“O futuro da Matriz Veicular no Sistema Energético Mundial”

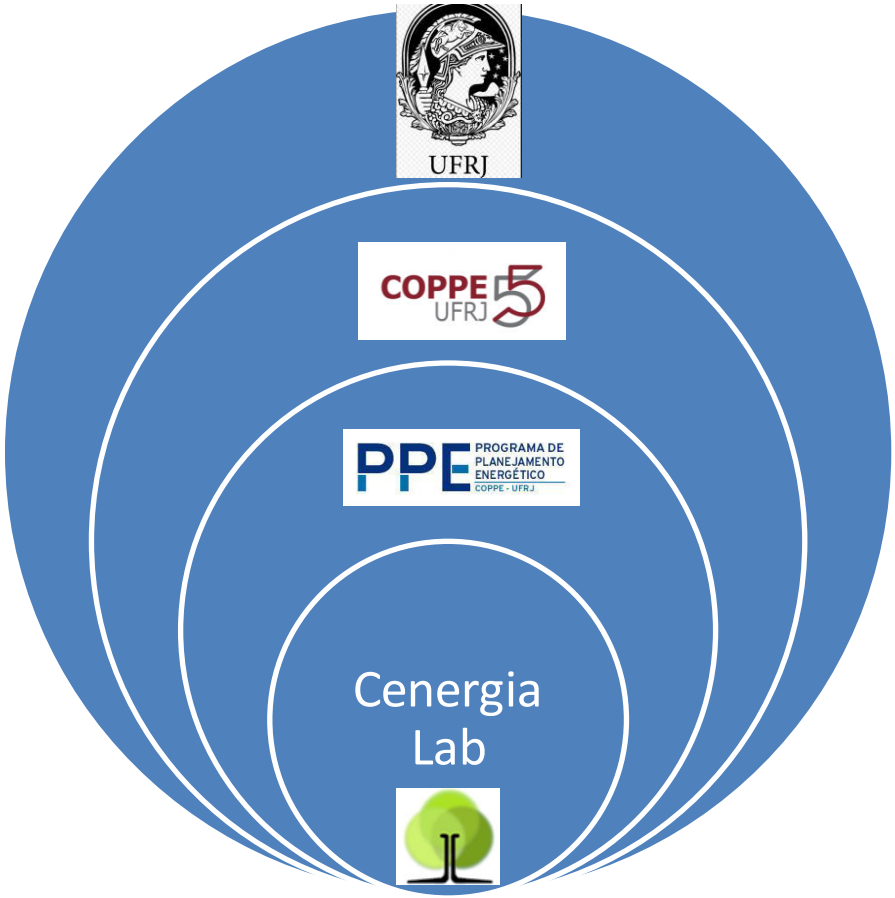
Alexandre Szklo

Prof. Associado COPPE/UFRJ

D.Sc

Eng. Químico

11 de Junho de 2019


UFRJ
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PROGRAMA DE
PLANEJAMENTO
ENERGÉTICO
COPPE - UFRJ
Cenergia
Lab

1. Ressalvas Gerais
2. Contexto
   i. Expansão da produção de HC leves
   ii. BEVs
   iii. Demografia
3. Oportunidades para Bioenergia
   i. Cenários de Longo Prazo
   ii. Novos usos - energia
   iii. Novos usos – materiais

1. **Ressalvas Gerais**
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Antes de tudo, uma ressalva de engenheiro químico que pode me dar um ar arrogante...

Muito do que tratarei aqui tem a ver com a diferença entre :

Equilíbrio versus Cinética

1. não há mais transferência de calor (equilíbrio térmico)
2. não há forças em desequilíbrio (equilíbrio mecânico)
3. não há transferência de massa e/ou reações químicas (equilíbrio químico)

X $velocidade = f \times p \times z$

Agora a ressalva de modéstia de quem desenvolve modelos matemáticos de engenharia

(se tiver tempo, mas não terei, farei um comentário judaico sobre modéstia...)

"The models **fail**, …

..as the Greek Demosthenes warned: "for every man believes what he wishes, though the reality is often different."

…

In this case, the use of mathematical tools by engineers like us should, as Craig et al. 2002 said: "...illuminate the consequences of action or inaction and thus lead to changes in behavior…," so that "…predicting problems can lead to changes that avoid them…".

(Szklo and Schaeffer, 2018, in Nature Research – Behavioural & Social Sciences)

9 ENCONTRO INTERNACIONAL COM O MERCADO AMÉRICA DO SUL 2019

LUBES TEM POLO

Com a colaboração de ICIS

Congresso de Bioenergia

"Etanol *Fluctuat nec mergitur*"

Alexandre Szklo

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Eng. Químico

COPPE UFRJ 55

31 de Julho de 2019

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Title: Market Fundamentals, Speculation and the Oil Price -SVAR analysis of the 1991-2015 period

Article Type: Full Length Article

Keywords: sign restriction; oil price; speculation

Corresponding Author: Mrs. Raquel Gonçalves,

Corresponding Author's Institution: UFRJ

First Author: Raquel Gonçalves

Order of Authors: Raquel Gonçalves; Alexandre Szklo, Professor; André Lucena, Professor

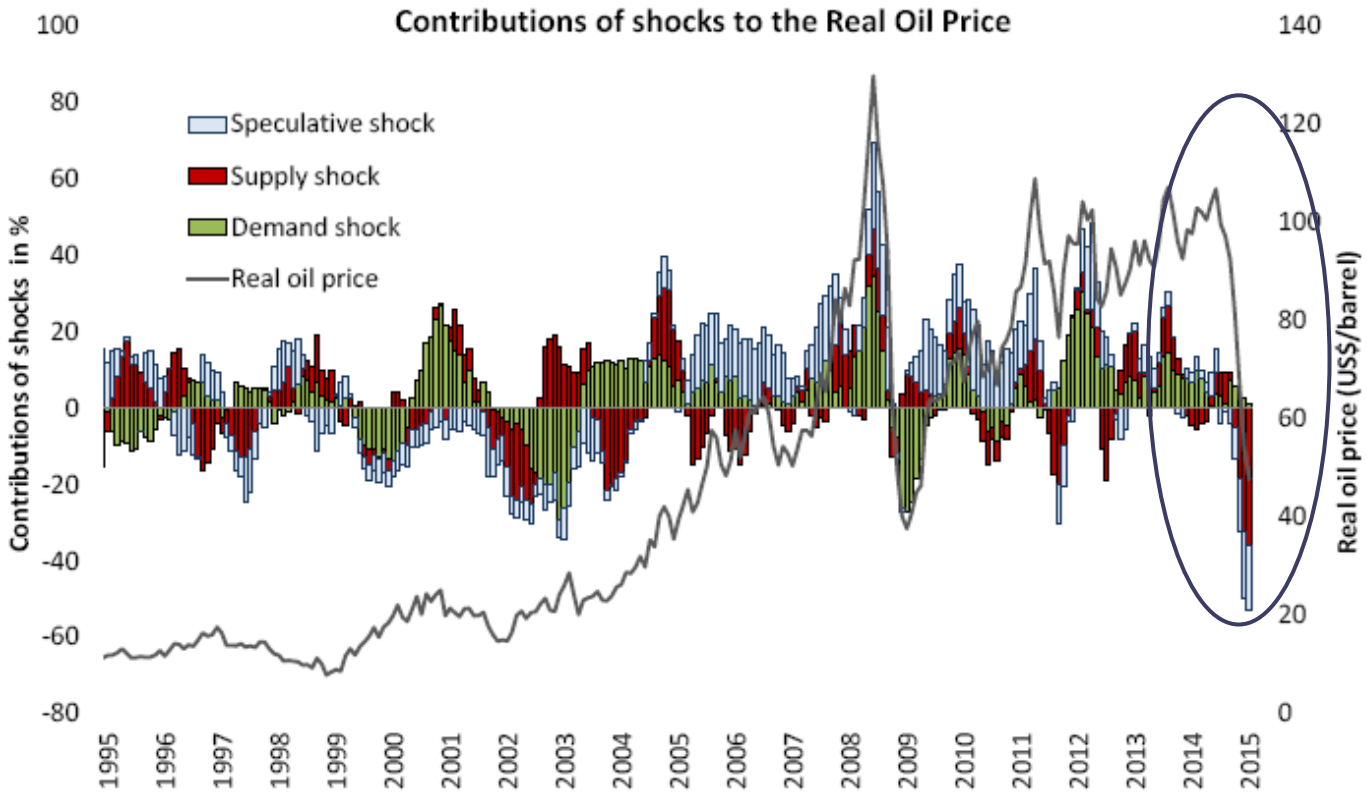
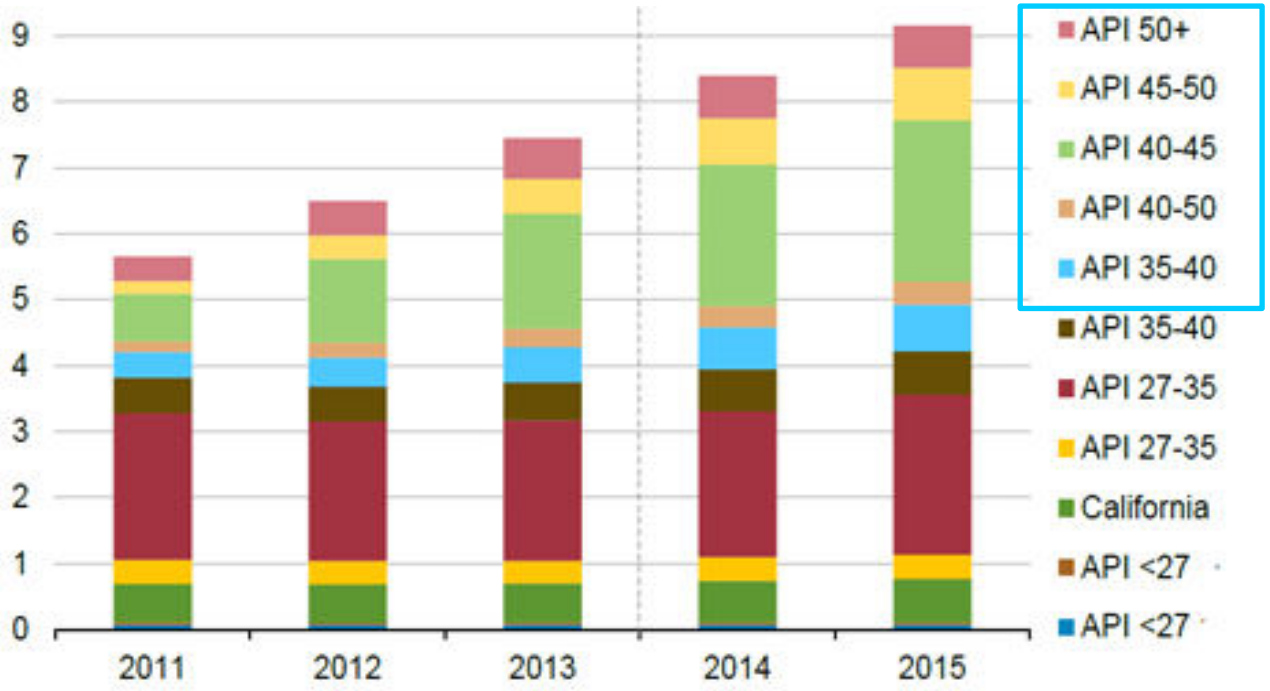


