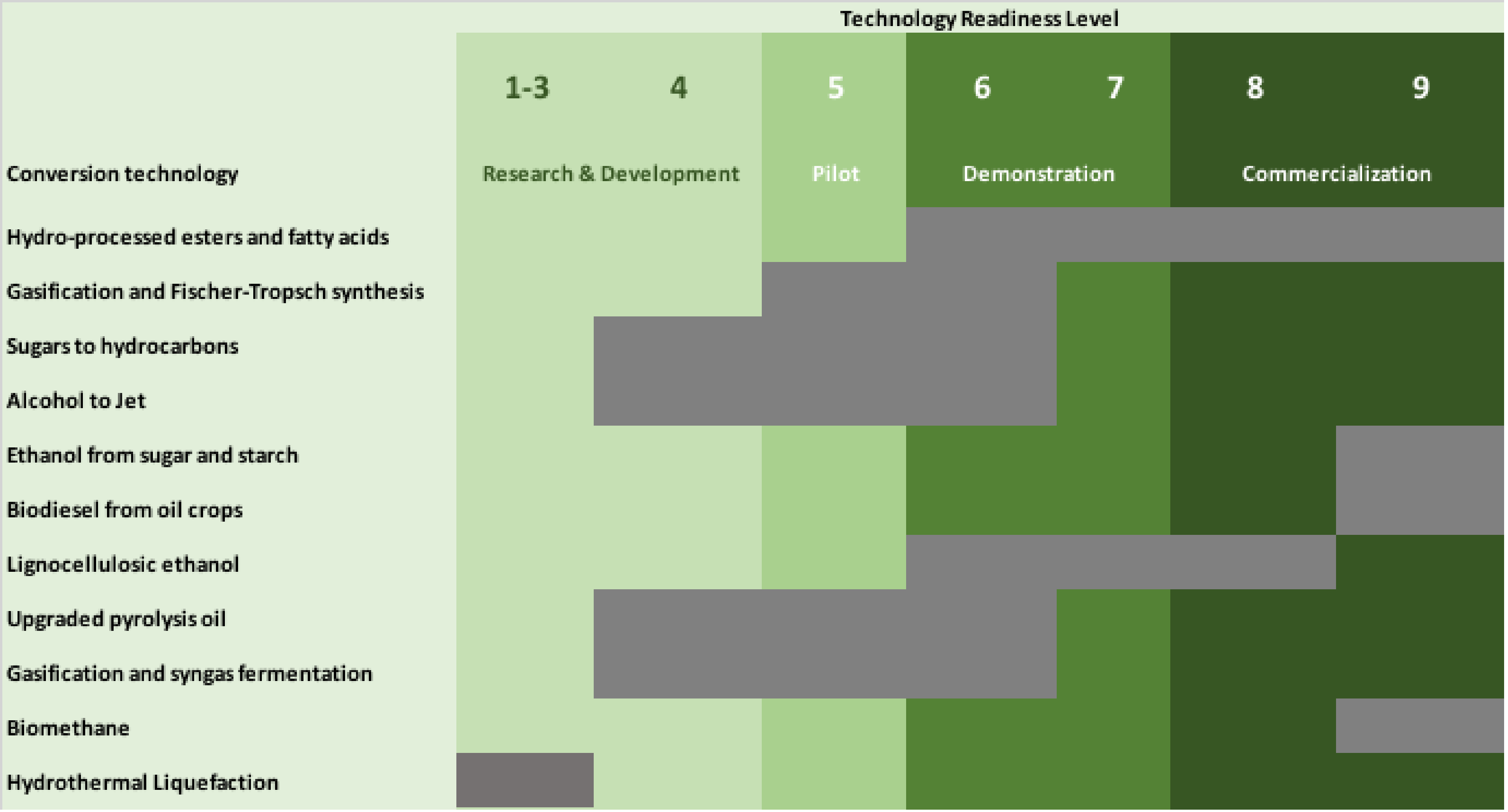


Average fuel consumption of LDV was improved by only 0.7 % and was 7.2 Lge *(Liters gasoline-equivalent)* per100km in 2017. This was slower than 1.8 % improvement per year between 2005 and 2016 and would appear to be due to the increasing size and weight of SUV’s in the vehicle fleet

Ratio of public charging infrastructure to electric vehicles, by country.



Commercialization status of selected biofuels conversion technologies.



