

PARIS
REINFORCE

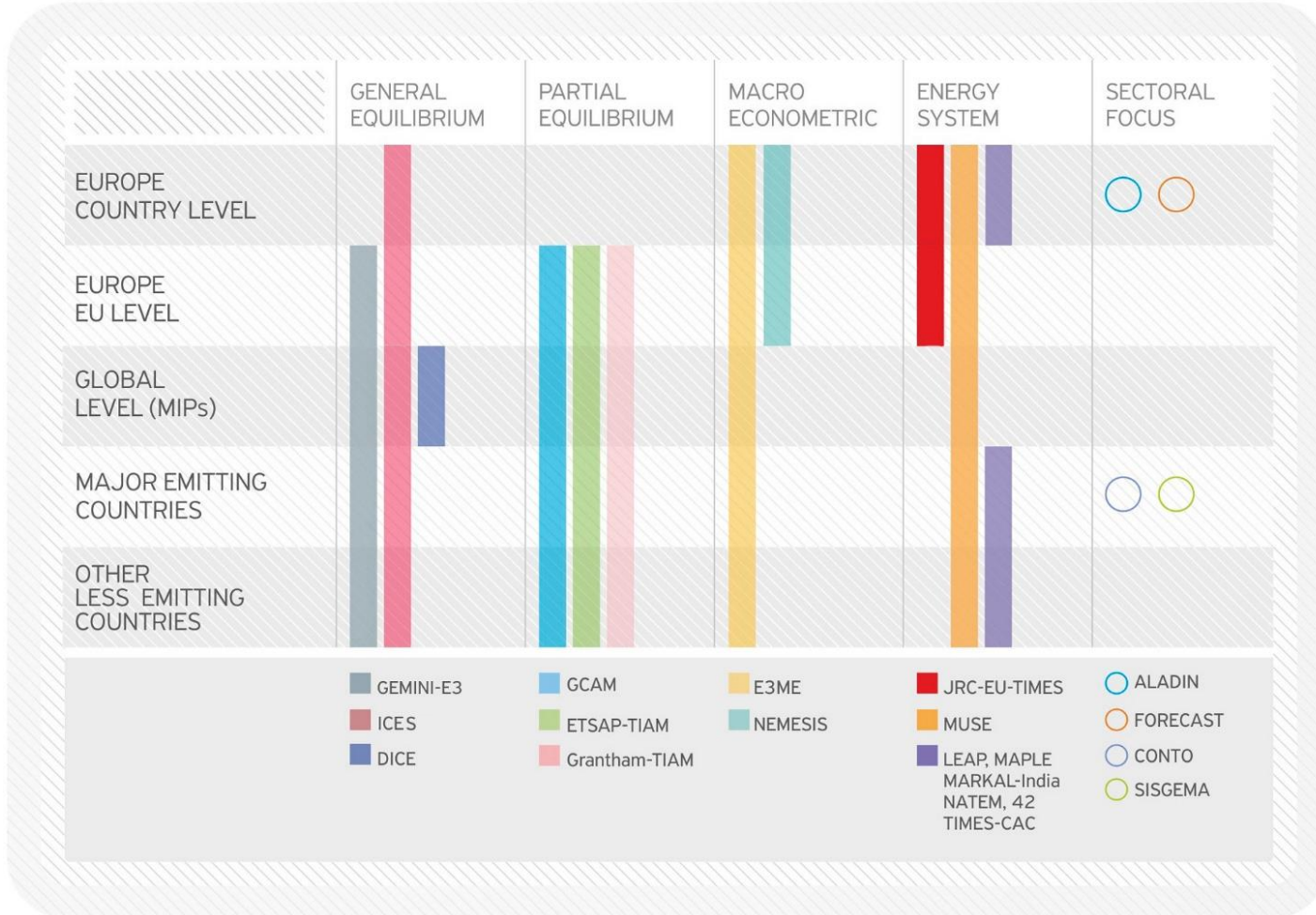


Low-carbon Transitions in Brazil

S. Giarola, A. Gambhir, A. Köberle (Imperial), Jakob Wachsmuth, P. Warnke (Fraunhofer ISI), K. Koasidis, A. Nikas (NTUA)
02/05/2022, Brazil Stakeholder Workshop



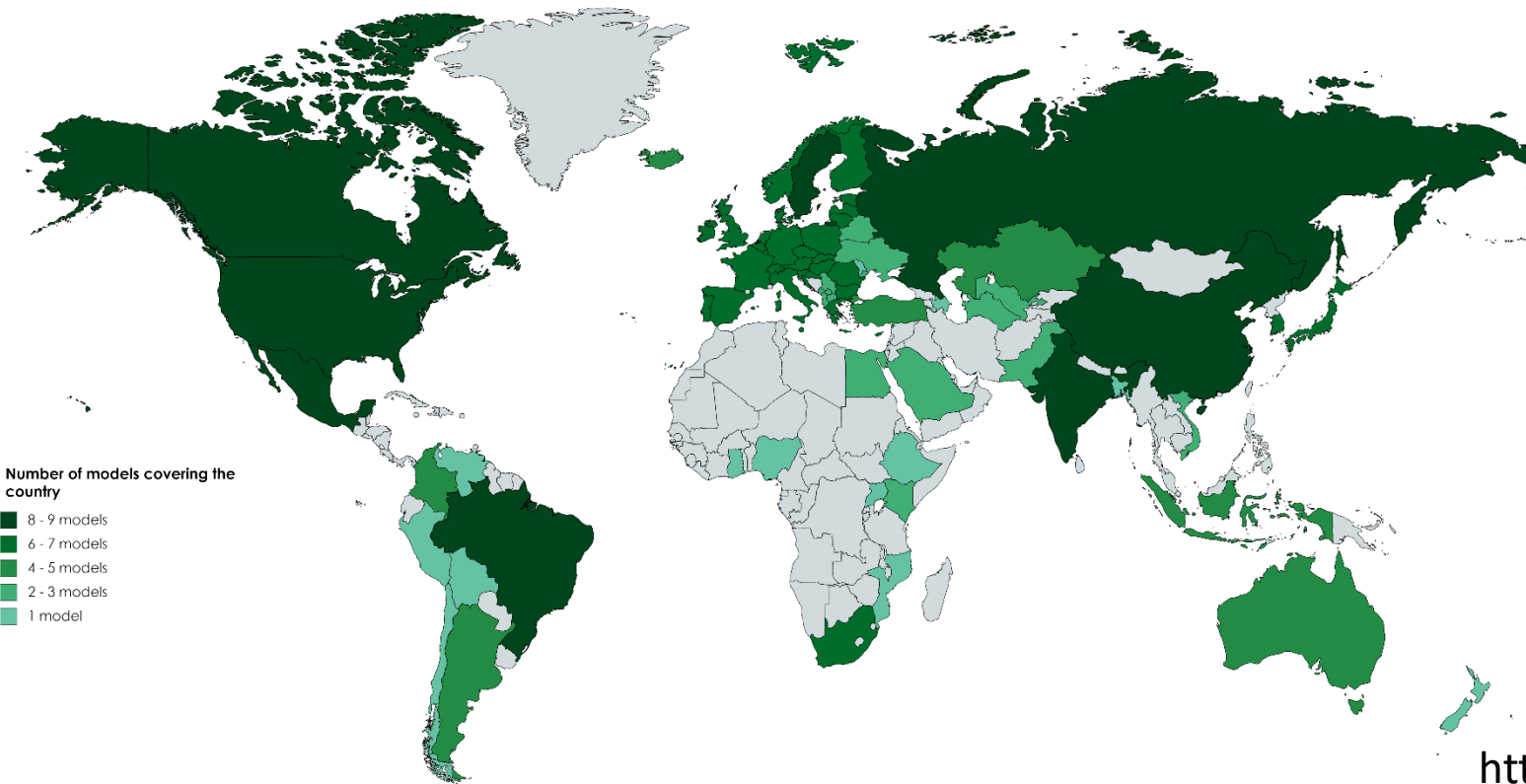
A demand-driven integrated, assessment modelling approach



Model	Type
GCAM PR 5.3	Partial Equilibrium
GEMINI-E3 7.0	CGE
ICES XPS 1.0	CGE
MUSE-Brazil	Agent-Based



WHAT CAN OUR MODELS DELIVER IN TERMS OF GEOGRAPHIC COVERAGE?



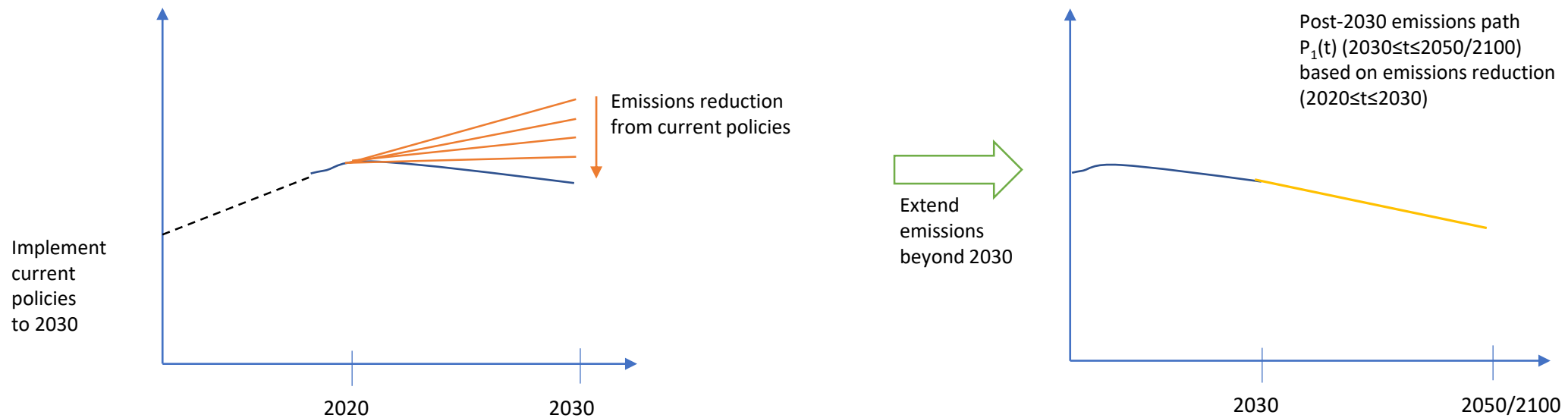
Model	Geographical coverage
GCAM PR 5.3	Global
GEMINI-E3 7.0	
ICES XPS 1.0	
MUSE-Brazil	5-region model of Brazil