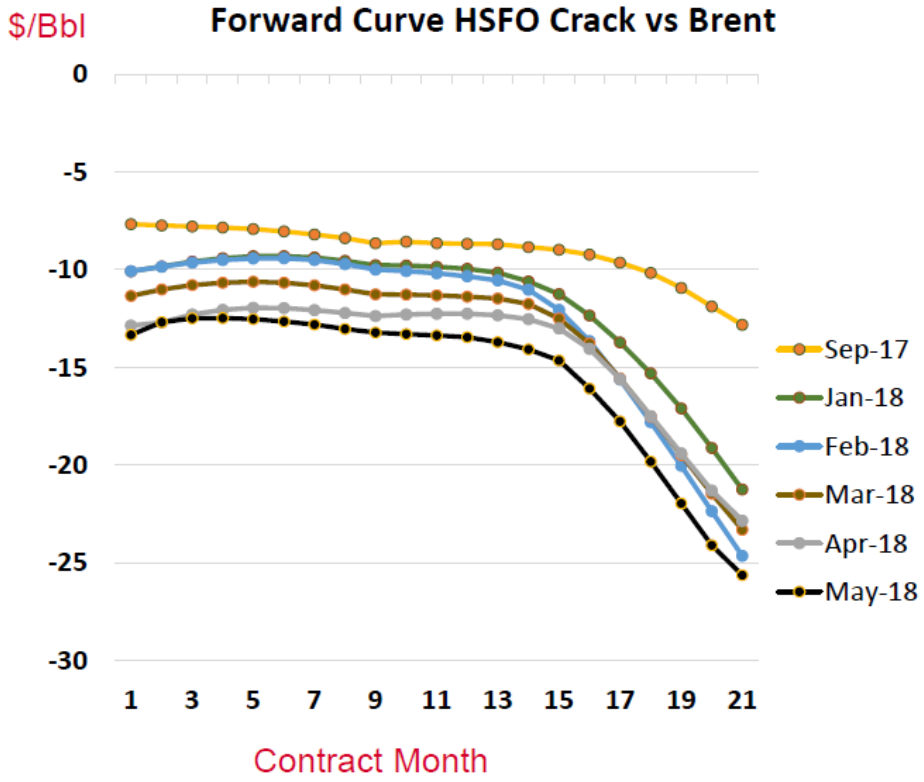
Figure 5 – Historic decomposition of the real oil price (WTI)

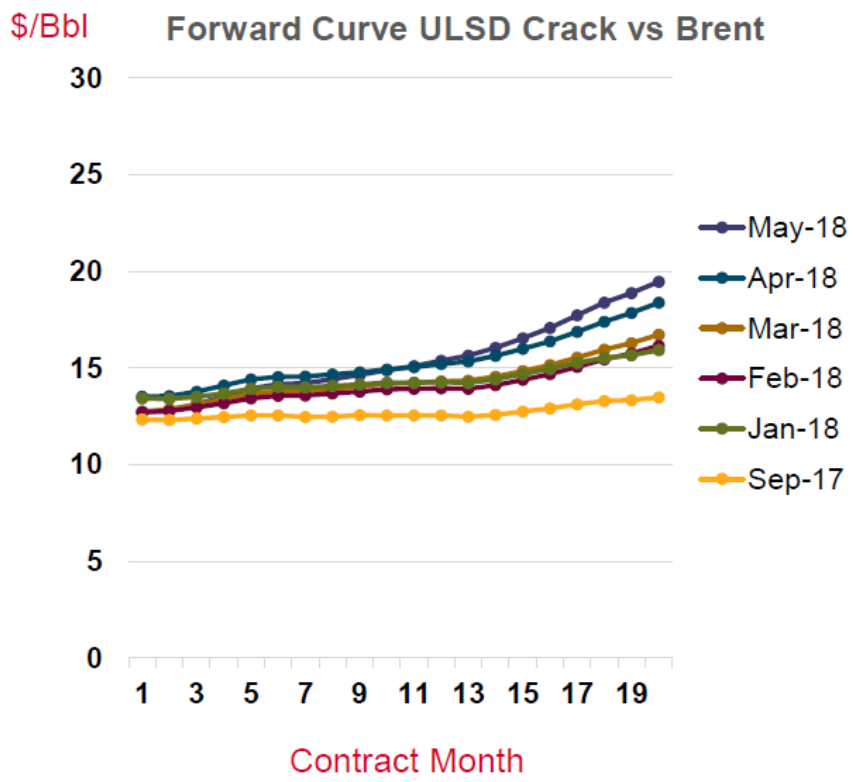


Produção de óleo bruto nos Estados Unidos por faixa de API, em MM bpd

MAKING WAVES:
FINAL COUNTDOWN TO IMO 2020

Rick Joswick
May 22, 2018






2.4
2.2
2
1.8
1.6
1.4
1.2
Jan 2018
Apr 2018
Jul 2018
Oct 2018
Jan 2019
Apr 2019
SOURCE: TRADINGECONOMICS.COM | OTC


RB1!
M
RBOB Gasoline Futures · 1M · NYMEX
O2.0528 H2.0854 L1.9264 C1.9909 −0.1323 (−6.23%)
End of Day
3.5000
3.0000
2.5000
1.9909
1.5000
1.0000
2015
2017
2019
2021

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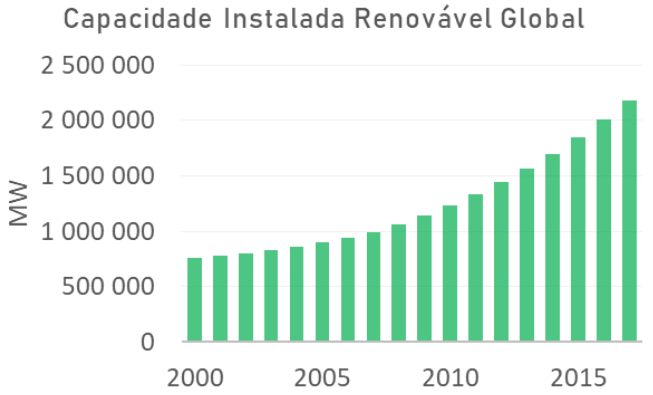
IEA: “Quando a China muda, tudo muda”

2017

- ✓ Rápido aumento da capacidade instalada renovável, custos decrescentes
- ✓ Crescente eletrificação da energia
- ✓ Grandes investimentos e avanços tecnológicos de tecnologias renováveis
- ✓ Maior orientação da economia chinesa para serviços e matriz energética mais limpa



IRENA (2018)

Zotin, 2018

Impactos ambientais locais e escalada de protestos por qualidade ambiental

Poluição do ar:

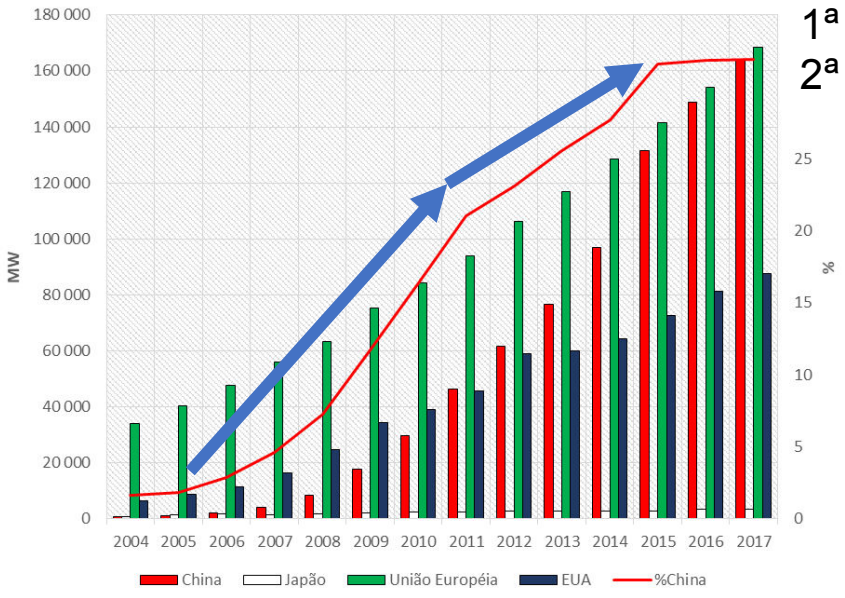
- Baixa eficiência do uso da energia
  - Carvão, indústria pesada, fornos domésticos
  - Emissões automotivas
- Poluentes primários e secundários
- Morte prematura de 1-1,2 mi pessoas/ano entre 1990 e 2015
- Perdas econômicas anuais de 0,5-6% do PIB
- MP: 11,1% de todas as mortes no país
- Urbanização e envelhecimento da população

Escalada de protestos por qualidade ambiental

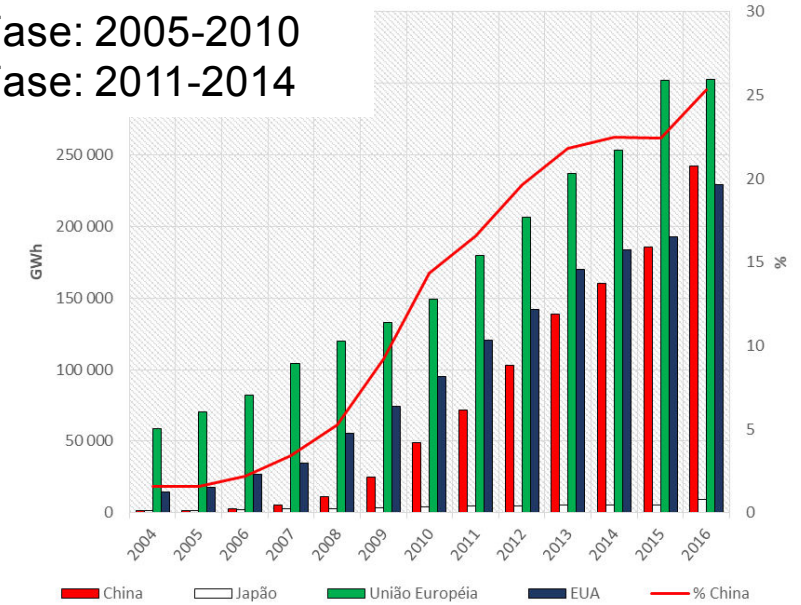
- 510.000 casos em 2005, em crescimento
- ONGAs pautam que NYMBY seja contornado
- Petições: 616.000 em 2006, crescem 30% a.a.
- Estabilidade social ameaçada

Zotin, 2018

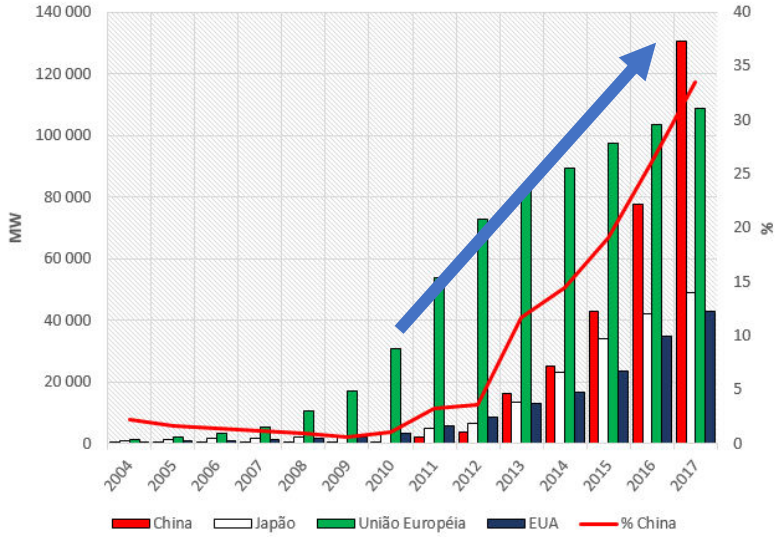
1ª Fase: 2005-2010
2ª Fase: 2011-2014



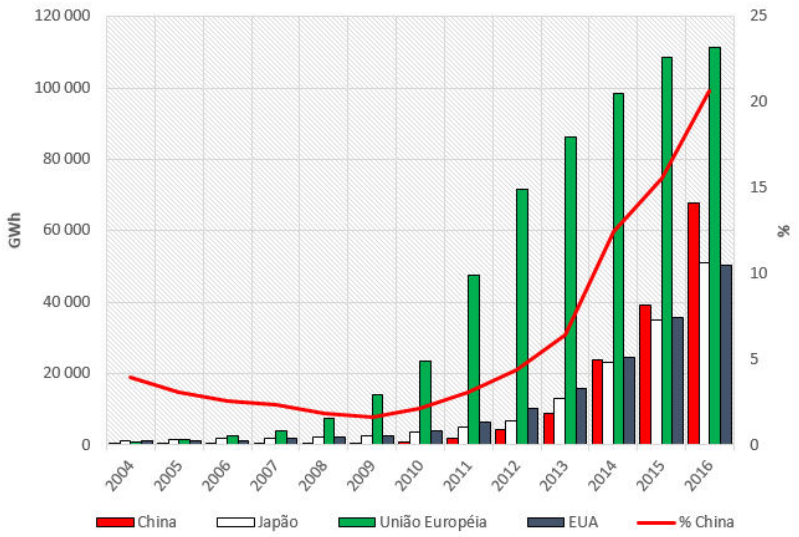
Capacidade instalada eólica na China. Fonte: IRENA (2018).