Tools and Strategies for enabling mitigation options to achieve transformative scenarios

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Tools and Strategies	Light Vehicle Electromobility Systems	Travel Demand Reductions and Fuel/Vehicle Efficiency
1. Education Behavioural Change and R&D	Behaviour change programs help EV's become more mainstream. R&D will help on the socio-economic structures that impede adoption of EV's and the urban structures that enable reduced car dependence and how EV's can assist grids (Newman, 2011; Taiebat and Xu, 2019; Newman, et al, 2020)	TDR can be assisted with digitalization, connected autonomous vehicles, modal shift, EVs and Mobility as a Service (Marsden et al, 2018; Shaheen et al, 2018).Knowledge gaps on TDR exist for longer distance travel (intercity); non-mandatory trips (leisure; social trips) and travel by elder people. Travel demand futuring tools can be open source (Marsden, 2018).
2. Access and Equity	Significant equity issues with EV's in the transition period can be overcome with programs. (IRENA, 2016)	TDR programs in cities can be inequitable so demand futures can address this by better links to spatial and economic development (Marsden et al, 2018), mindful of diverse local priorities, personal freedom and personal data.
3. Financing Economic Incentives and Partnerships	Multiple opportunities for financing, economic incentives and partnerships with clear economic benefits can be assured especially using the role of value capture in enabling such benefit. The nexus between EV's and the electricity grid needs opportunities to demonstrate positive partnership projects (Sierczhula, 2014; Zhang et al, 2014; Mahmud et al, 2018; Newman Davies-Slate and Jones, 2018)	Carbon budget implications of different demand futures should be published and used to help incentivize Net Zero projects (Marsden, 2018)

Tools and Strategies for enabling mitigation options to achieve transformative scenarios

Tools and Strategies	Light Vehicle Electromobility Systems	Travel Demand Reductions and Fuel/Vehicle Efficiency
4. Co-benefits and Overcoming Fragmentation	The SDG benefits in zero carbon light vehicle transport systems are being demonstrated and these can now be quantified as nations mainstream this transition. Holistic projects are clearly more able to demonstrate such benefits. New methods for doing Benefit Cost Ratios that make more of health benefits in productivity are now improving transit and active transport business cases/investment decision-making (UK DoT, 2019; Buonocore et al, 2019; Sharma et al, 2020).	A focus on people-centred solutions for future mobility with more pluralistic and feasible sets of outcomes for all people can be achieved when they focus on more than simple benefit cost ratios but include well-being and livelihoods, considering transport as a system, rather than loosely connected modes as well as behaviour change programs (Gov Office for Science, 2019; Newman 2011; Newman et al, 2017).
5. Regulation and Assessment	With zero carbon light vehicle systems rapidly growing the need for a full assessment of regulatory barriers can assist each city and region as well as providing different economic opportunities and a sustainable business model (Bocken et al, 2016). How EV's can be related to walkability in cities (Speck, 2018).	Implementing a flexible regulatory framework is needed for most TDR (UK DoT, 2019). Regulatory assessment can help with potential additional (cyber) security risk due to digitalization, AVs, IoT and Big Data on travel demand (Shaheen, 2018). Assessment tools and methods need to be simplified but taking account of greater diversity of population, regions, blurring of modes and distinct spatial characteristics (Newman and Kenworthy, 2015)

Cont.

Tools and Strategies for enabling mitigation options to achieve transformative scenarios

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Tools and Strategies	Light Vehicle Electromobility Systems	Travel Demand Reductions and Fuel/Vehicle Efficiency
6. Governance and Institutional Capacity	Governance and institutional capacity can now provide international exchanges and education programs based on successful cities and nations enabling light vehicle decarbonisation to create more efficient and effective policy mechanisms towards self-sustaining markets (Green, 2014; Skjolsvold and Ryghaug, 2019).	TDR works better if adaptive decision-making approaches focus on more inclusive and whole of system benefit-cost ratios (Yang et al, 2020; Marsden, 2018).
7.Enabling infrastructure	There is a need for investments in the infrastructure that can support alternative fuels for LDVs. Large-scale electrification of LDVs requires expansion of low-carbon power systems, while charging or battery swapping infrastructure is needed for some segments. (Ahmad et al. 2020; Gnann et.al. 2018).	Ensuring space for active transport and urban activities is taken from road space where necessary (Gossling, 2020; Gossling et al, 2016). Increasing the proportion of walking city and transit fabric in urban areas will structurally enable reductions in car use. (Section 10.2 and Newman and Kenworthy, 2015). Creating transit activated corridors of TOD's based on rail or mid-tier transit using value capture for financing will create inherently less car dependence (McIntosh et al, 2017; Newman et al 2019).

Cont.

