Análise de Sustentabilidade Ambiental (ASA) incluindo perspectiva de ciclo de vida de diferentes fontes energéticas

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ISA, 4 de Dezembro de 2023

O desafio da descarbonização

EU legislative acts

RED DIRECTIVE:

DIRECTIVE 2009/28/EC: on the promotion of the use of energy from renewable sources

DIRECTIVE (EU) 2018/2001: on the promotion of the use of energy from renewable sources

Renewable Energy Directive - REDI: meta em 2020 de 10% de energia renovável nos transportes

Targets for 2030 - Diretiva (UE) 2018/2001 (REDII)

- Sectorial transport target of renewables of **14%** by 2030
- Sub-target for advanced biofuels of 3.5% by 2030
- Multipliers of 1.2 for shipping and aviation, 4 for EV, 1.5 for electricity in trains
- 1st generation biofuels are capped at 7%

O desafio da descarbonização

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FUEL QUALITY DIRECTIVE

DIRECTIVE 2009/30/EC : specification of petrol, diesel and gas-oil and introducing a mechanism to monitor and reduce greenhouse gas emissions

DIRECTIVE (EU) 2015/652: Laying down calculation methods and reporting requirements pursuant to Directive 98/70/EC of the European Parliament and of the Council relating to the quality of petrol and diesel fuels

O desafio da descarbonização

EU strategic documents

COM(2011) 14, WHITE PAPER, Roadmap to a Single European Transport Area – Towards a competitive and resource efficient transport systems

COM/2013/017: Clean Power for Transport: A European alternative fuels strategy

COM(2016) 50: A European Strategy for Low-Emission Mobility

COM(2020) 789: Sustainable and Smart Mobility Strategy – putting European transport on track for the future

Green Deal (12/2020), New European Bauhaus (01/2021), Action Plan for Zero Pollution for Air, Water and Soil (05/2021), Fit for 55 (07/2021)

O desafio da descarbonização

Fit for 55 : policies fit for reducing net greenhouse gas emissions by at least 55% by 2030, compared to 1990 levels

ETS

TRANSPORT AND THE EMISSIONS TRADING SYSTEM (ETS): PUTTING A PRICE ON CARBON

Road

- Extension of the ETS to road transport and building fuels from 2026;
- Focus on upstream fuel suppliers (rather than households and car drivers);
- Revenues to be channelled to support vulnerable households and investments in cleaner mobility.

Aviation

- Tighter cap on the number of allowances for intra-EU flights, starting from current levels and reduced by 4.2% annually;
- Full phase-out of free allowances by 2026;
- Extra-European flights to be subject to offsetting under the international CORSIA scheme.

Maritime

- Gradual extension of the ETS to maritime starting in 2023, with a 3-year phase in period;
- Focus on large ships (above 5000 gross tonnage) accounting for 90% of CO_2 emissions;
- Intra-EU traffic and 50% of extra-EU voyages covered by the scheme.

EC, 2021

O desafio da descarbonização

Fit for 55 : policies fit for reducing net greenhouse gas emissions by at least 55% by 2030, compared to 1990 levels

Vehicle sales

EC, 2021

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O desafio da descarbonização

Fit for 55 : policies fit for reducing net greenhouse gas emissions by at least 55% by 2030, compared to 1990 levels

Infrastructure

Public charging and hydrogen refuelling stations will be widely available, interoperable and easy to use, including at fixed intervals along Europe's major transport corridors

National fleet based targets for charging stations for cars and vans – those could lead to approximately*:

2025	2030	2040	2050
1 million	3.5 million	11.4 million	16.3 million

Recharging pools for cars and vans
- on the TEN-T core network: at least 300 kW power output every 60 km by 2025 and at least 600 kW by 2030;
- on the TEN-T comprehensive network: at least 300 kW power output every 60 km by 2030 and at least 600 kW by 2035.

Hydrogen refuelling stations
- will be made available every 150 km by 2030 along the TEN-T core network;
- in every urban node serving both light duty and heavy duty vehicles by 2030.

Recharging points for heavy duty vehicles
- on the TEN-T core network: at least 1400 kW of recharging points every 60 km by 2025 and at least 3500 kW by 2030;
- on the TEN-T comprehensive network: at least 1400 kW power output every 100 km by 2030 and at least 3500 kW by 2035;
- in every urban node and at every safe and secure parking by 2030.