https://www.i2am-paris.eu/detailed_model_doc/

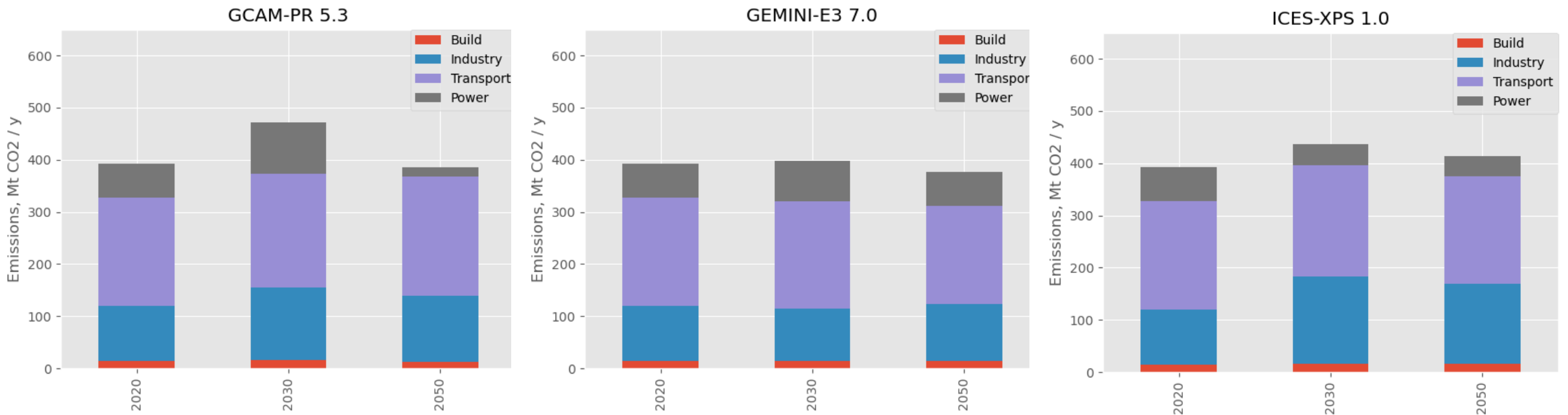


The PARIS REINFORCE project has received funding from the European Union's Horizon 2020 Research and Innovation Programme under grant agreement No 820846.

We use first our ensemble of global models to project policies beyond 2030



Energy systems emissions in Brazil are projected to peak in 2030

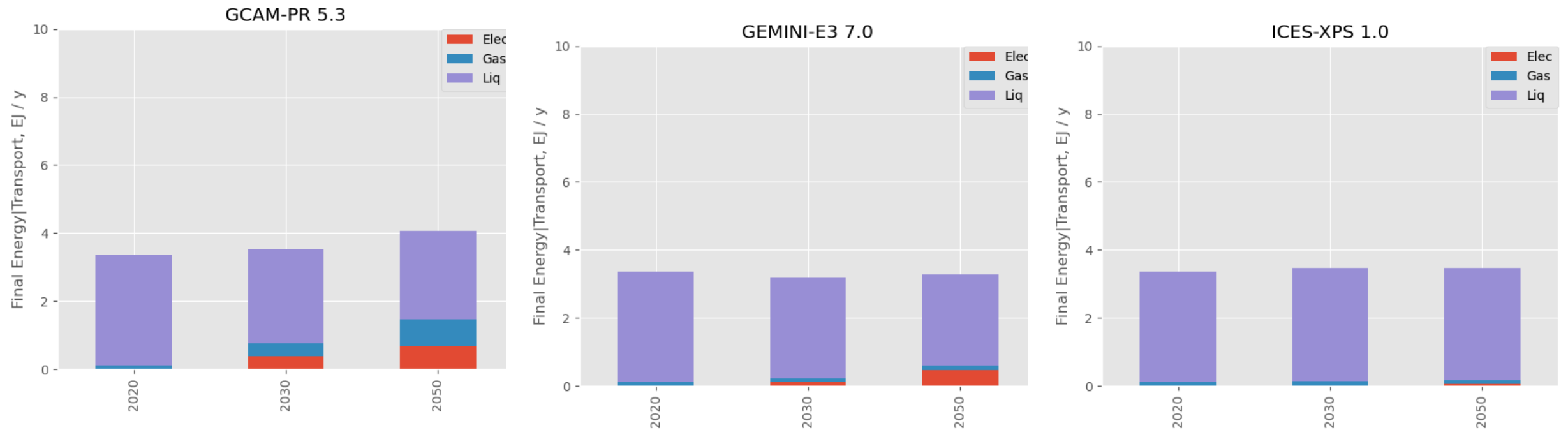


[Sognaes et al.](#), *Nature Climate Change* volume 11, pages 1055–1062 (2021)