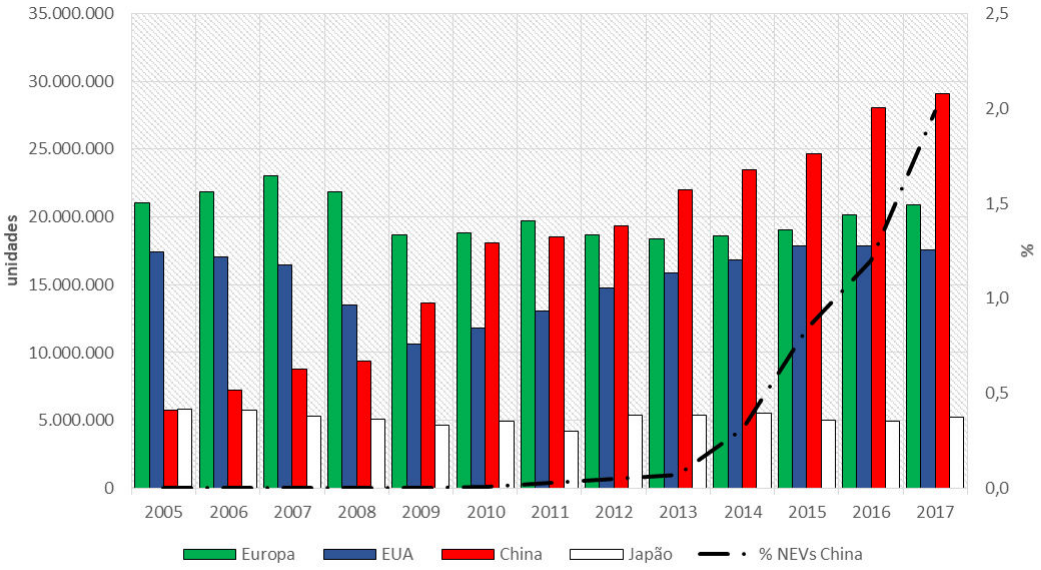
Capacidade de geração eólica na China. Fonte: IRENA (2018).



Capacidade instalada solar na China. Fonte: IRENA (2018).

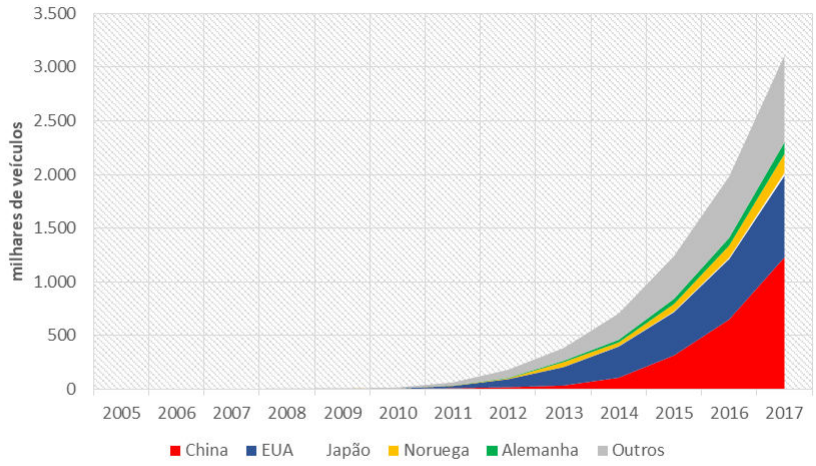


Capacidade de geração solar na China. Fonte: IRENA (2018).



Vendas de novos veículos no mundo. Fonte: (IEA, 2018; OICA, 2017).

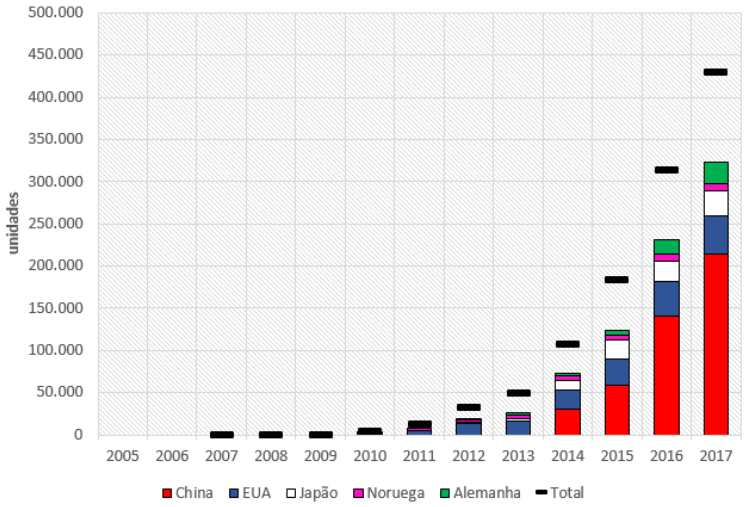
3ª Fase: 2015-2017



Estoque de NEVs no mundo. Fonte: (IEA, 2018).

Companhia	% Mercado global	País
Contemporary Amperex Technology	19	China
Panasonic	16	Japão
BYD	12	China
OptimumNano	9	China
LG Chem	7	Coréia
Guoxuam High-Tech	5	China
Samsung SDI	4	Coréia
Beijing National Battery Technology	3	China
BAK	3	China
Funeng Technology	2	China
Outras	20	

Mercado global de baterias. Fonte: (MERICS, 2018).



Postos de recarga públicos. Fonte: (IEA, 2018).

China muda o equilíbrio ou acelera um processo em curso?

Haveria um processo em curso?

		Generation and trading				Industrials retail			Residential retail			Electric vehicles		
		Gas power plants	Power trading	Renewable energy	Grid-connected storage	Electricity sales	On-site generation (e.g., rooftop PV)	Other services (e.g., demand response)	Residential electricity retail	On-site generation (e.g., rooftop solar)	Other services (e.g., smart home)	Public charging infrastructure	Private charging (home or office)	Autonomous driving or car sharing
Europe	TOTAL	Yes	Yes	Yes (Multiple)	Yes (Saft)	Yes	Yes	Yes (GreenFlex)	Yes (Lampiris, Direct Energie)	Yes	Incidental activity (Direct Energie)	Yes (G2mobility, PitPoint)	Yes (G2mobility)	Not active
	bp	Yes	Yes	Yes (Lightsource, others)	Tesla partnership	Planned	Yes	Not active	Not active	Yes (Lightsource)	Incidental activity (Ubiworx)	Yes (Chargemaster)	Yes (Chargemaster)	Venture capital (Drover)
	Shell	Yes	Yes	Yes (Silicon Ranch Corp)	Asset Finance (one project)	Yes	Limited activity	Limited activity	Yes (First Utility)	Not active	Venture capital	Yes (NewMotion)	Yes (NewMotion)	Venture capital (FarePilot)
	equinor	Limited activity	Yes (Danske Commodities)	Yes (Multiple)	Venture capital	Not active	Not active	Limited activity	Not active	Not active	Not active	Venture capital (Chargepoint)	Venture capital (Chargepoint)	Not active
	eni	Yes	Yes	Limited activity (Apodi project)	Exploring	Yes	Not active	Limited activity	Yes	Not active	Not active	Not active	Not active	Not active
U.S.	ExxonMobil	Not active	Yes	Not active	Not active	Not active	Not active	Not active	Not active	Not active	Not active	Not active	Not active	Not active
	Chevron	Not active	Yes	Reducing emphasis	Not active	Not active	Not active	Not active	Not active	Not active	Not active	Not active	Not active	Not active

Source: Bloomberg NEF, companies Note: Values are based on BNEF assessment and subject to qualitative interpretation.

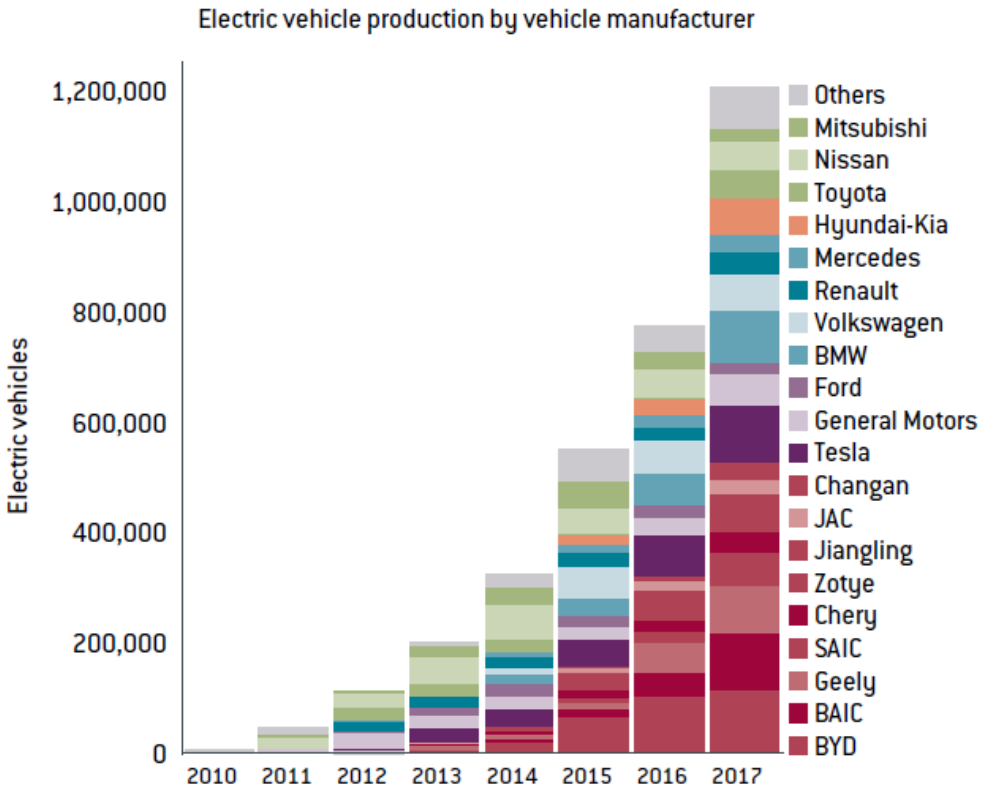
Haveria um processo em curso?

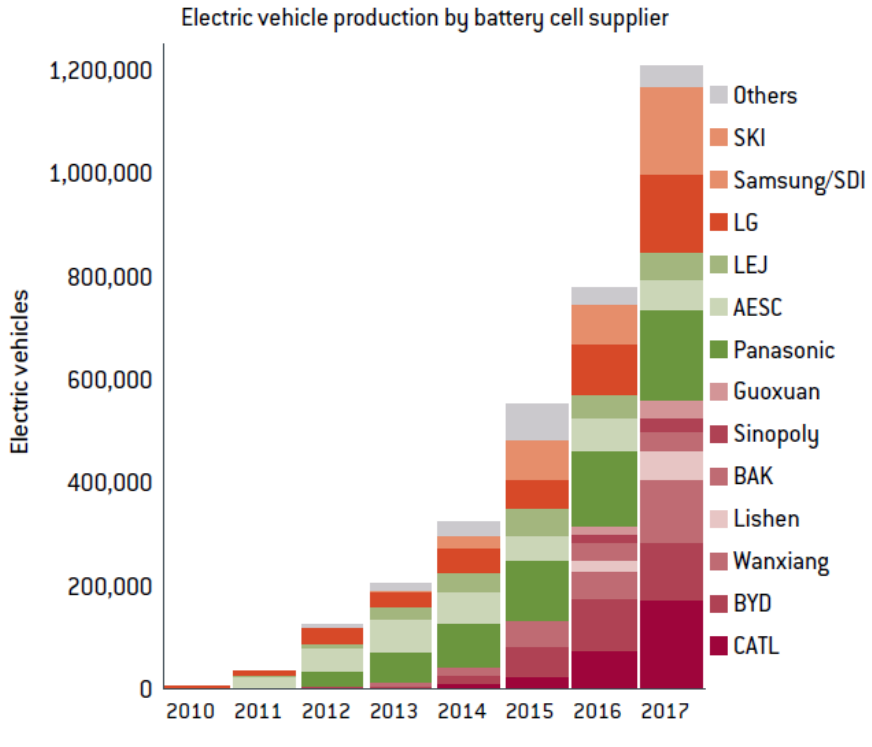
Ranking of top automotive R&D spending companies

Rank 2015			Share of sector R&D	Share of sector sales	Sector R&D, cumulative share
1	Volkswagen	Germany	12.62%	8.49%	13%
2	Toyota Motor	Japan	7.46%	8.62%	20%
3	General Motors	USA	6.39%	5.57%	26%
4	Daimler	Germany	6.05%	5.95%	33%
5	Ford Motor	USA	5.71%	5.47%	38%
6	Honda Motor	Japan	5.09%	4.43%	43%
7	Robert Bosch	Germany	4.82%	2.81%	48%
8	BMW	Germany	4.79%	3.67%	53%
9	Fiat Chrysler Automobiles	Italy	3.81%	4.40%	57%
10	Nissan Motor	Japan	3.76%	3.70%	61%
32	Tesla	USA	0.59%	0.15%	
38	Great Wall Motors	China	0.36%	0.41%	
46	Guangzhou Motors	China	0.25%	0.17%	

Fredriksson et al 2018

Haveria um processo em curso?