EC, 2021

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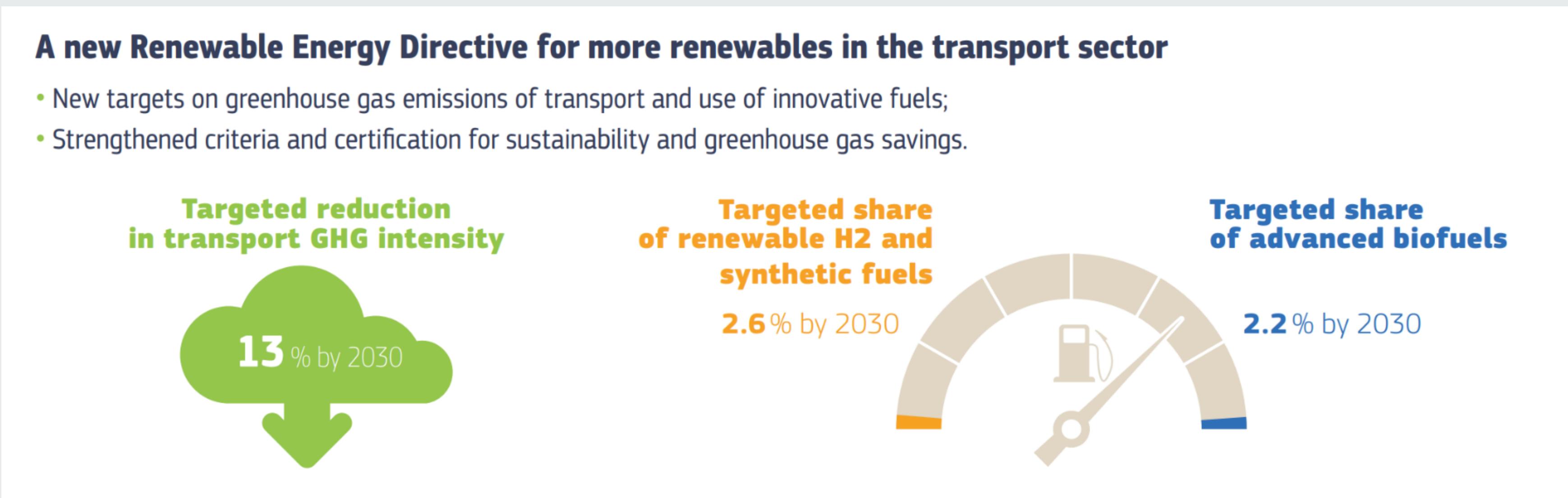
O desafio da descarbonização

Fit for 55 : policies fit for reducing net greenhouse gas emissions by at least 55% by 2030, compared to 1990 levels Energy