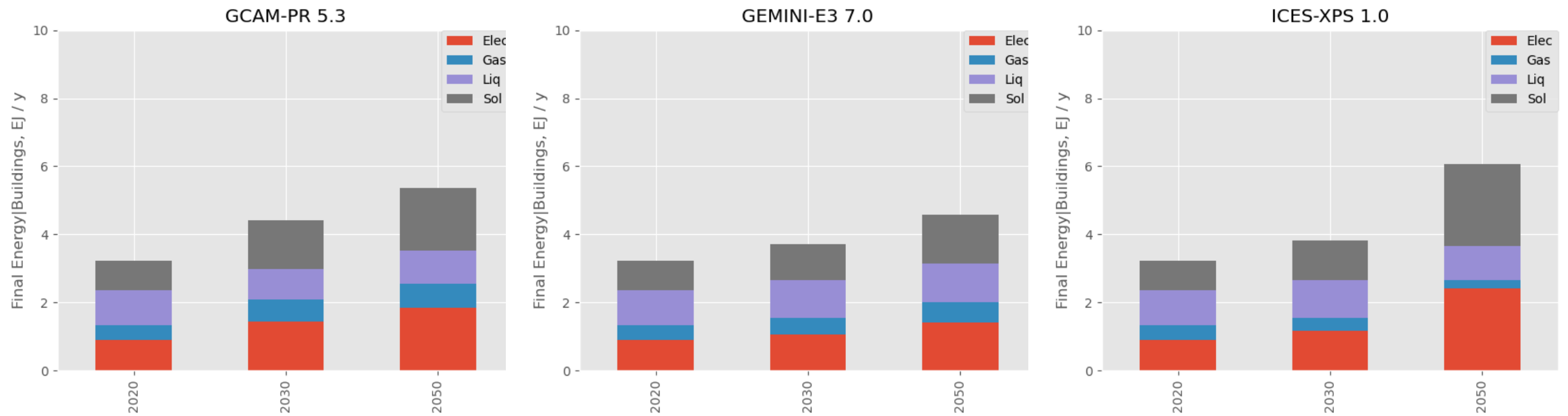


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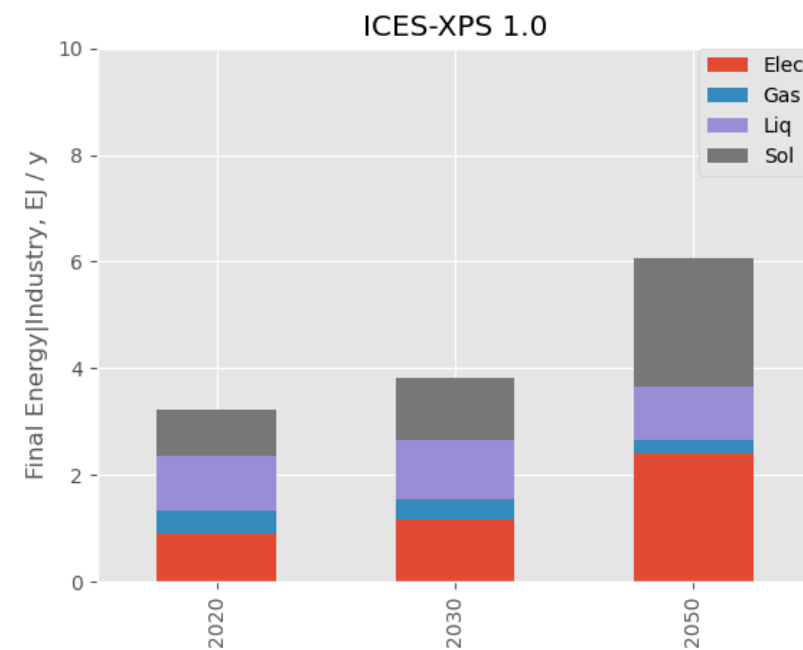
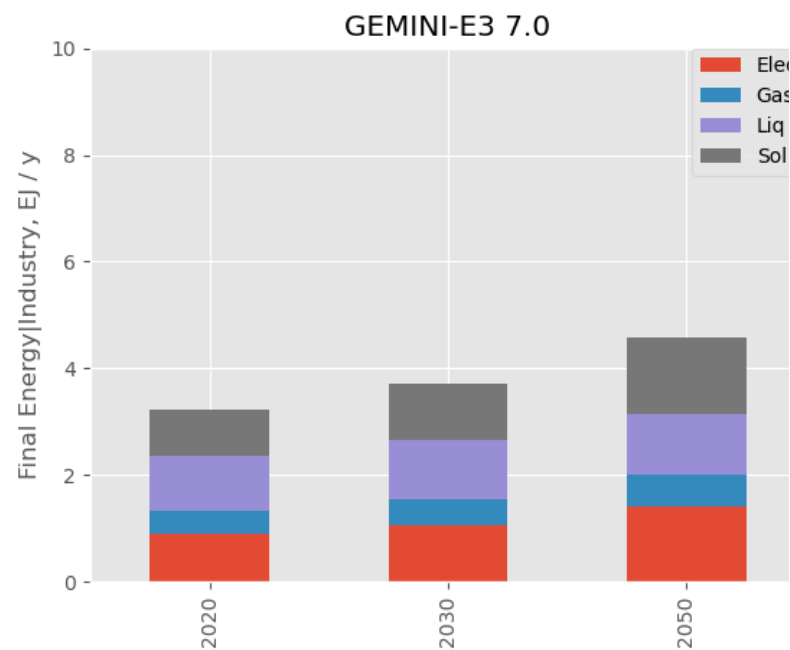
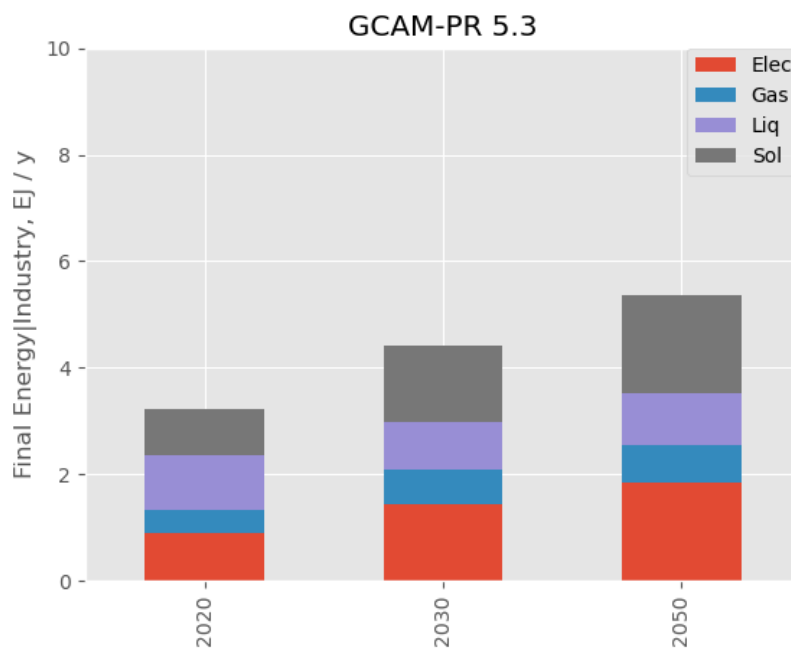
A low to moderate electrification is shown in transport



Electrification is projected to grow in buildings



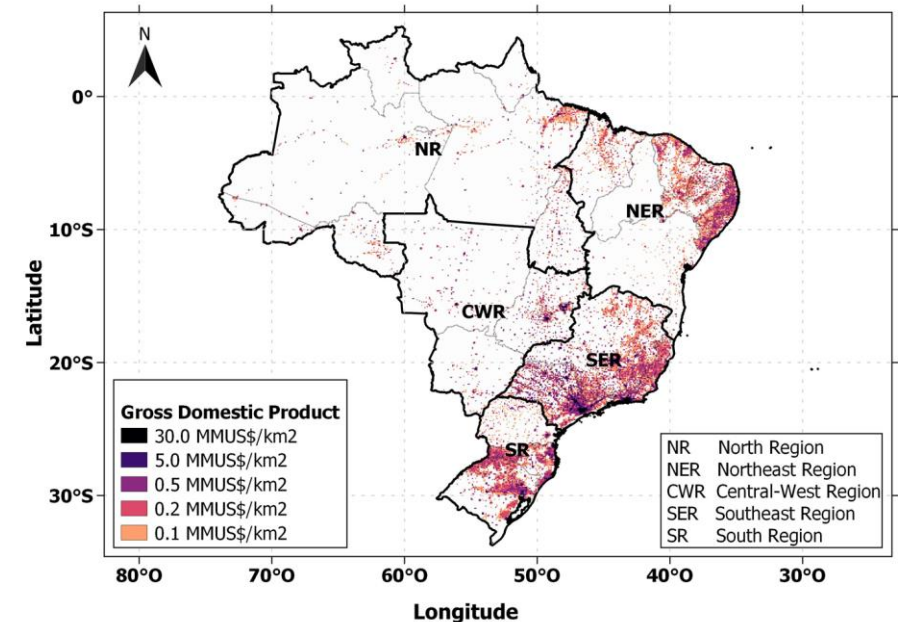
Fuel switching in industry favours liquid-to-electricity substitution



We use then the specific model from our ensemble of national models to project policies and model decarbonisation pathways

MUSE-Brazil

- Agent-based: modelling key players' decision-making
- Simulation model with limited foresight
- Low-carbon technologies: fuel switching, DAC, CCS (BECCS), electrification, hydrogen, renewables
- Socio-economic: "Business As Usual" (SSP2)
 - Giarola et al. (2021), Science of The Total Environment, 783

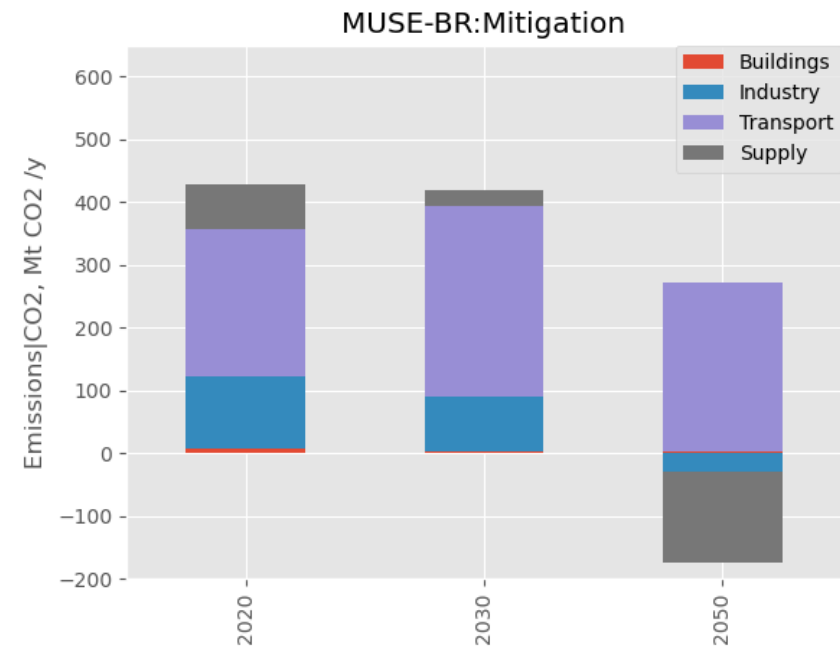
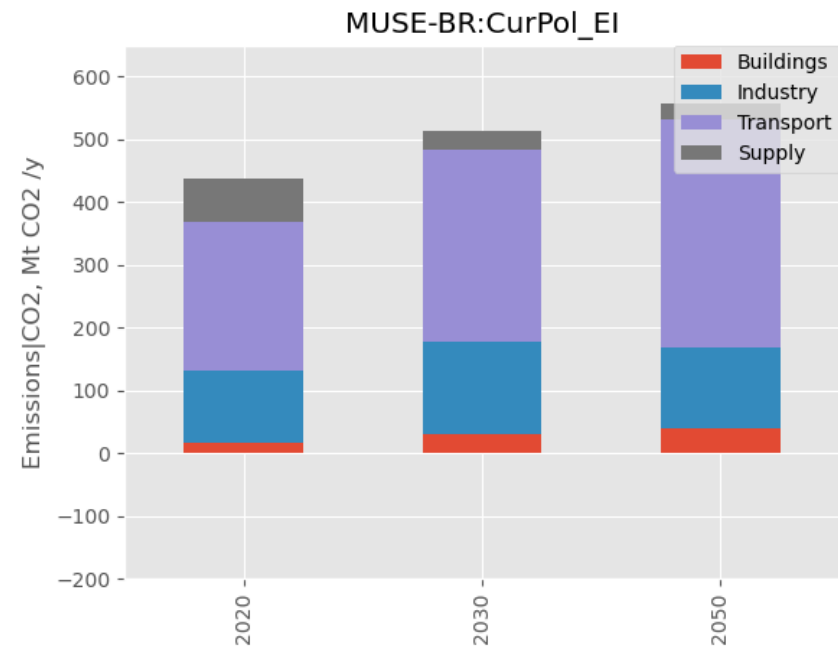


Scenarios

- Current policies: models current policies until 2030, constrains emissions between 2030 and 2050 extending the emission intensity reduction obtained from 2020 and 2030
- Mitigation: projects net-zero on energy system emissions before 2055 (by 2052)