Regional Mitigation Options : Biofuel Brazilian Perspectives (LDV)

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Hybrids & Flex- fuel as a technological transition

- Given the high efficiency of the diesel engine**, much of the effort has been placed on developing biofuels compatible with diesel engines**.
- Given the fleet size of ICE, **much of the effort has been toward low carbon fuels.**
- Given the available biomass in Brazil, much of the effort has been toward **" sustainable bioenergy" assuring the sustainable supply chain.**

Biodiesel blends

Hydrotreated vegetable oil (HVO)

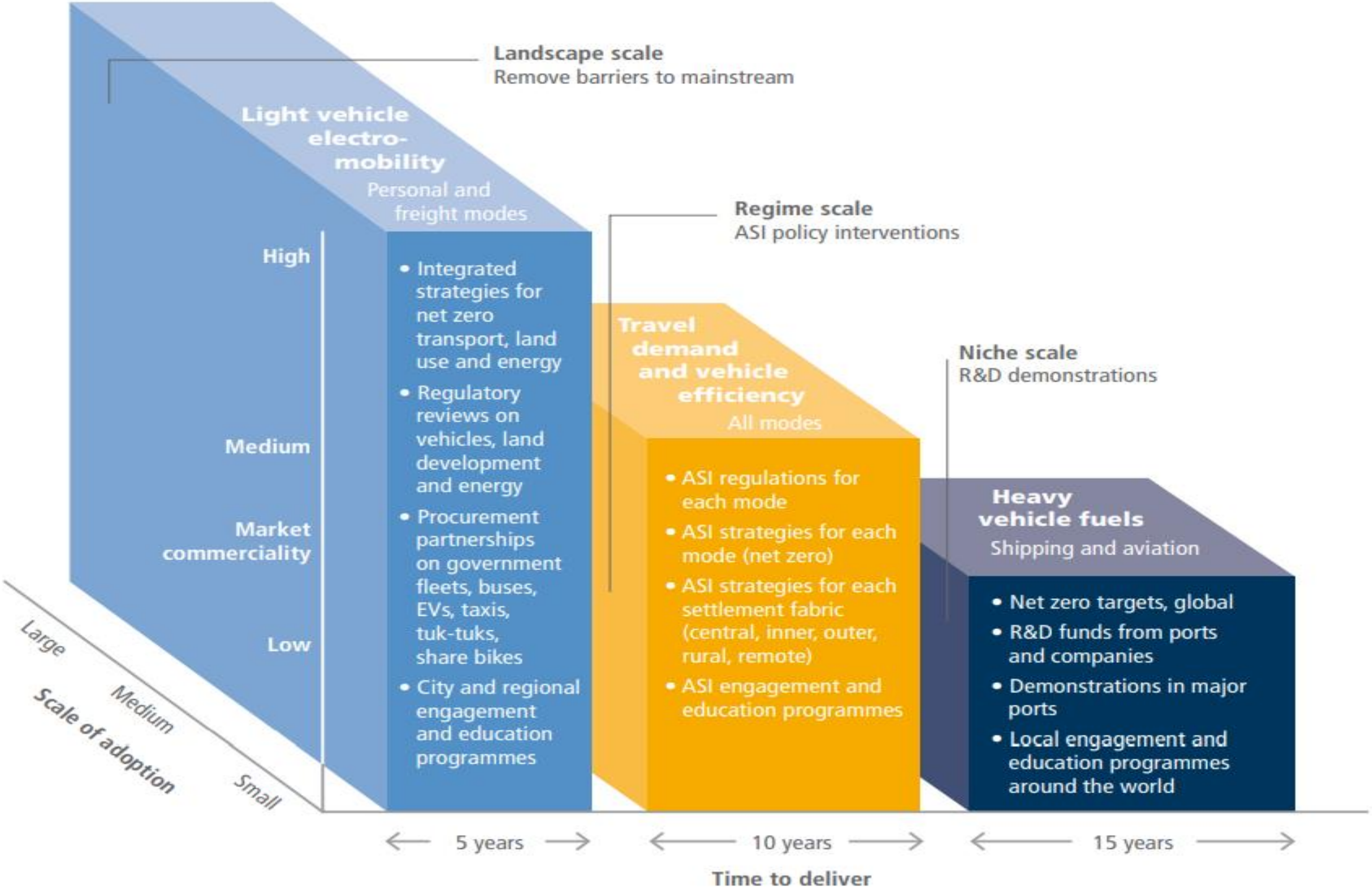
Ethanol fuels

Bioenergy according to different raw material and industrial process

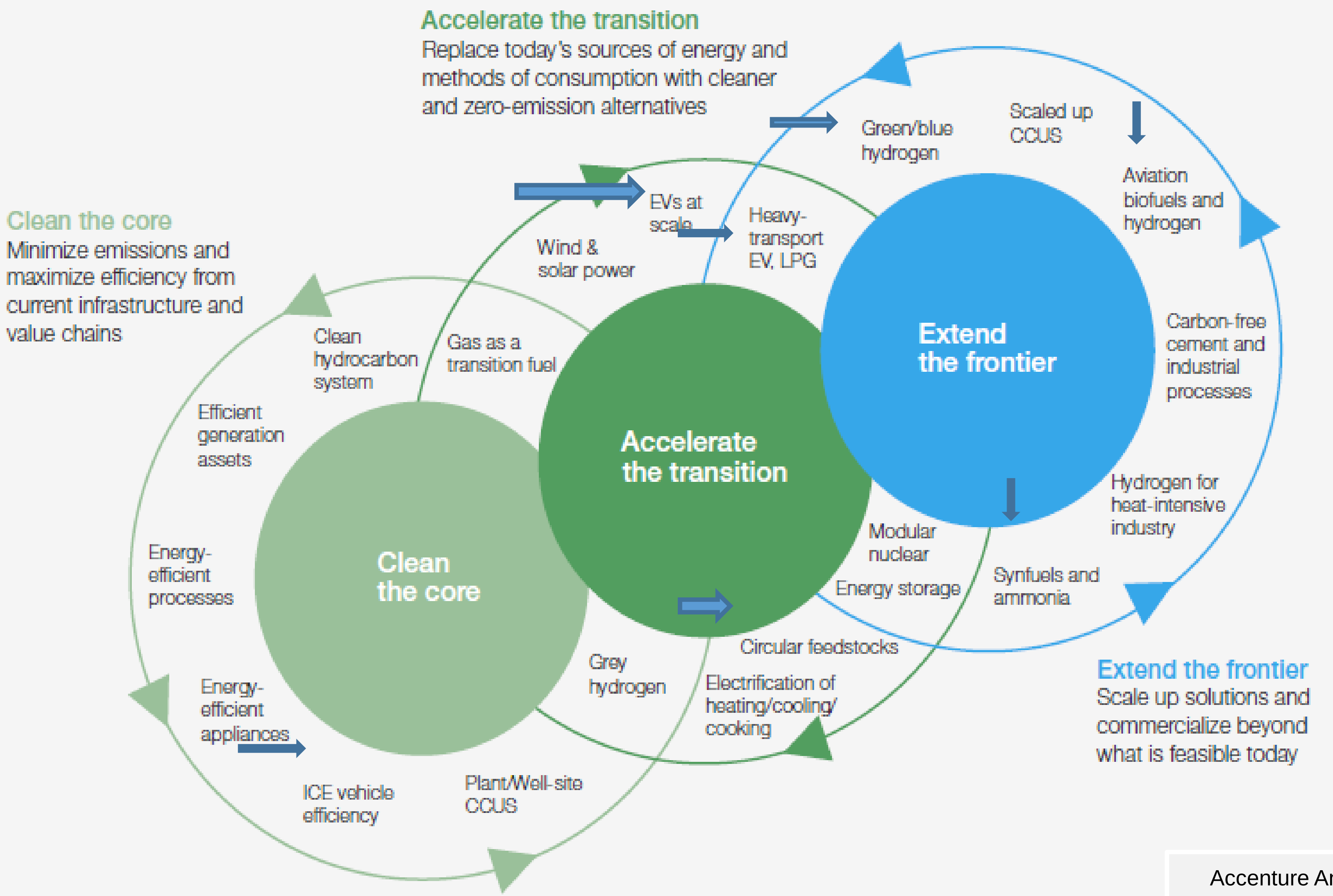
Regional Mitigation Options : Biofuel & H2 Brazilian Perspectives (LDV)

- Fuel production from vegetable oils via catalytic reactions;
- Production of **biofuel and electricity** from bagasse and sugarcane straw;
- High quality **biodiesel** production from pyrolysis bio-oil;
- **Biodiesel** production by transesterification of vegetable oils using reactors with contacting membranes ;
- Production of gaseous **biofuels** (C_1, C_2, C_3) from glycerol (a by-product of biodiesel) and CO_2;
- **Biogas** production from organic waste: transforming an environmental liability into an energy asset aiming at sustainable development;
- **H_2** production via biogas reform (CH_4) with CO_2 or H_2O using catalytic membrane reactors.

Mitigation Options and Enabling Conditions for Transport



Vision of the Future



Accenture Analysis , 2020

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