Fredriksson et al 2018

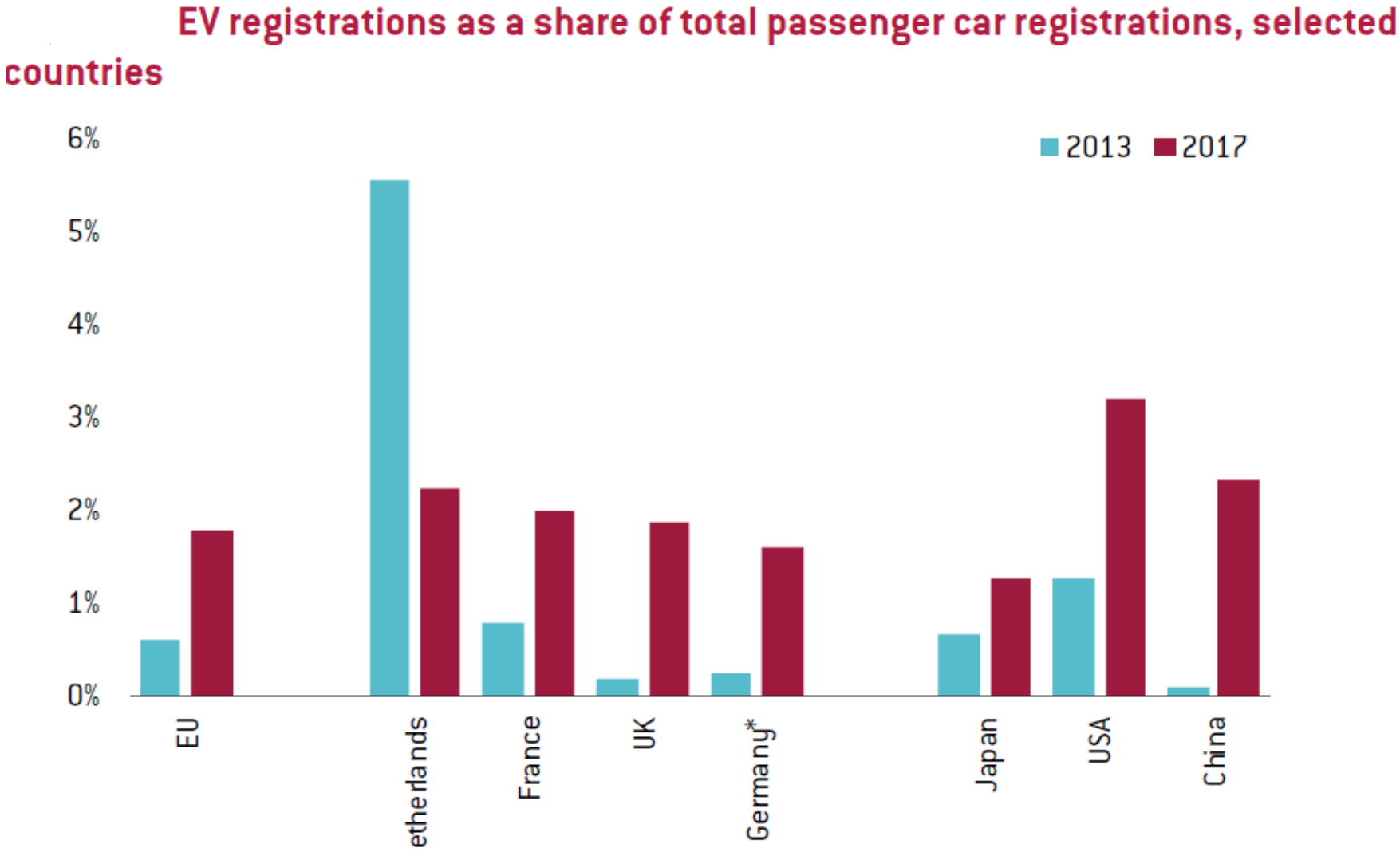
Haveria um processo em curso?

Firms	Target dates	Sales targets
Volkswagen	2021-2025	20-30% of sales
Audi		25-30% of sales
BMW		15-25% of sales
Honda		Hybrid, plug-in hybrid, battery electric and fuel cell cars to make up two thirds of Honda's European sales by 2025
Mercedes		15-25% of sales
BYD		240k units
GM	2017-19	30k Bolts in 2017
Ford	2020-21	40% line-up, including hybrids
Volvo		1m cumulative by 2025
Tesla		1m by 2020
Toyota		1.5m
Nissan		20% of European sales
Changan		400k units cumulative
SAIC		600k units (200k domestic brand)

Haveria um processo em curso?

Algo como 20 megacidades no mundo anunciaram planos de *banir* carros baseados em MCI até 2030: Paris, por exemplo, inclui carros a diesel e gasolina para circulação no centro da cidade, Copenhagen tem planos de *banir* carros a diesel antes de 2020, Londres Central planeja zonas de zero emissão (ZEZs) até 202, enquanto Oxford indica banir qualquer veículo não elétrico até 2020. No caso da Ásia, Beijing restringe emplacamento de carros não elétricos (expectativa de alocar 60% do emplacamento para BEVs até 2020).

Mas...


EV registrations as a share of total passenger car registrations, selected countries
2013
2017
6%
5%
4%
3%
2%
1%
0%
EU
etherlands
France
UK
Germany*
Japan
USA
China

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Transportation Research Procedia 19 (2016) 18 – 32

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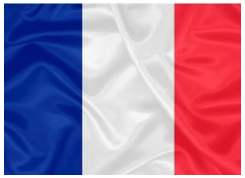

International Scientific Conference on Mobility and Transport Transforming Urban Mobility, mobil.TUM 2016, 6-7 June 2016, Munich, Germany

From weak signals to mobility scenarios: A prospective study of France in 2050

Vincent Kaufmann, Emmanuel Ravalet *

Contents lists available at ScienceDirect

Journal of Transport Geography

journal homepage: www.elsevier.com/locate/jtrangeo

The gender turnaround: Young women now travelling more than young men

Sara Tilley [a,*], Donald Houston [b]

[a] University of Edinburgh, OPENspace Research Centre, Edinburgh College of Art, 74 Lauriston Place, Edinburgh EH3 9DF, UK
[b] University of Portsmouth, Department of Geography, Buckingham Building, Lion Terrace, Portsmouth, PO1 3HE, UK

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Transportation Research Procedia 13 (2016) 49 – 60

Transportation Research Procedia

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European Transport Conference 2015 – from Sept-28 to Sept-30, 2015

What drives mobility trends: results from case studies in Paris, Santiago de Chile, Singapore and Vienna

Mirko Goletz[a,*], Irene Feige[b], Dirk Heinrichs[a]

[a] German Aerospace Center (DLR), Institute of Transport Research, Rutherfordstr. 2, 12489 Berlin, Germany
[b] Institute for Mobility Research (ifmo), Petuelring 130, 80788 Munich, Germany

CONDICIONANTES DA DEMANDA POR VEÍCULOS LEVES PRIVADOS PARA ATENDER A MOBILIDADE URBANA NOS ESTADOS UNIDOS

Rachel M. Henriques[1], Camila Ludovique[2], Alexandre Szklo[3]

$$PV_i = \alpha + \beta_1 * Densidade_i + \beta_2 * Renda_i + \beta_3 * Idade_i + \varepsilon_i$$

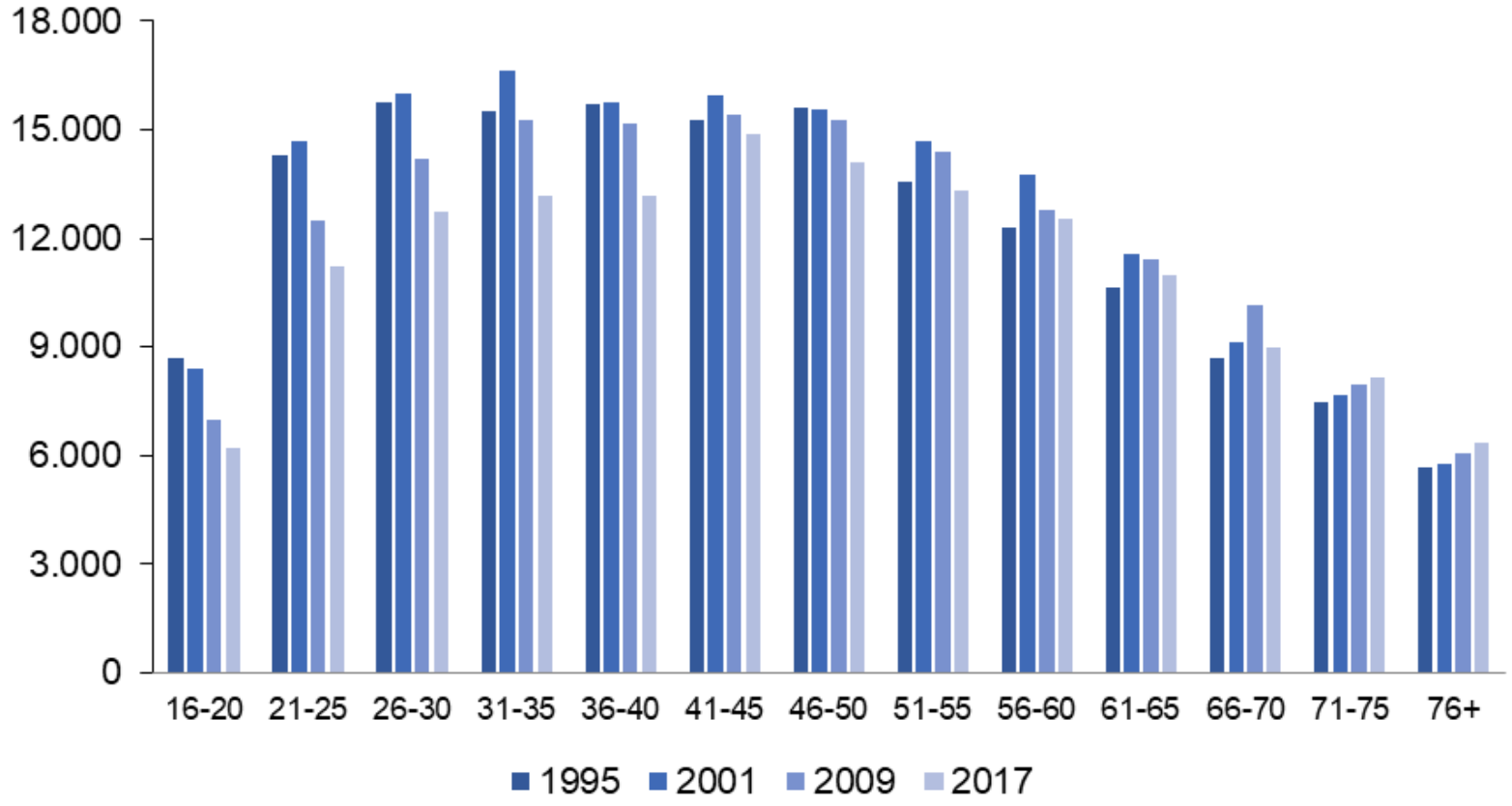
Onde PV_i representa o percentual de veículos leves utilizados para transporte na cidade i; α é o intercepto; $Densidade_i$ representa a densidade na cidade i; $Renda_i$ representa a renda mediana da população na cidade i; $Idade_i$ representa a idade mediana da população na cidade i; e, ε_i o termo aleatório. Admite-se que ε_i são variáveis aleatórias independentes de média zero e variância σ^2 constante.