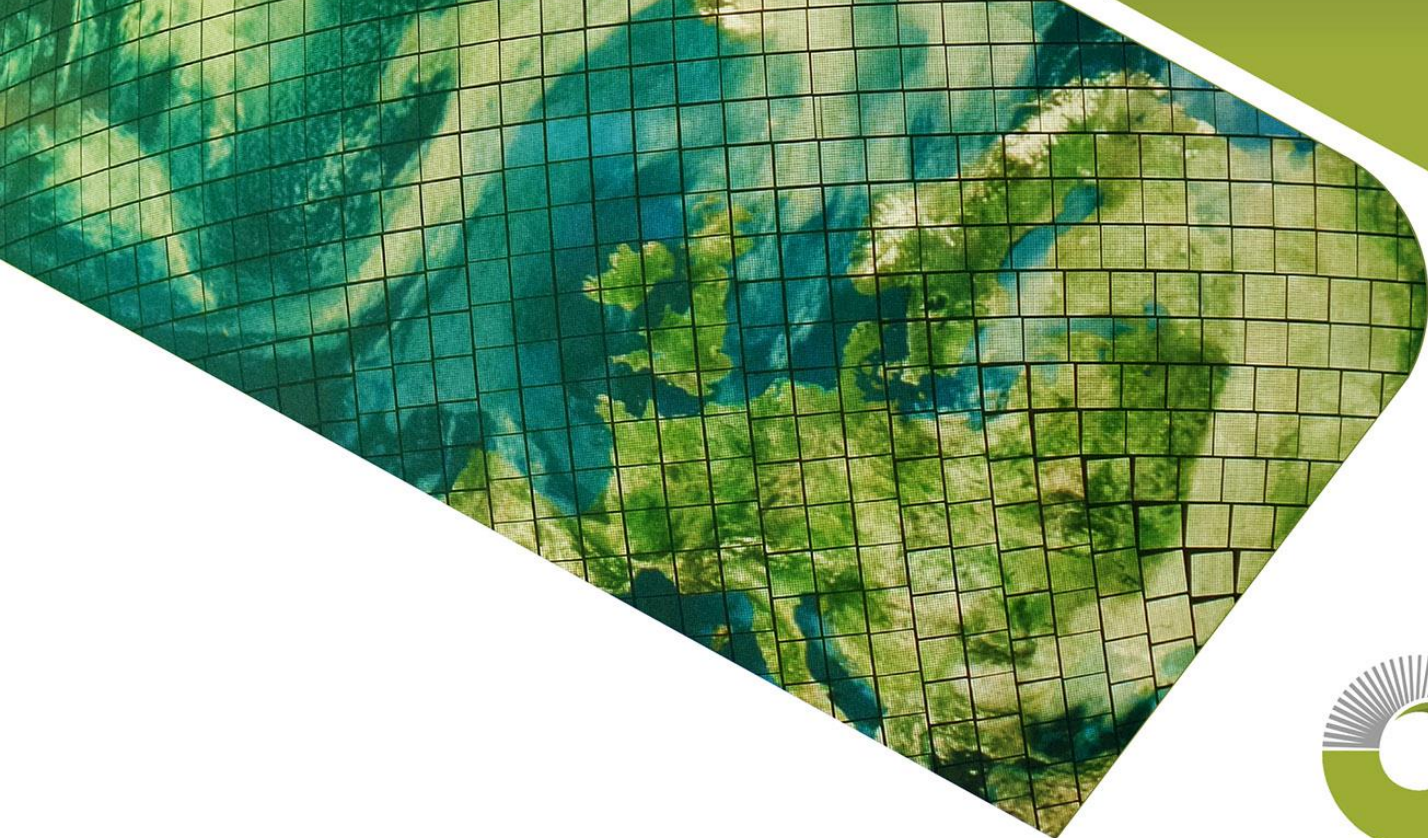
Mitigation anticipates emission peak before 2030



- The mitigation scenario shows a high reliance on biofuels (up to 80 % of road fuel use) and CCS (~350 Mt / y by 2050), as well as a lower role for electrification in road transport (lower than 15 % of road fuel use)
- Other mitigation studies show:
 - focus on bioenergy. AFOLU emissions are to be contained and CCS is important in energy and also fuel generation [1, 2]
 - some works analyse electrification of transport: they consider up to 50 % of the total fleet to become electrified and rely on modal split (private cars-to-electric buses) between 2030 and 2050 [3, 4]
- Is our projected role assumed for CCS too optimistic? Could electrification be considered a more important enabler of the transition?

1. Köberle A. et al (2022), *Cimatic Change*, 170; Can global models provide insights into regional mitigation strategies? A diagnostic model comparison study of bioenergy in Brazil
2. Rochedo P. et al (2018), *Nature Climate Change*, The thread of political bargaining to climate mitigation in Brazil, <https://doi.org/10.1038/s41558-018-0213-y>
3. La Rovere et al. (2015). Pathways to deep decarbonization in Brazil, SDSN – IDDRI
4. Baran and Legey (2013). *Technological Forecasting and Social Change*, 80, 907-917; The introduction of electric vehicles in Brazil: Impacts on oil and electricity consumption





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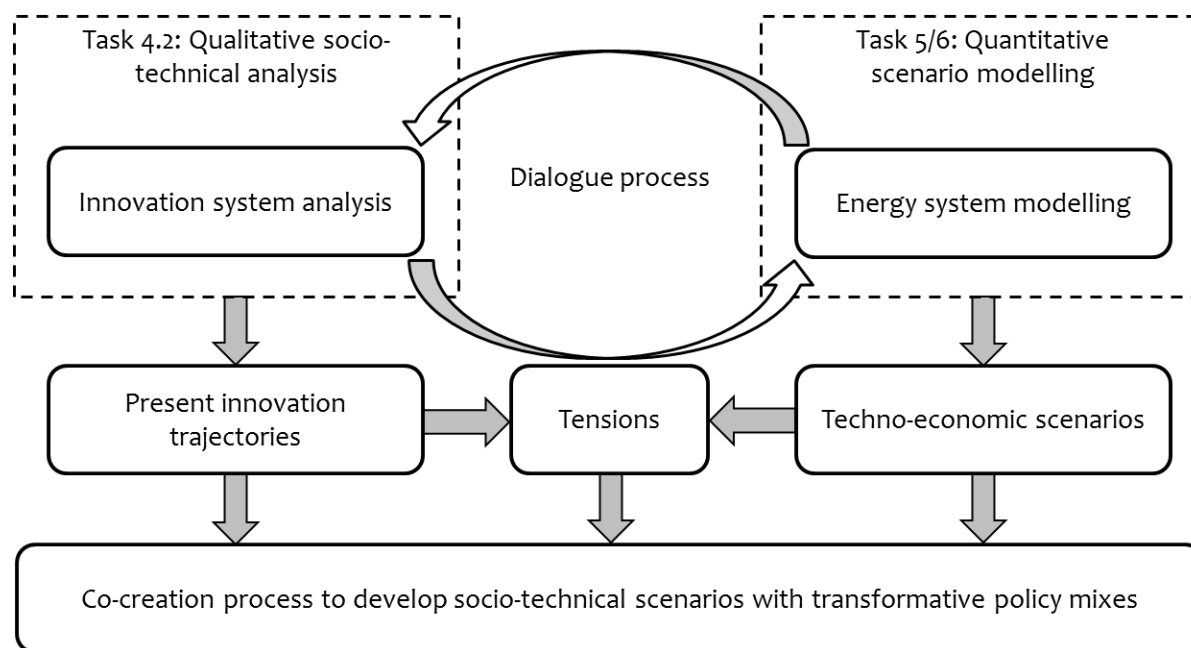
- Sectoral Analysis:**
- **CCS, bioenergy**
 - **Electrification of transport**

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Our objective within PARIS REINFORCE:

To extend quantitative techno-economic scenarios in line with the Paris targets to socio-technical narratives by describing a transformative policy mix based on innovation system analyses



Transformative policy mixes:

- combine technology push and demand pull but address also systemic concerns
- pay attention to societal experimentation + phase-out of non-sustainable practices
- involve new institutional arrangements and governance structures

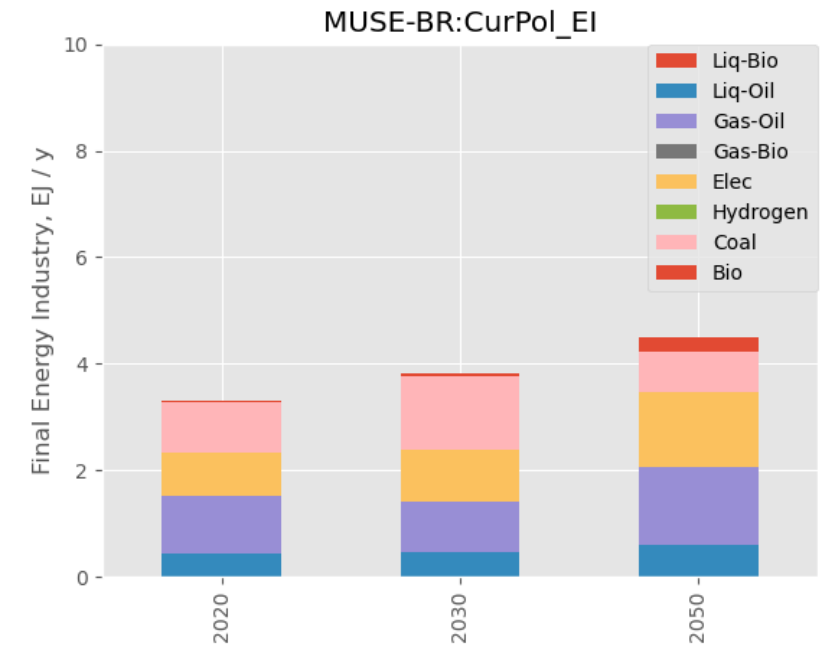
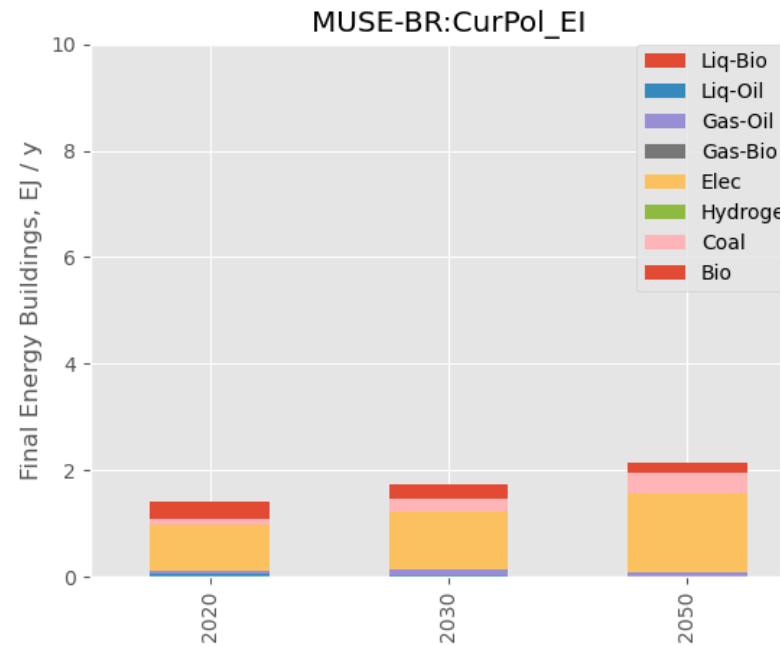
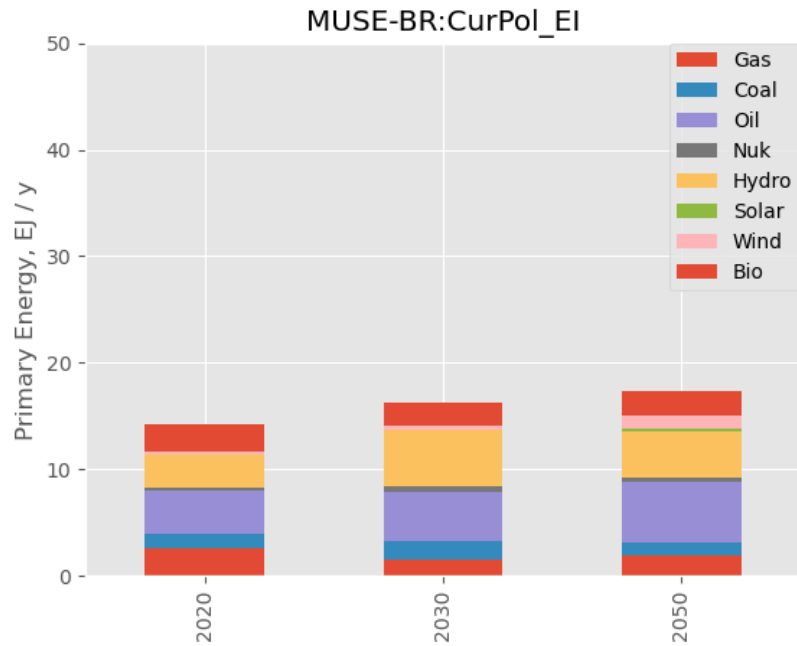
Case study for Brazil: Sustainable transport