Tabela 1: Parâmetros dos modelos de regressão.

	Seção 2005		Seção 2016	
Variáveis	*Coeficiente*	*p-value*	*Coeficiente*	*p-value*
Intercepto	5,0364	< 2e-16 ***	5,5413	< 2e-16 ***
Densidade	-0,0110	0,0144 *	-0,0356	2,42e-08 ***
Idade	0,1256	3,92e-06 ***	0,2250	4,30e-14 ***
Renda	-0,0824	8,21e-06 ***	-0,1541	7,96e-15 ***
R^2	0,2173		0,3907	
p-value	1,04E-09		< 2,2e-16	

Notas: *** 0.001; ** 0.01; * 0.5

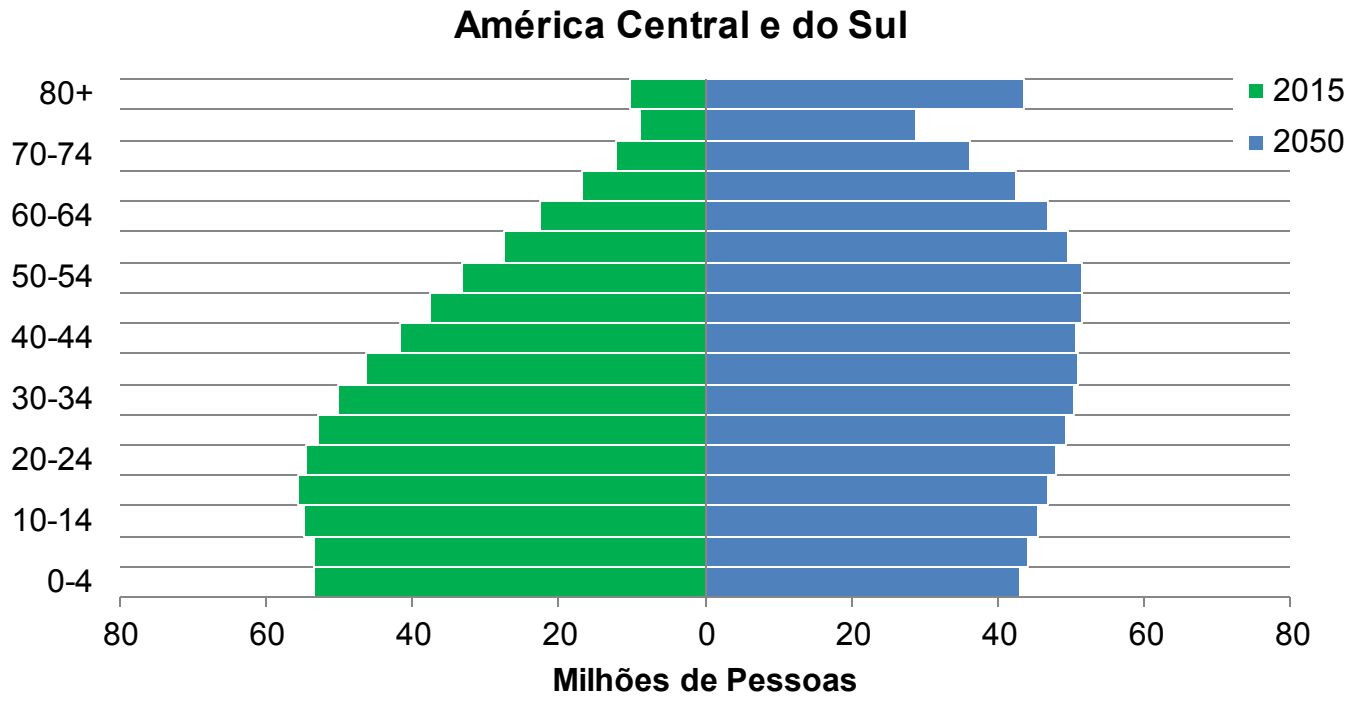
EUA



Distância anual percorrida por faixa etária nos EUA (v-mt)

Fonte: FHA (2018)

E o Brasil?



UN/DESA (2017)

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“Our IAM T*ools*”

‘‘Predictions are hard to make, especially about the future’’. (Alternatively attributed to Nobel physicist Niels Bohr and former New York Yankees catcher Yogi Berra)

Integrated Assessment Models

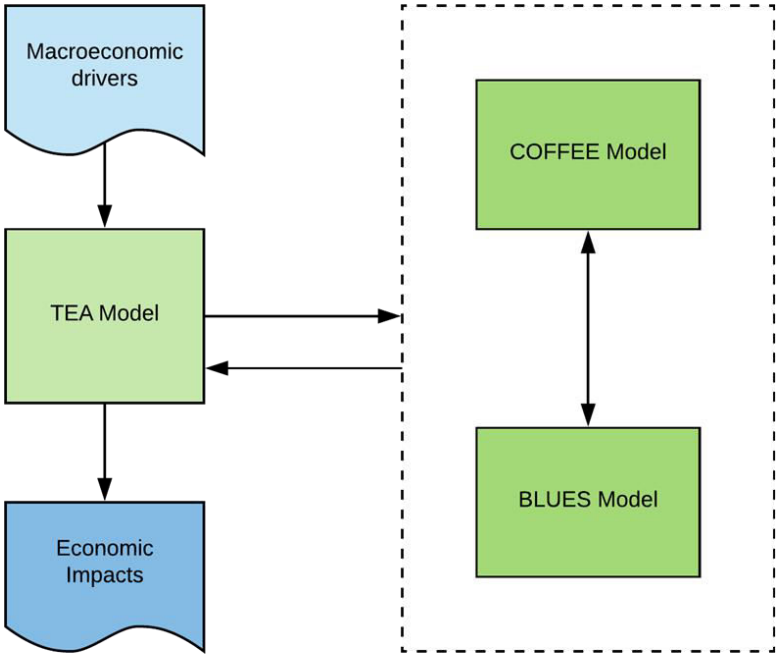
- Research centres with Global IAM

National Team	Models	Country	Model type
CSIRO	TIMES-AUS	Australia	Energy system
COPPE	BLUES, COFFEE	Brazil	Integrated Assessment
ECCC	GCAM-Canada, EC-MSMR	Canada	Energy system, Macro-economy
NCSC, ERI	PECE	China	Integrated energy system
E3Modelling	PRIMES	EU-28	Energy system
TERI	MARKAL	India	Energy system
BAU, CREP-ITB	ExSS, AFOLU Dashboard	Indonesia	Energy system, AFOLU, waste
NIES	AIM/Enduse [JPN]	Japan	Energy system
HSE	TIMES-RUS, ROBUL/ CBS-CFS3	Russia	Energy system, Forestry
UOS	TIMES, AIM-Korea	South Korea	Energy system
PNNL	GCAM	USA	Integrated Assessment

Model Linkages

Total-**E**conomy **A**ssessment (**TEA**) – CGE Model

Economy-Energy–Land Use GTAPinGAMS Recursive dynamic 18 regions



COmputable **F**ramework For **E**nergy and the **E**nvironment (**COFFEE**)

- Optimization model – Energy and Land Use
- 18 regions
- Translation into GAMS

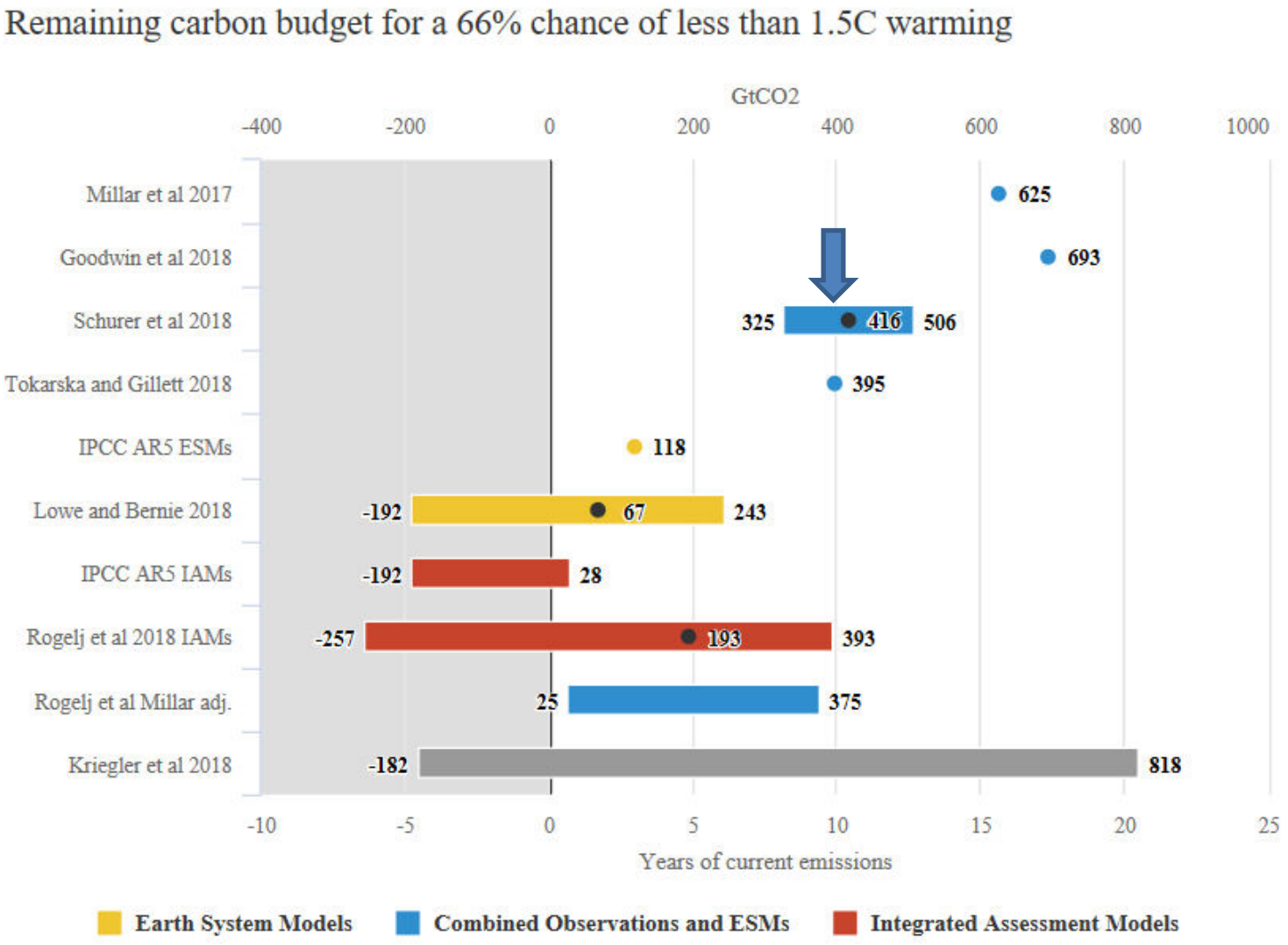
Brazil **L**and-**U**se and **E**nergy **S**ystems Model **(BLUES)**

- Optimization model – Energy and Land Use
- 6 Brazilian regions
- Translation into GAMS

The COFFEE Model

Scenario Protocol for the Global Energy System (cd-Links)