- Innovation system analysis for the fuel sector in Brazil
- Reference and Deep Mitigation Scenario based on the MUSE Brazil model.

Sources: own representation

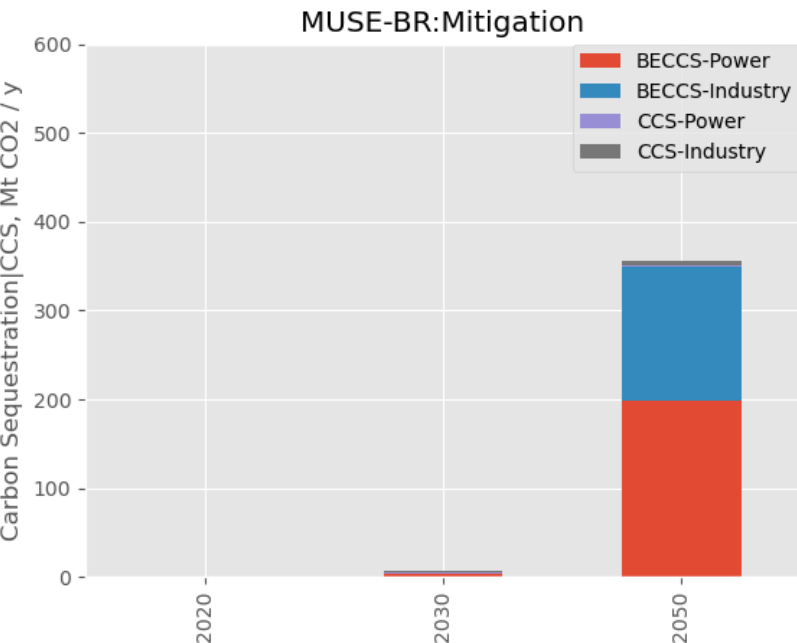
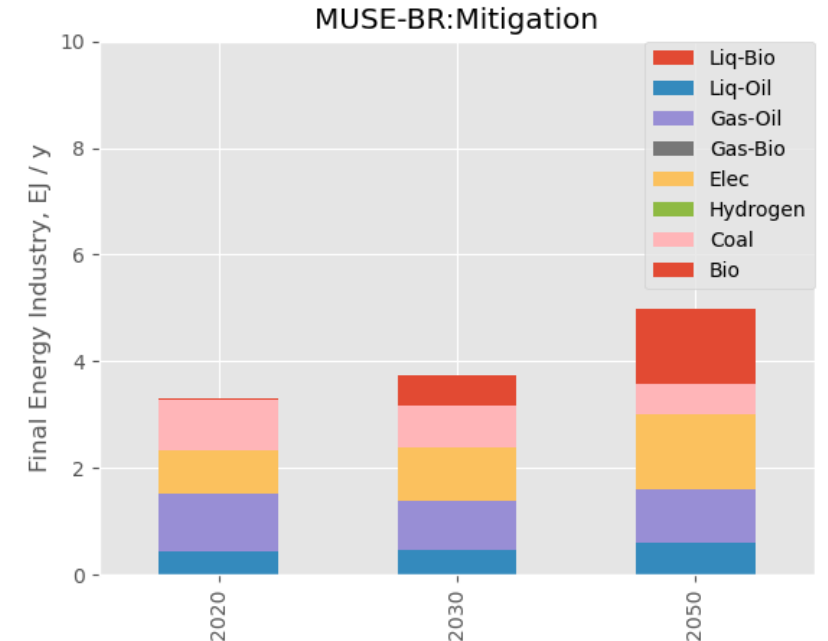
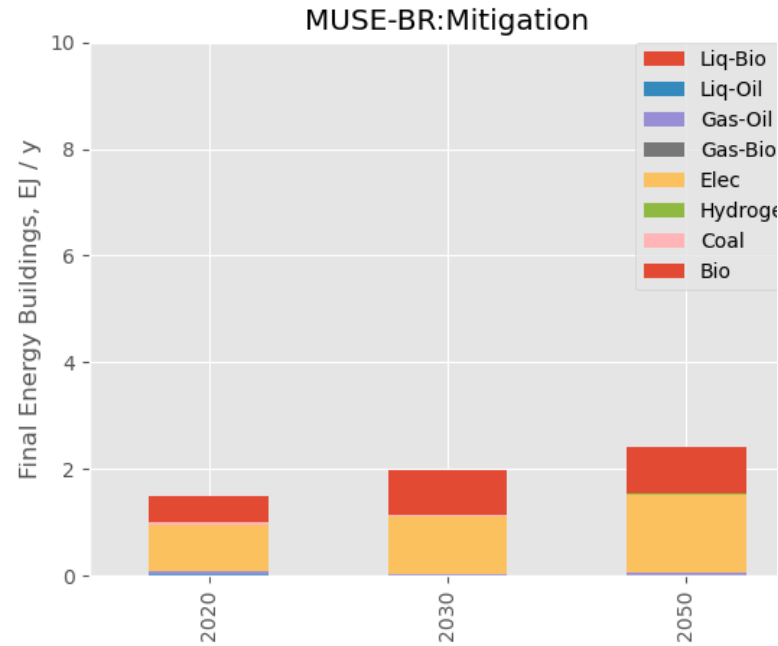
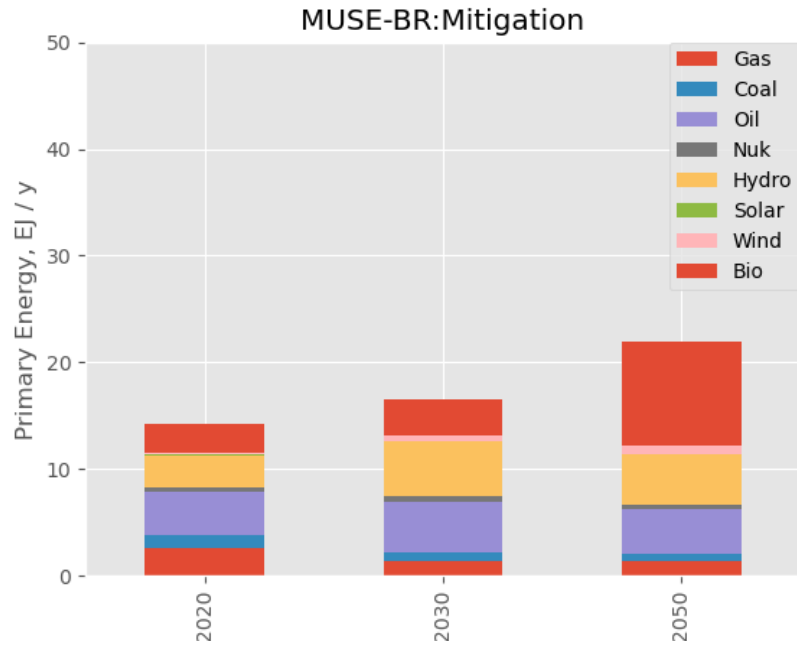