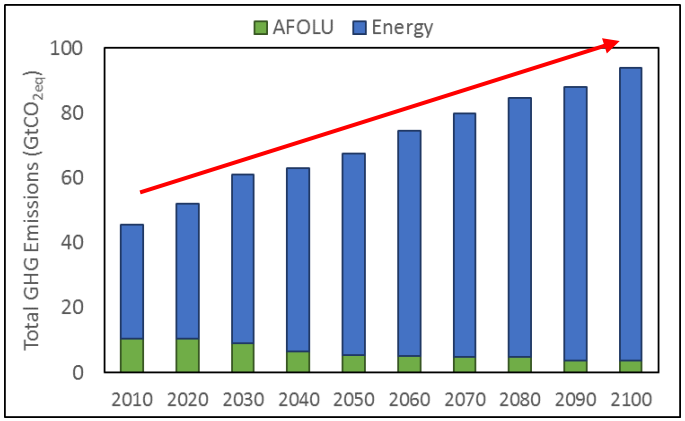
- **Global Current Policies (GCP)**: based on current and indicated policies for all regions (energy, land and climate)
- **Global 2°C (G2D)**: GCP + global budget of 1,000 $GtCO_2$
- **Global 2°C without CCS (G2D_noCCS)**: GCP + global budget of 1,000 $GtCO_2$ + Unavailability of CCS (fossil and/or bioenergy)
- **Global 1.5°C (G1.5D)**: GCP + global budget of 400 $GtCO_2$



From Jan 2018 to 2100

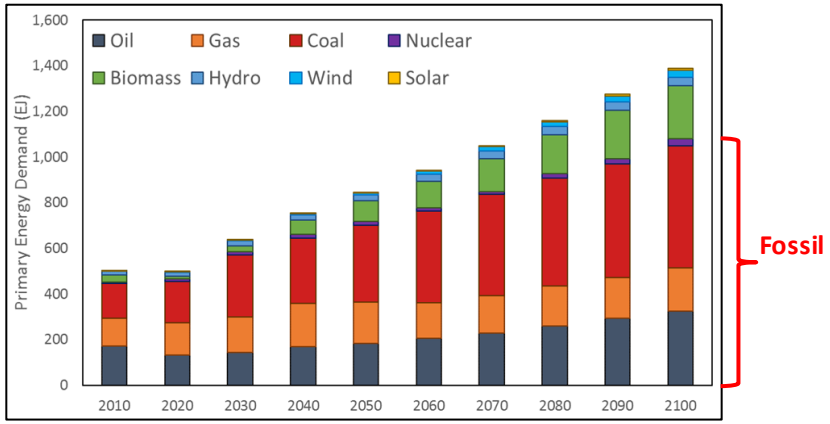
COFFEE: Current Policies (GCP)

GHG Emissions ($GtCO_{2eq}$)

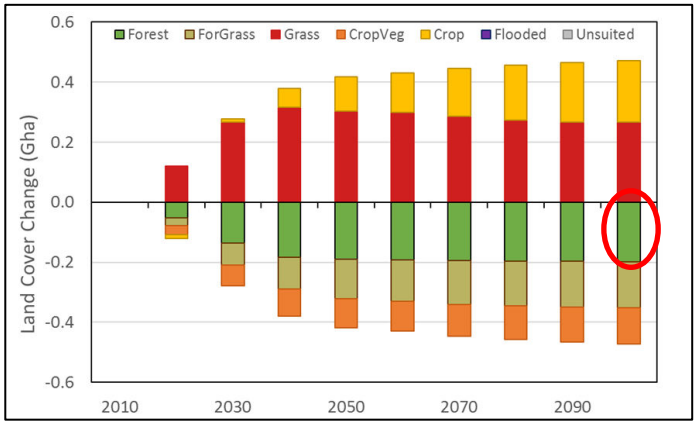


Cumulative Emissions: 5,500 $GtCO_2$

Primary Energy (EJ)

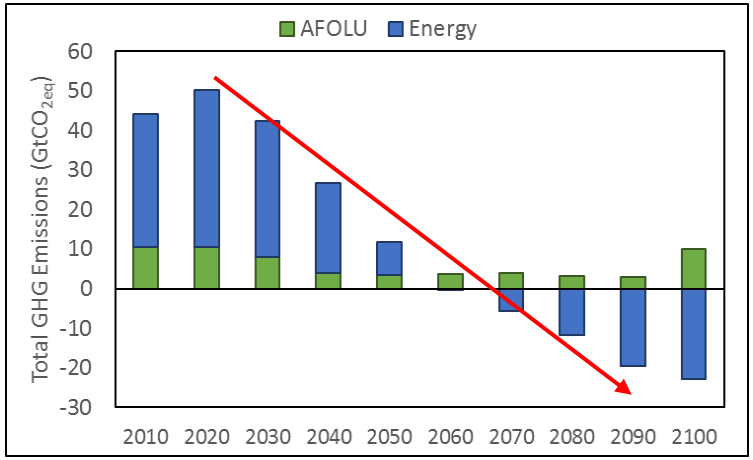


Land Use Change (Gha)



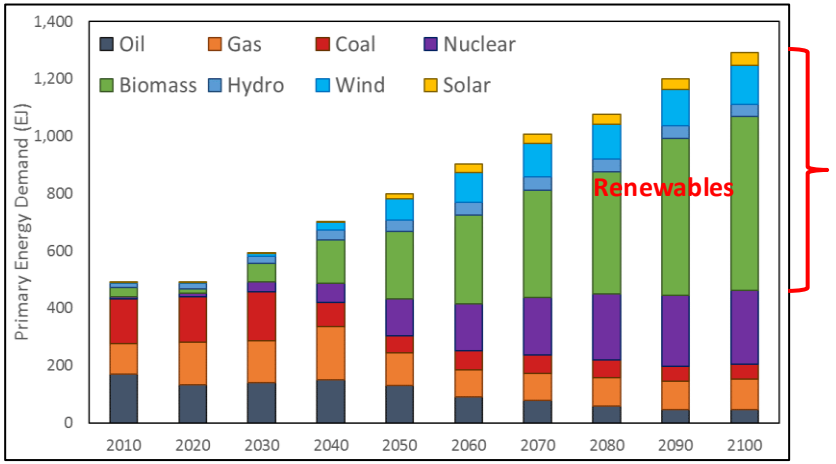
COFFEE: 1.5°C Scenario (G1.5D)

GHG Emissions ($GtCO_{2eq}$)

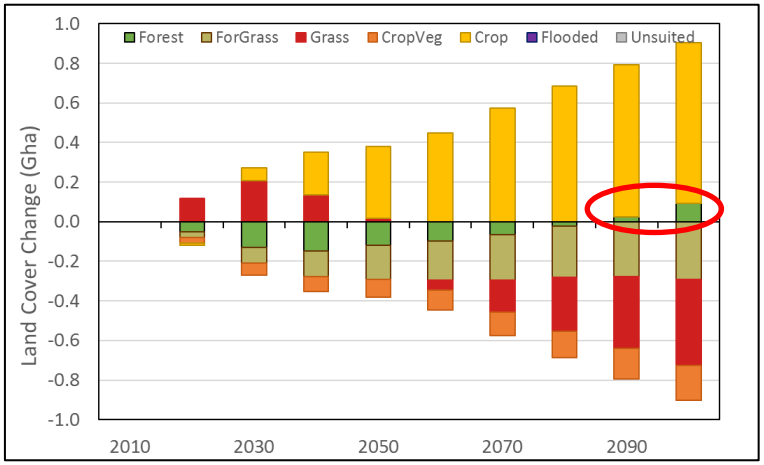


Cumulative Emissions: 5,500 $GtCO_2$

Primary Energy (EJ)

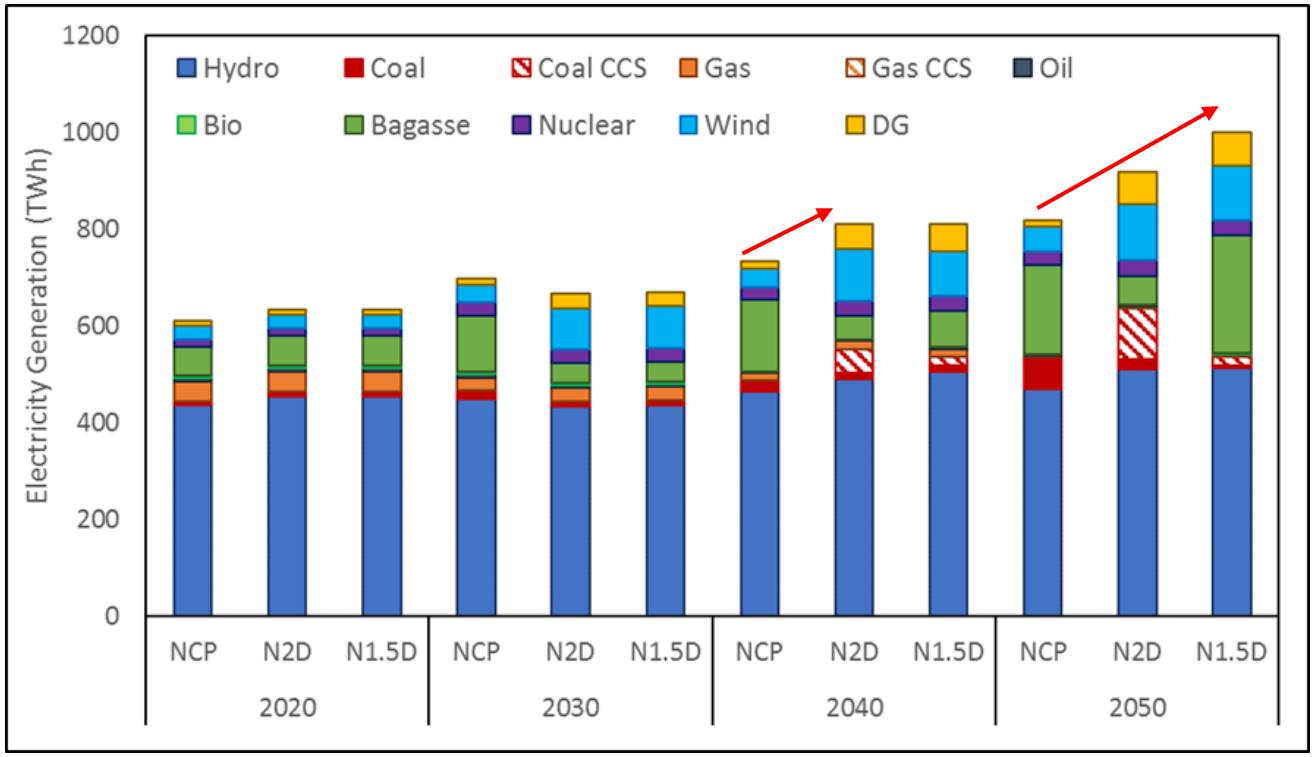


Land Use Change (Gha)