The reference scenario for energy supply in Brazil



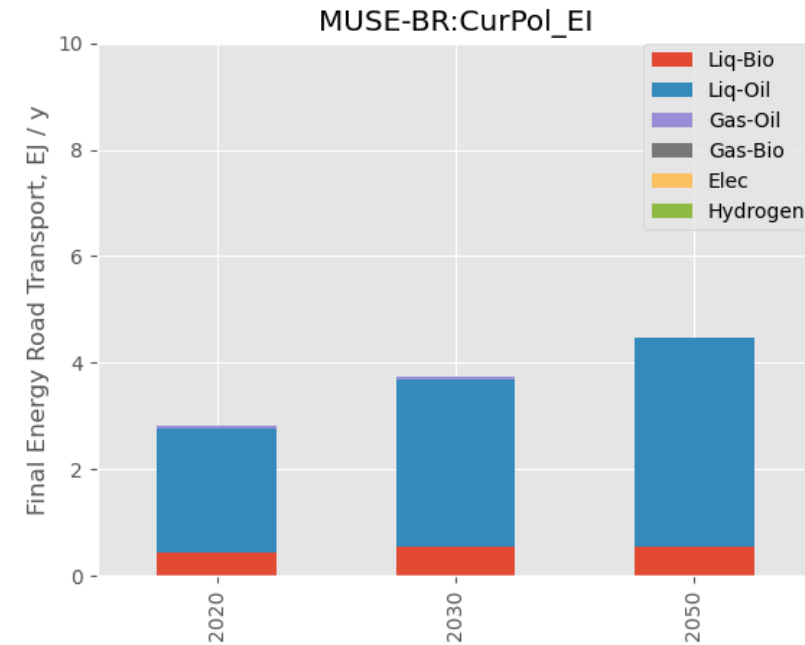
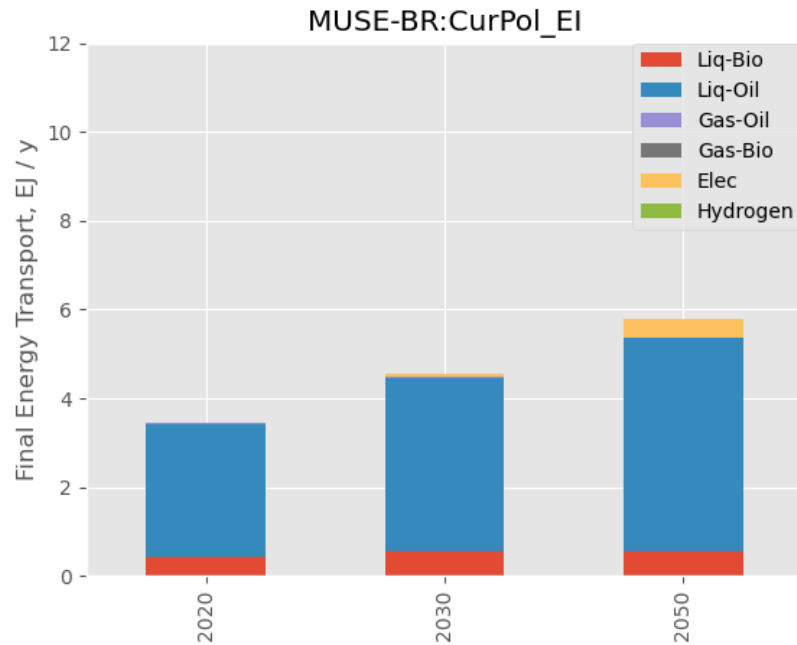
Energy supply sector in Brazil	Assumptions in the reference scenario	Key findings in the reference scenario
CCS	<ul style="list-style-type: none"> CCS and DAC available in industry, power generation, and fuel generation 	<ul style="list-style-type: none"> No substantial use of CCS
Bioenergy	<ul style="list-style-type: none"> Target on bioenergy capacity (13 GW) by 2030 	<ul style="list-style-type: none"> Use of biomass increases stable: in power generation biomass competes with uptake of renewables
Overall	<ul style="list-style-type: none"> Target on solar (3.5 GW), wind (27.1 GW), and hydro (123.7 GW) by 2030 Carbon price profile to extend policies beyond 2030 	<ul style="list-style-type: none"> Overall primary energy slightly increases, as service demand growth is compensated by increase in efficiency targets

The deep mitigation scenario for energy supply in Brazil



Energy supply sector in Brazil	Assumptions in the deep mitigation scenario	Key findings in the deep mitigation scenario compared to the reference
CCS	<ul style="list-style-type: none"> CCS (and BECCS) available in industry, power generation, and fuel generation 	<ul style="list-style-type: none"> Strong expansion of CCS in energy supply and industry
Bioenergy	<ul style="list-style-type: none"> Same socio-economic, technology, and policy assumptions as in reference 	<ul style="list-style-type: none"> Strong expansion of bio-energy use
Overall	<ul style="list-style-type: none"> Higher carbon prices than reference to reach net-zero 	<ul style="list-style-type: none"> Other changes limited

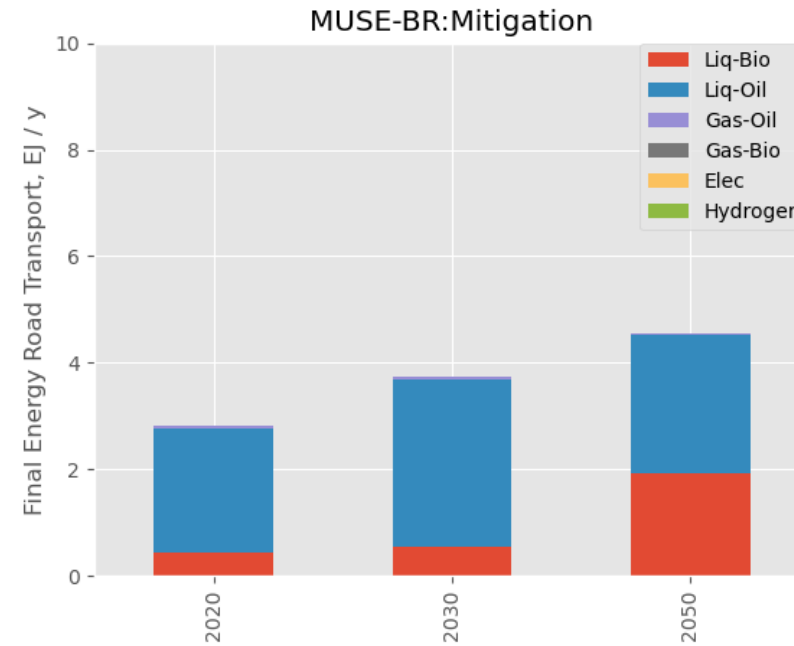
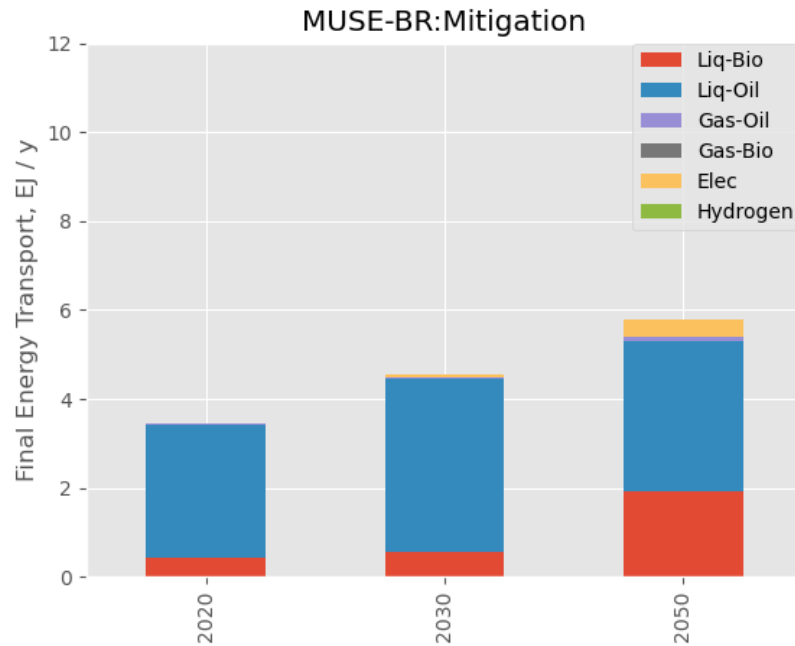
The reference scenario for the transport sector in Brazil



Transport sector in Brazil	Assumptions in the reference scenario	Key findings in the reference scenario
Overall	<ul style="list-style-type: none"> All low-carbon technologies available 	<ul style="list-style-type: none"> Increase of energy demand No contribution from hydrogen
Road transport	<ul style="list-style-type: none"> Biofuel share to 27 % and 10 % for ethanol and biodiesel in ICE engines Efficiency targets in ICE engines 	<ul style="list-style-type: none"> Use of gases to a limited extent Electrification of buses (post 2050)
Other modes	<ul style="list-style-type: none"> Electrification and hydrogen options 	<ul style="list-style-type: none"> Electrification of trains

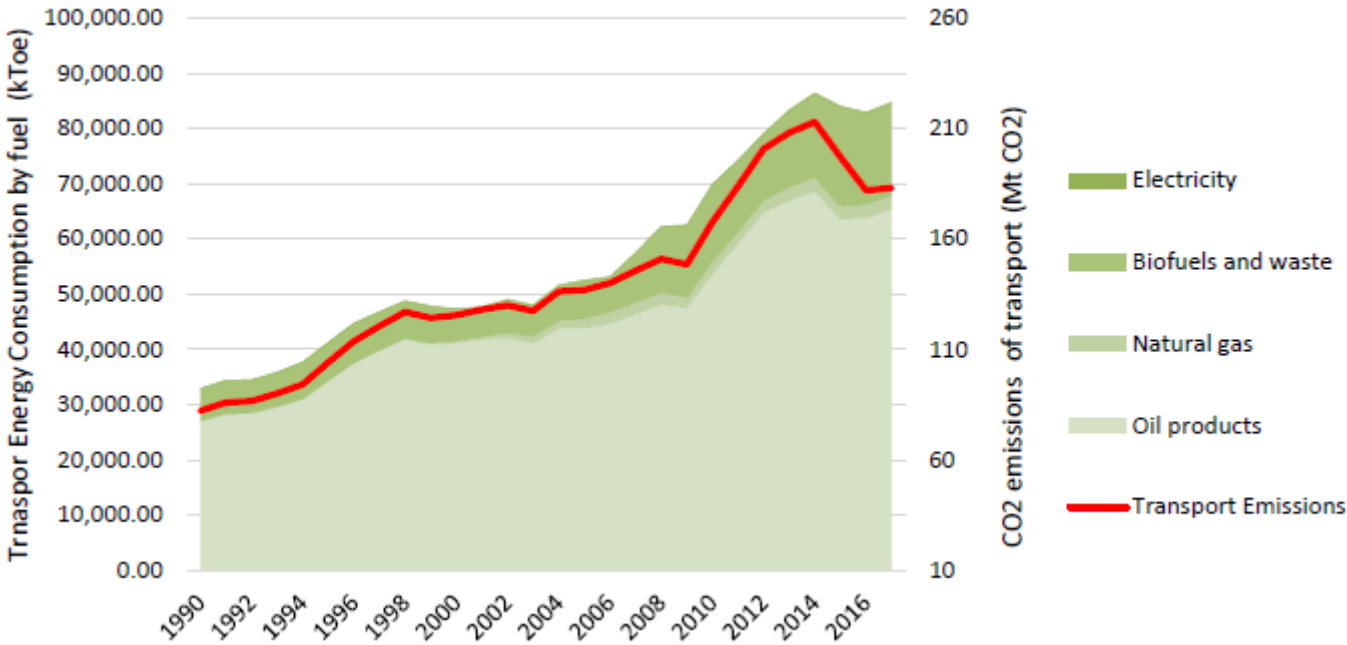


The deep mitigation scenario for the transport sector in Brazil



Transport sector in Brazil	Assumptions in the deep mitigation scenario	Key findings in the deep mitigation scenario compared to the reference
Overall	<ul style="list-style-type: none"> Higher carbon price to reach net-zero 	<ul style="list-style-type: none"> Increase in energy demand No contribution from hydrogen
Road transport	<ul style="list-style-type: none"> Same socio-economic, technology, and policy assumptions as in reference 	<ul style="list-style-type: none"> Use of gases to a limited extent Increase in use of biofuels Higher electrification (post-2050)
Other modes	<ul style="list-style-type: none"> Same socio-economic, technology, and policy assumptions as in reference 	<ul style="list-style-type: none"> Similar electrification for trains as in reference

- Despite Brazil being a prominent biofuel producer, fossils accounted for 77% in the transport energy mix
- Recent emissions reduction due to the introduction of the flex-fuel (ethanol blend) LDV fleet (2003) and the biodiesel legislation in 2005 (and 2017) for freight transport (HDV)



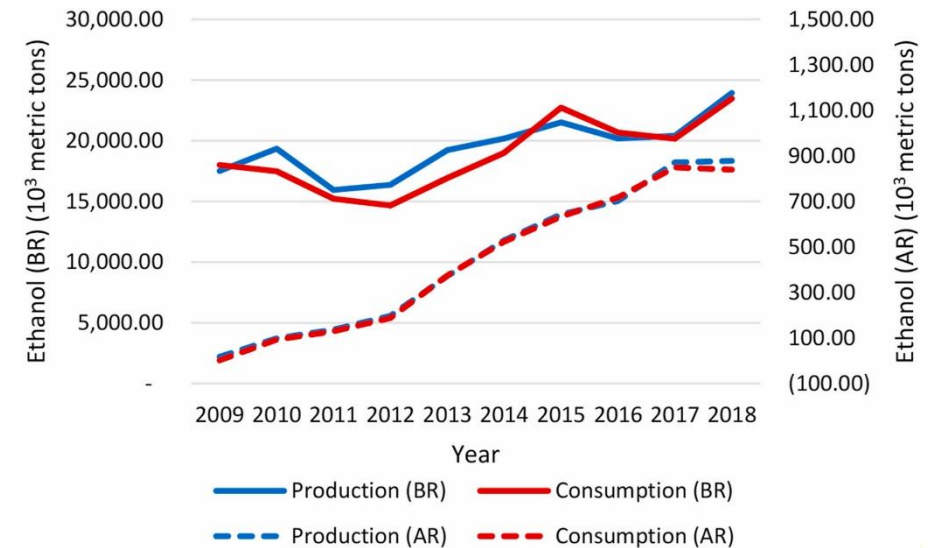
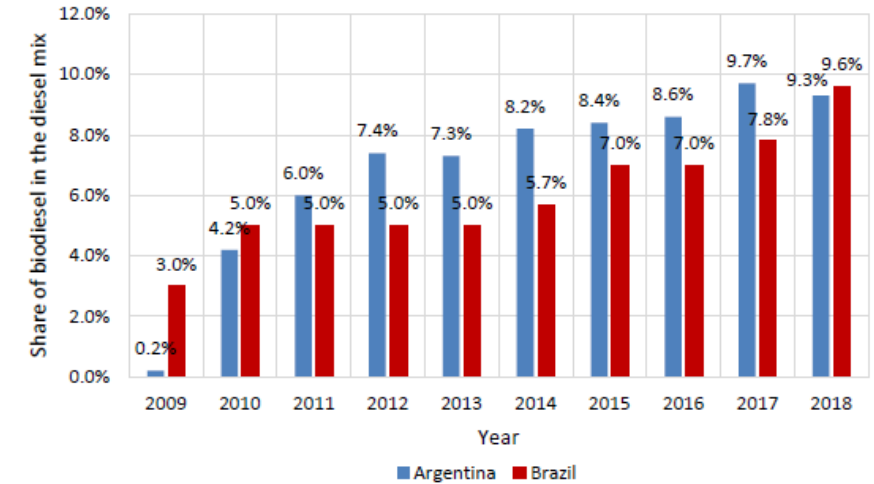
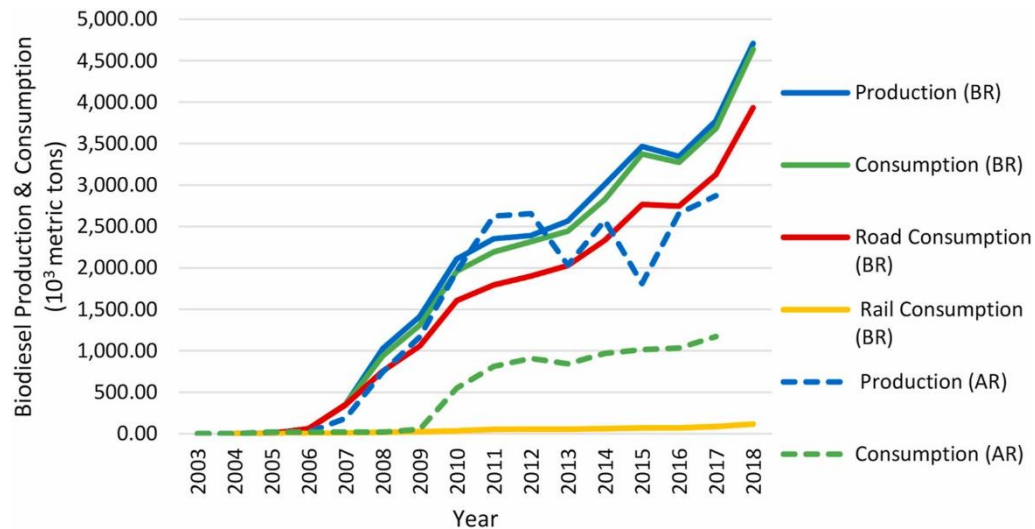
Third Period (2005-2018)			
		2005	2018
Oil Products	They also include diesel and gasoline. New LDVs introduced in 2003 that led to a more efficient fleet. Passenger vehicles used solely gasoline. Freight transport, on the other hand, is heavily dependent on diesel.	Almost 84%	Reduced at 77%
Biofuels	Mainly increased due to national environmental policy. Brazil focuses on self-consumption, 10% mandate. Key policy questions: How do we move forward? How to improve variety in biofuel feedstock?	13%	Increased to almost 20%
Natural gas	No important increase in this period. No policies related to this fuel type.	Around 3%	Around 3%
Actors	<ul style="list-style-type: none"> • Petrobras, global oil company located in Brazil • IBP (Brazilian Petroleum, Gas and Biofuels Institute), introduced to represent the industry's companies. • National Petroleum Agency (ANP) • National Council for Energy Policy (CNPE) 		
Legislation	2005: PNB (Brazilian Biodiesel Program): Aiming for the increased use of biofuels such as biodiesel. 2017: RenovaBio with higher biofuel targets, affected by the NDCs set in the Paris Agreement.		