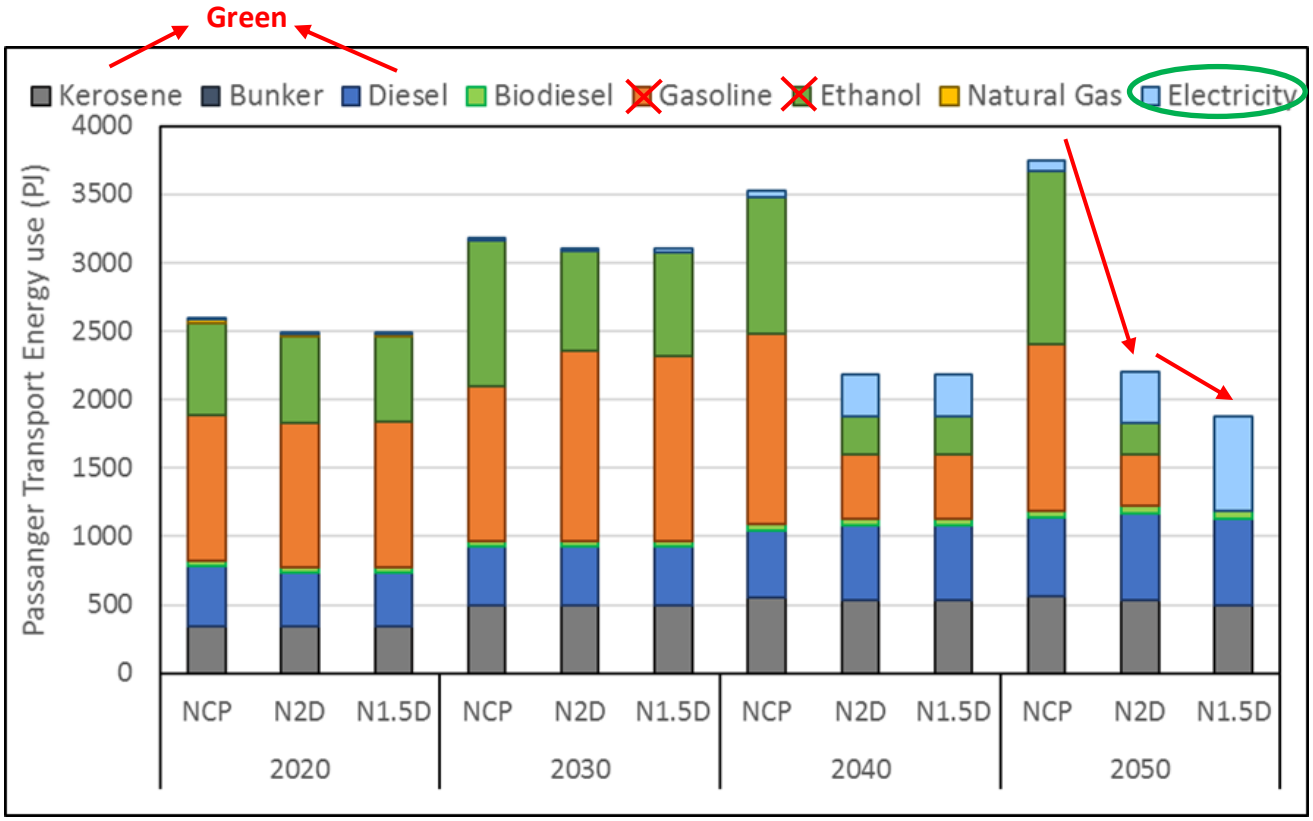
BLUES: Scenario Comparison

Electricity Generation (TWh)

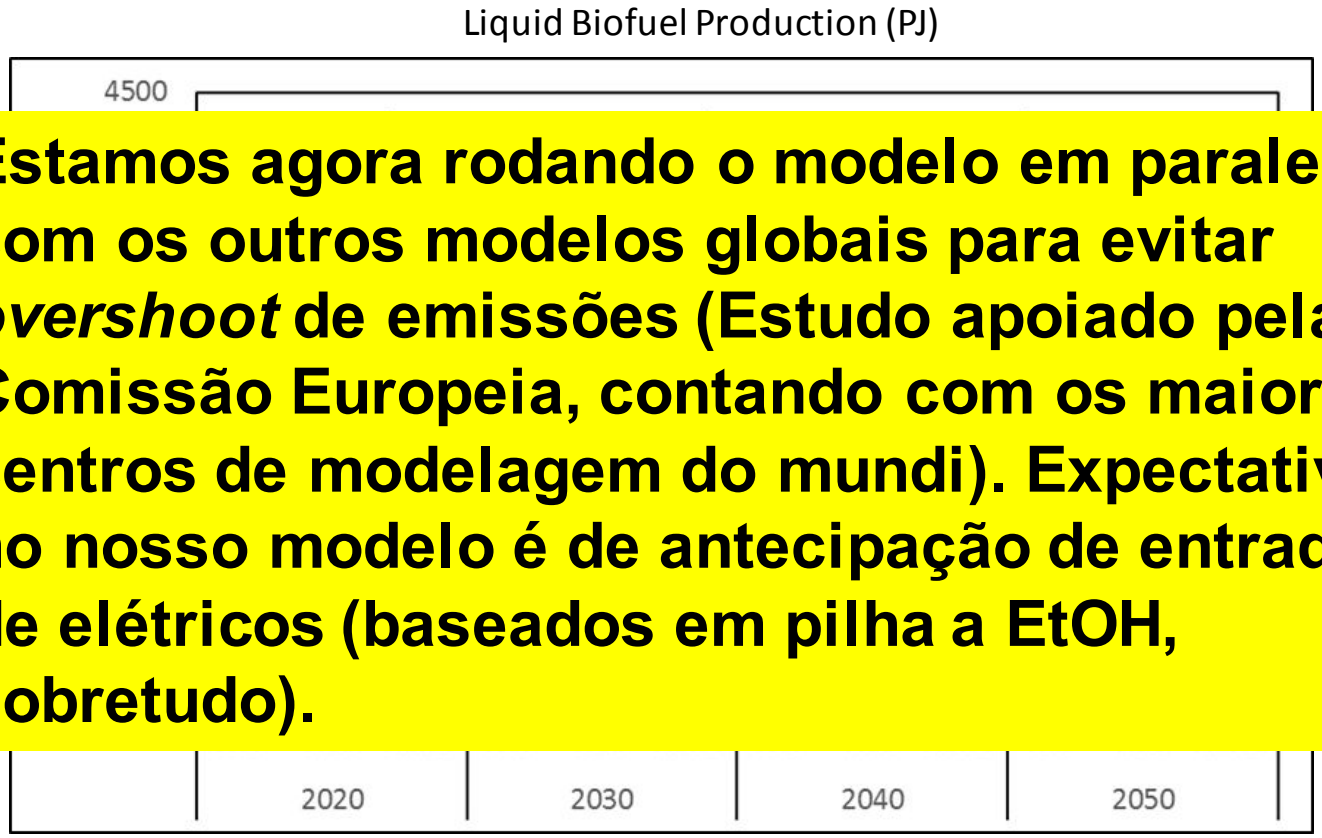


BLUES: Scenario Comparison

Transport Sector – Passenger Energy Use



BLUES: Scenario Comparison



Estamos agora rodando o modelo em paralelo com os outros modelos globais para evitar *overshoot* de emissões (Estudo apoiado pela Comissão Europeia, contando com os maiores centros de modelagem do mundi). Expectativa no nosso modelo é de antecipação de entrada de elétricos (baseados em pilha a EtOH, sobretudo).

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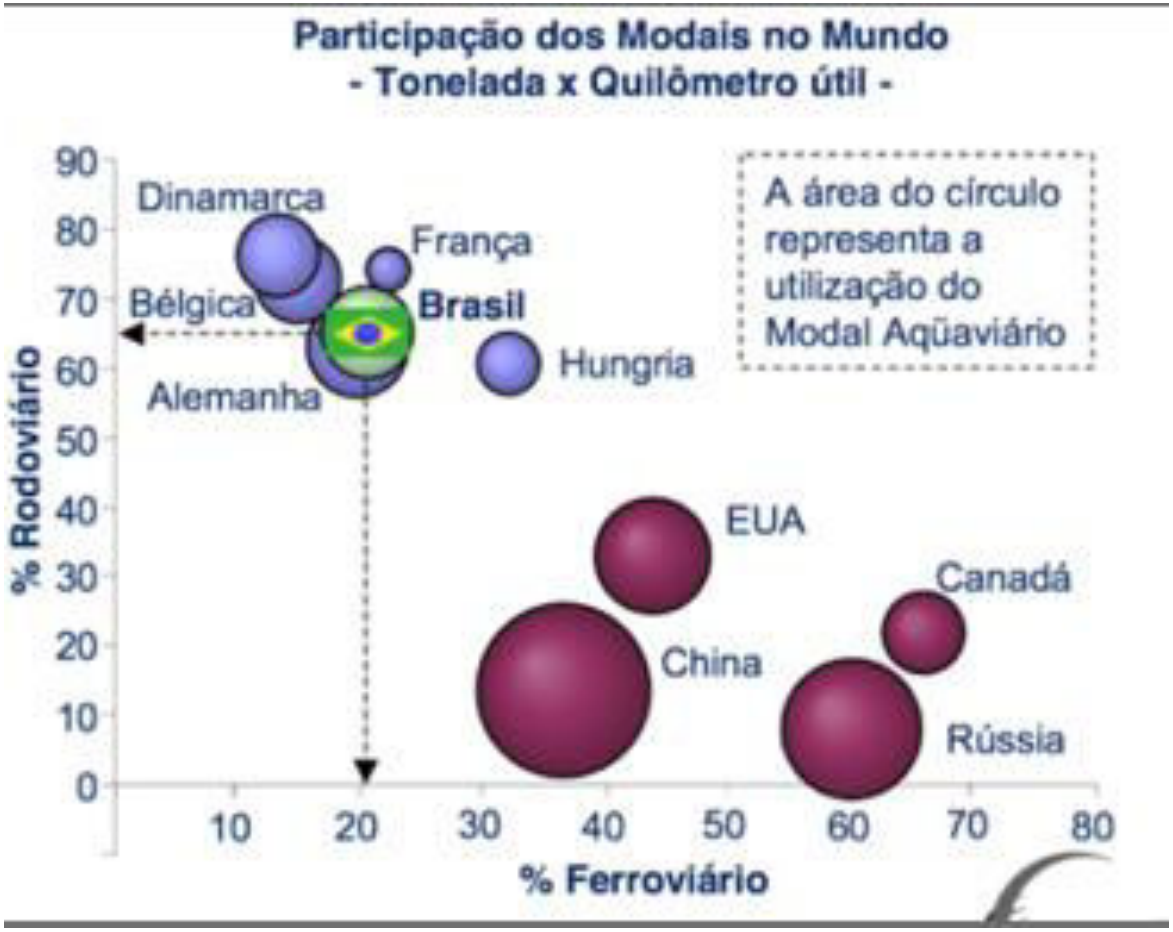
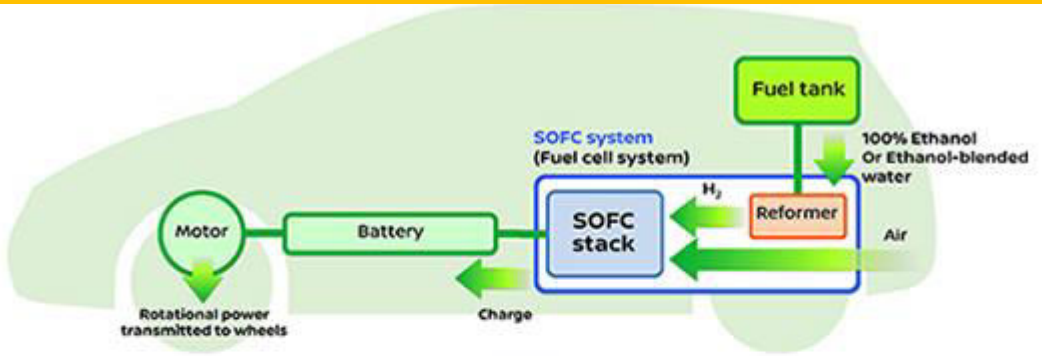
Modal Rodoviário – Veículos Pesados ou Leves



Modal Rodoviário – Veículos Pesados ou Leves



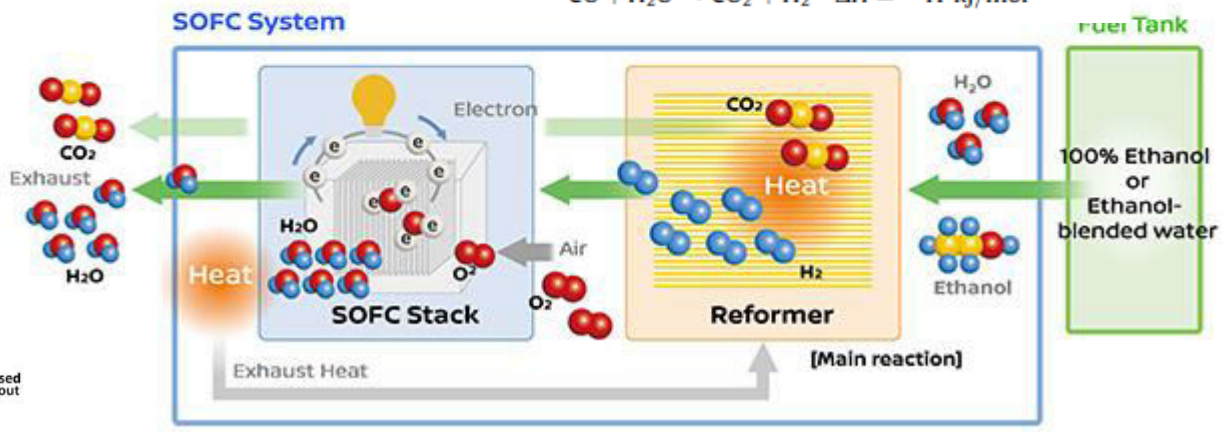
Specifications of research prototype vehicle