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Source: Nikas, A. et al. (2022)

- Biodiesel production rapidly rising in the previous decade, mainly consumed domestically.
- After reaching the 10% mandate in the fuel mix, concerns over the ability to meet demand forced abandoning the 12% pledge.
- After the post-1975 ethanol rise, market remained stagnated, only recently showing signs of growth

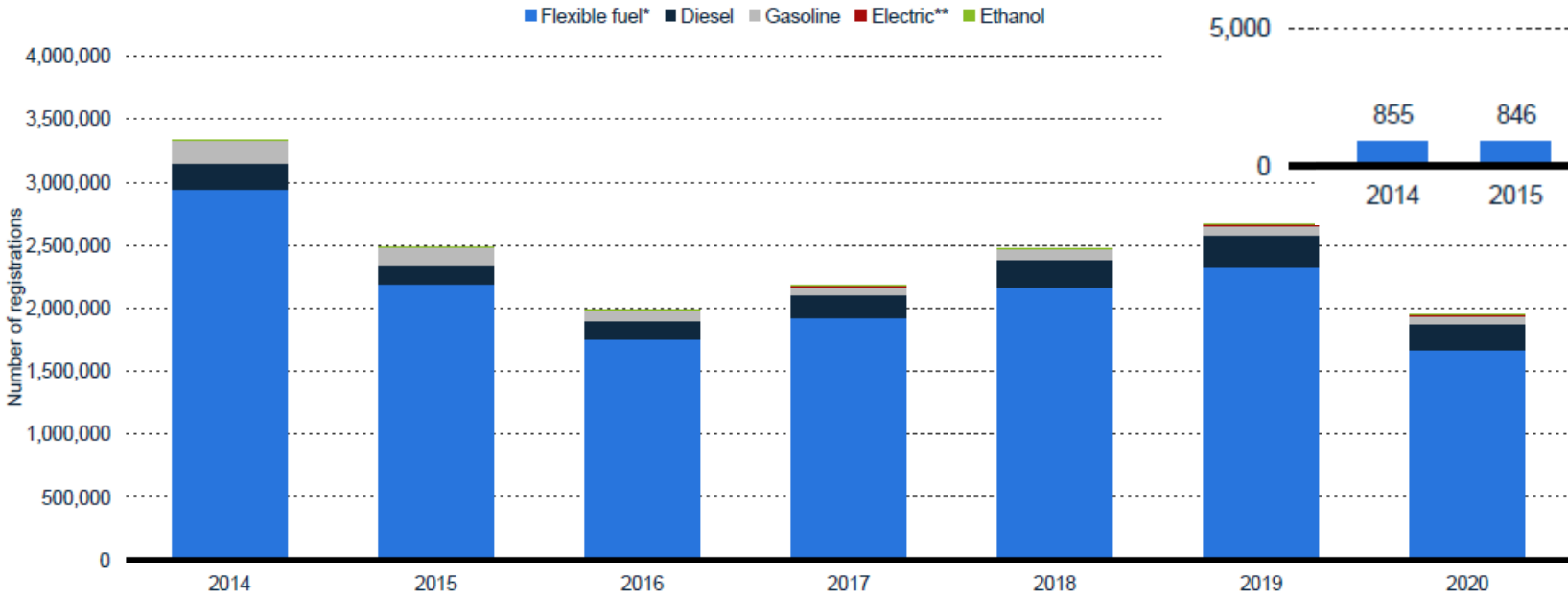
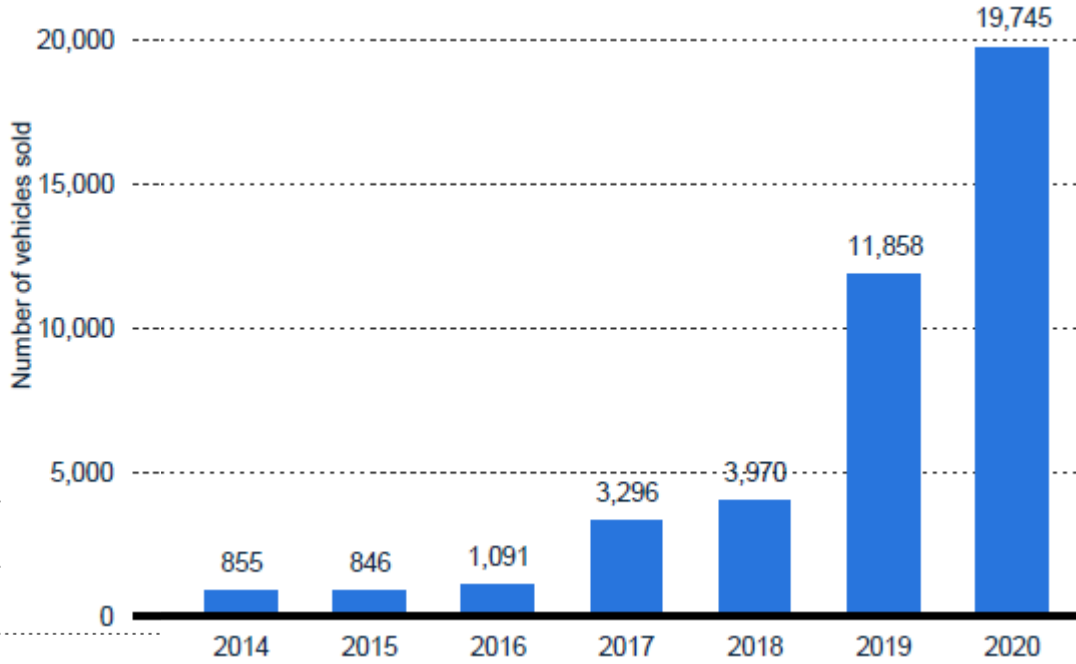


Source: Nikas, A. et al. (2022)



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- Early in 1975, ethanol started being a substitute for gasoline (LDV fleet),
- Currently, LDV sales is still strongly dominated by flex fuel vehicles, which can use both ethanol and gasoline
- E-vehicles sales have started to grow exponentially since 2016, but absolute levels are still comparably low



Source: STATISTA based on Associação Nacional dos Fabricantes de Veículos Automotores; RENAAM; Associação Brasileira do Veículo Elétrico



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	Transformation bottlenecks (generic examples!!)
Social feasibility	<ul style="list-style-type: none"> • lack of acceptance by important groups • deviation from societal trends + norms • required behavioral changes
Political feasibility	<ul style="list-style-type: none"> • established power structures • limitations of current political system. • deviation from political targets + strategies
Technological feasibility	<ul style="list-style-type: none"> • transformation of physical infrastructures • required technological maturity of certain technologies not yet available
Economic feasibility	<ul style="list-style-type: none"> • mobilizing needed investments • need of importing certain goods. • deviation from current market trends
Socio-economic impacts	<ul style="list-style-type: none"> • job losses • price increases deemed unacceptable
Socio-ecological impacts	<ul style="list-style-type: none"> • additional uses of land and other natural resources deemed unacceptable

Source: Wachsmuth, J.; Jackwerth-Rice, T.; Seus, S.; Warnke, P. (2021): Outlining a Methodology for Co-Creating Transformative Policy Mixes. Full paper at the IST 2021 conference.



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Conceptual background: Transformation bottlenecks + policy mix elements

	Transformation bottlenecks (generic examples!!)	Relevant policy mix elements (generic examples!!)
Social feasibility	<ul style="list-style-type: none"> • lack of acceptance by important groups • deviation from societal trends + norms • required behavioral changes 	<ul style="list-style-type: none"> • Inclusive policy making: Processes that foster dialogue, new ways of thinking or interaction modes, societal experimentation, user spaces or demonstration projects, e.g. roundtables, living labs • Flexible governance: adaptive mechanisms that reflect power structures btw. governments, market actors + civil society, e.g. public private partnerships • Systemic instruments: linking different elements (stakeholder and activities) of innovation systems, e.g. institutionalized niche markets
Political feasibility	<ul style="list-style-type: none"> • established power structures • limitations of current political system. • deviation from political targets + strategies 	
Technological feasibility	<ul style="list-style-type: none"> • transformation of physical infrastructures • required technological maturity of certain technologies not yet available 	<ul style="list-style-type: none"> • Technology push: Instruments that pay attention to innovative technology options, e.g. grants for demonstration projects, investment loans • Demand pull: Mechanisms that stimulate the demand side (economic or regulatory), e.g. quotas, contracts for difference • Systemic instruments: mechanisms that foster the provision of the required infrastructures, e.g. regulation of discriminatory-free access
Economic feasibility	<ul style="list-style-type: none"> • mobilizing needed investments • need of importing certain goods. • deviation from current market trends 	
Socio-economic impacts	<ul style="list-style-type: none"> • job losses • price increases deemed unacceptable 	<ul style="list-style-type: none"> • Systemic instruments: mechanisms that tackle structural change and social inequalities as well as socio-ecological impacts • Inclusive policy making: processes that foster participation of 'dormant' stakeholder
Socio-ecological impacts	<ul style="list-style-type: none"> • additional uses of land and other natural resources deemed unacceptable 	

Source: Wachsmuth, J.; Jackwerth-Rice, T.; Seus, S.; Warnke, P. (2021): Outlining a Methodology for Co-Creating Transformative Policy Mixes. Full paper at the IST 2021 conference.



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Transformation bottlenecks for the transport sector in Brazil

	Bottlenecks for more ambition in the transport sector (literature-based, ELABORATED DURING THE WORKSHOP)	Bottlenecks for realization of the deep mitigation scenario (literature-based, ELABORATED DURING THE WORKSHOP)
Social feasibility	<ul style="list-style-type: none"> • Lack of integration of family farmers into production process • Private consumer uptake of e-mobility 	<ul style="list-style-type: none"> • Acceptance of BECCS • Acceptance of large-scale hydropower expansion
Political feasibility	<ul style="list-style-type: none"> • Partial resistance by oil and automotive industries 	<ul style="list-style-type: none"> • Resistance by powerful actors with other interests • No CCS legal framework yet (mainly onshore; first initiative a few months ago)
Technological feasibility	<ul style="list-style-type: none"> • Maturity of advanced biofuels (which?) • Infrastructure rollout for e-mobility • Lack of global battery production capacities 	<ul style="list-style-type: none"> • Maturity of CCS technologies
Economic feasibility	<ul style="list-style-type: none"> • Growing transport activity • fossil Diesel dominating for heavy-duty vehicles (HDVs) • Infrastructure for expansion of railways • Access to credits (batteries, no incentives) 	<ul style="list-style-type: none"> • Large-scale investments in BECCS needed with uncertain revenue
Socio-economic impacts	<ul style="list-style-type: none"> • Increasing costs of mobility (Diesel price sensitivity) 	<ul style="list-style-type: none"> • Potential job losses in oil sector • ...
Socio-ecological impacts	<ul style="list-style-type: none"> • Potential negative impacts of biofuel production on deforestation, biodiversity and food security 	<ul style="list-style-type: none"> • Potential negative impacts of large-scale hydropower expansion

Source: own representation of Koasidis, K. et al. (2020a) and expert knowledge