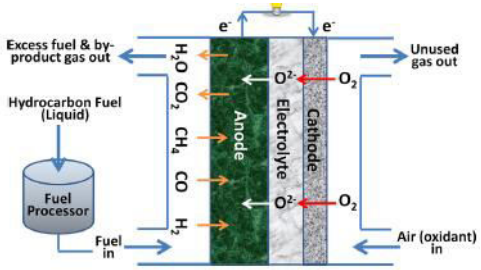
Features	Specs.
Base vehicle	e-NV200
Battery Capacity	24kWh
Powertrain	Electricity
	100% Ethanol
Fuel tank capacity	30L
SOFC power	5kW
Driving range	Over 600km

Note: specifications are for Nissan's research prototype vehicle, and are subject to change.

$$C_2H_5OH + H_2O \rightarrow 2CO + 4H_2 \quad \Delta H = +260\ \text{kJ/mol}$$

$$CO + H_2O \rightarrow CO_2 + H_2 \quad \Delta H = -41\ \text{kJ/mol}$$





https://www.bio.org/sites/default/files/1030AM-Mikio%20Matsumoto.pdf

https://www.nissan-global.com/EN/TECHNOLOGY/OVERVIEW/e_bio_fuel_cell.html

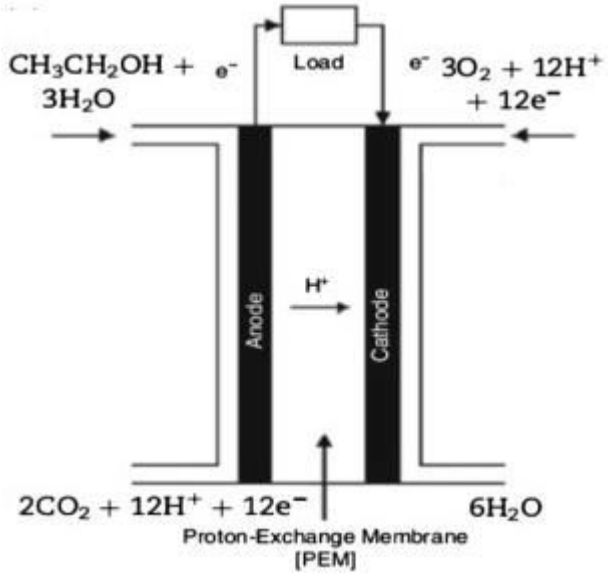
Modal Rodoviário

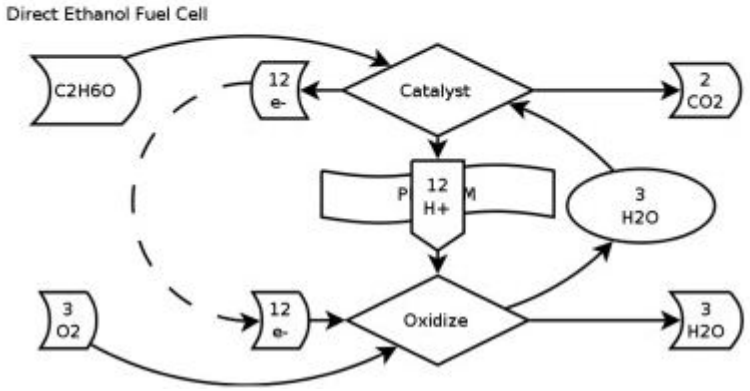
ou DEFC?

anode reaction: $CH_3CH_2OH + 3H_2O \rightarrow 2CO_2 + 12H^+ + 12e^-$,

cathode reaction: $3O_2 + 12H^+ + 12e^- \rightarrow 6H_2O$,

overall reaction: $CH_3CH_2OH + 3O_2 \rightarrow 2CO_2 + 3H_2O$.





https://doi.org/10.1016/j.apenergy.2015.10.124

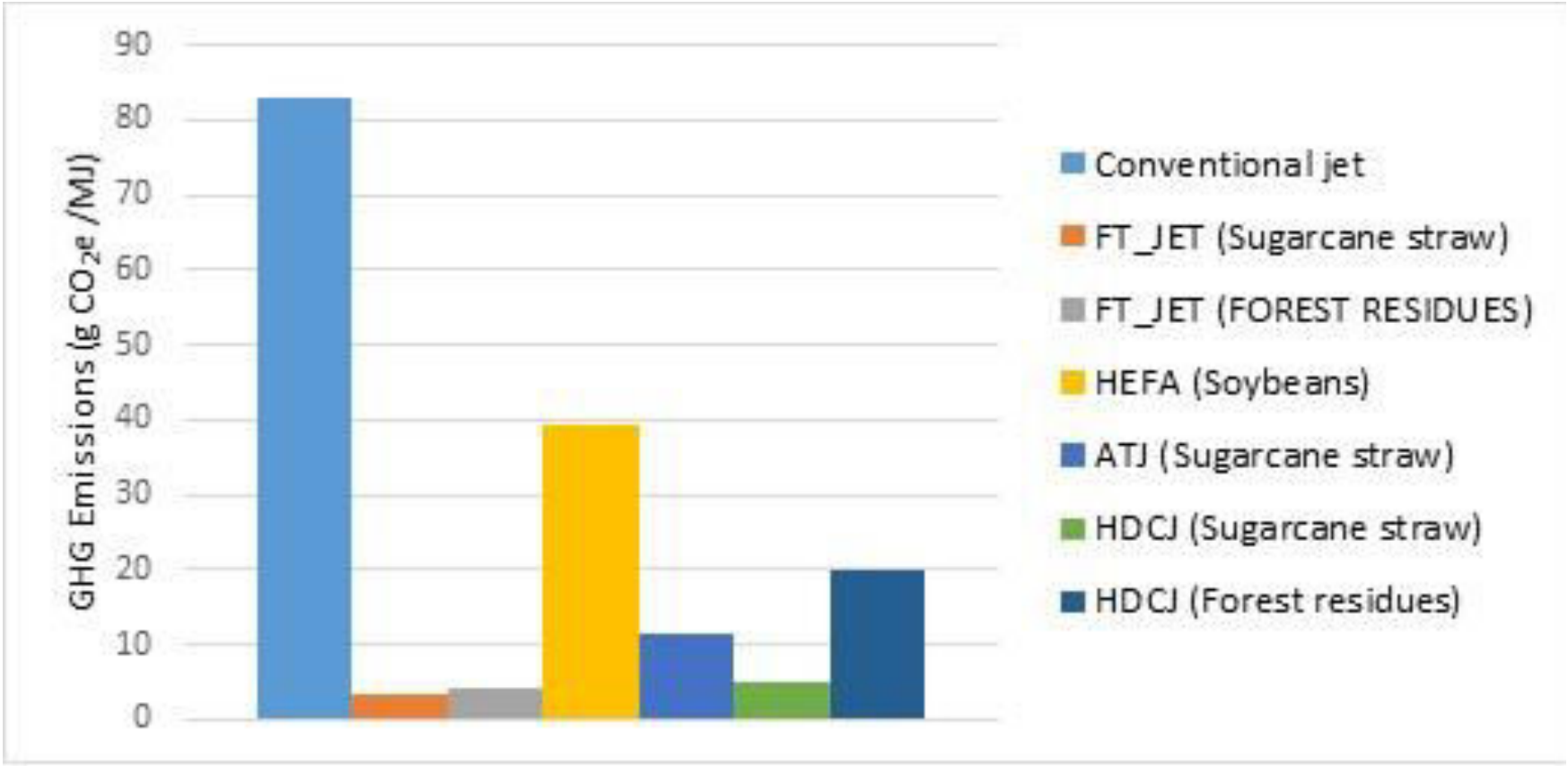
https://doi.org/10.1016/j.ijhydene.2012.07.059

Modal Roviário – Veículos Pesados

Kenworth T680 Day Cab

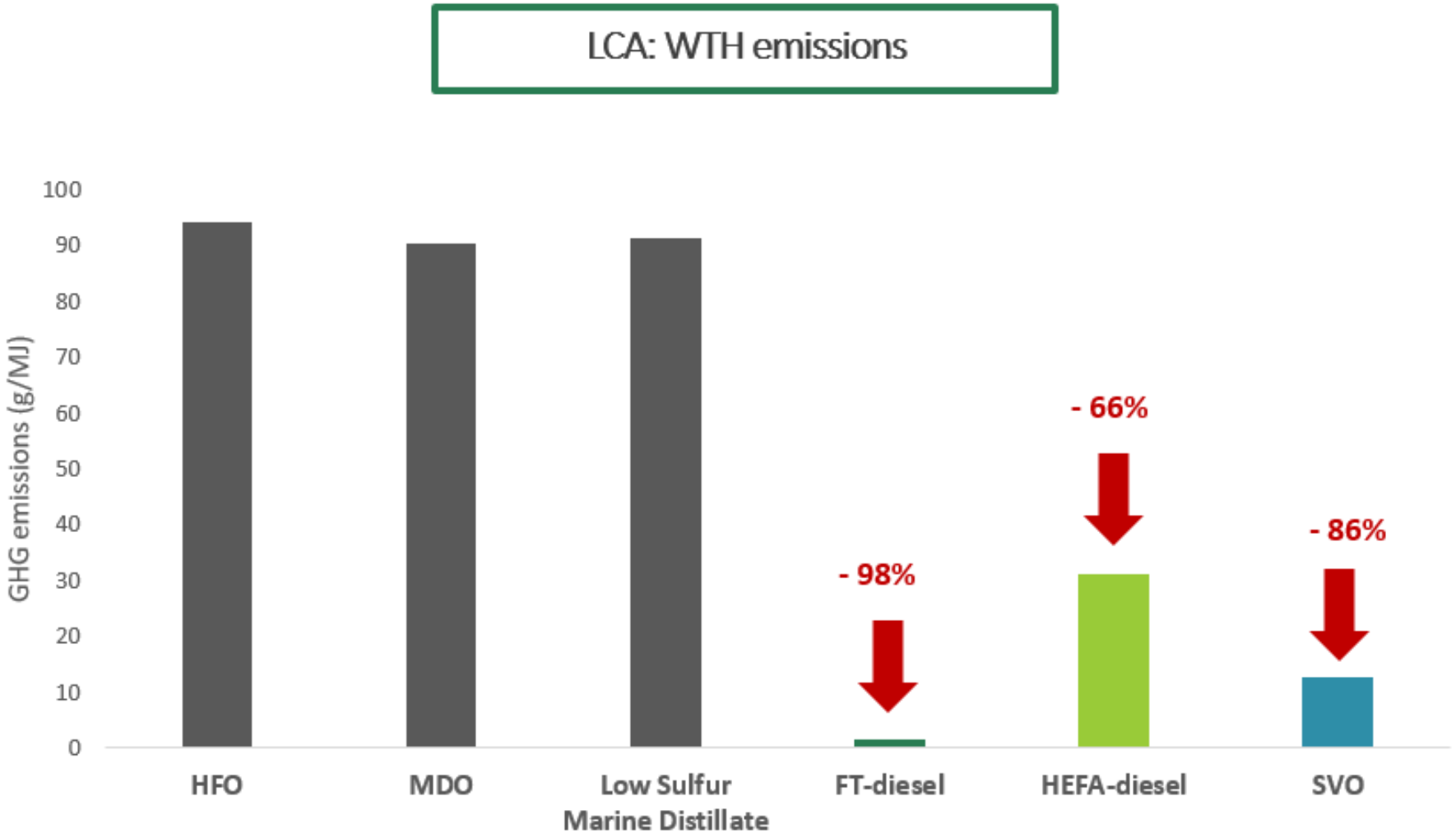
Biojet

Carvalho, Pereira-Portugal, Szklo, 2016.



Biobunker

Carvalho, Pereira-Portugal, Szklo, 2019.



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Tempo para o comentário judaico sobre modéstia?

OBRIGADO

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