EC, 2021

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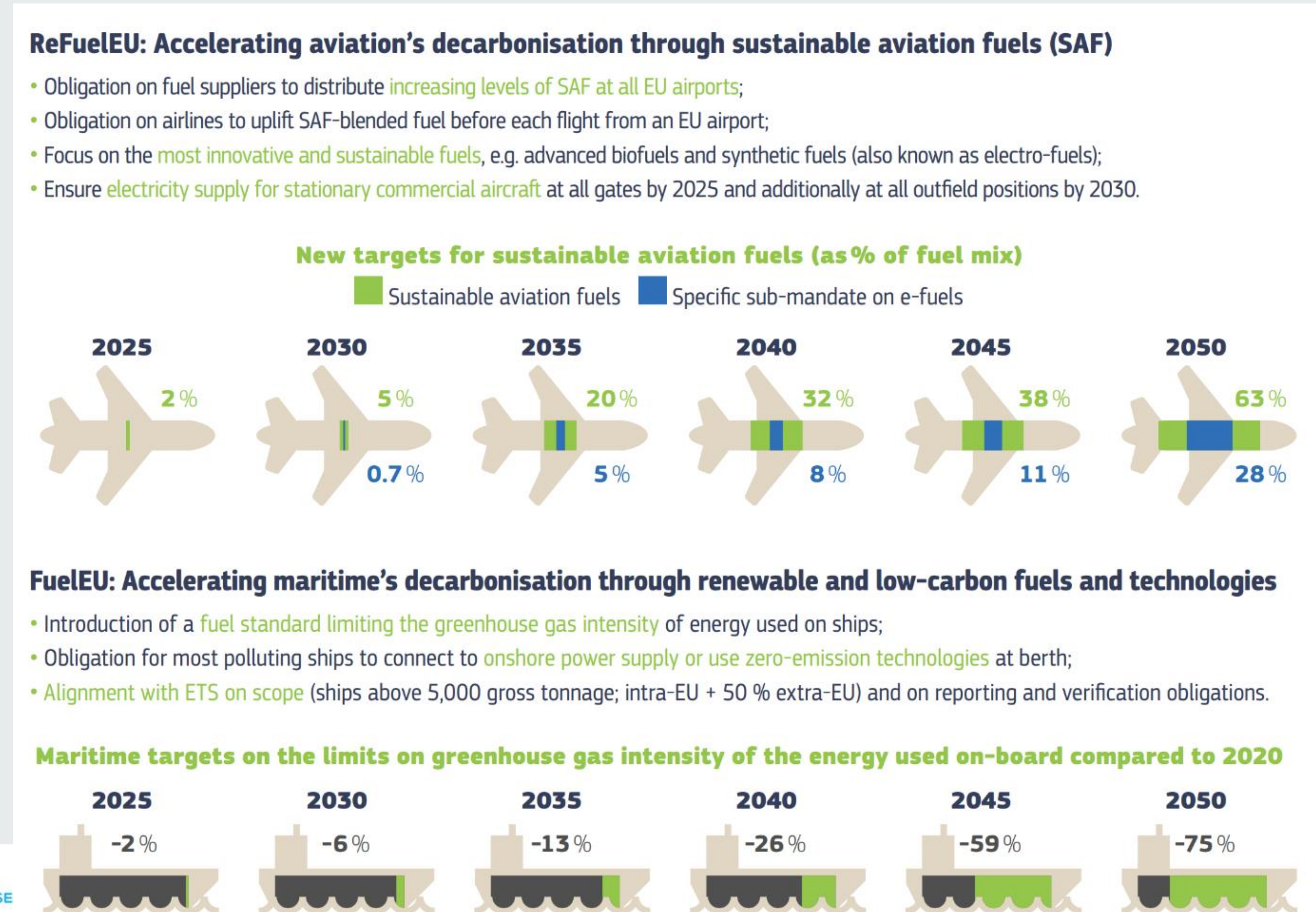
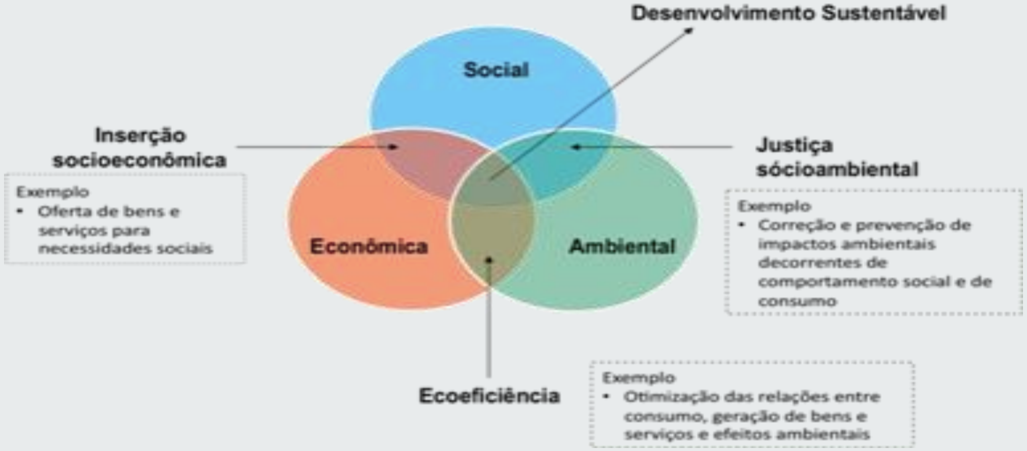


EC, 2021

Análise de Sustentabilidade Ambiental

O conceito de sustentabilidade é complexo, pois incorpora variáveis interdependentes, incluindo:

- **Questão ambiental:** com o meio ambiente degradado, o ser humano abrevia o seu tempo de vida; a economia não se desenvolve; o futuro fica insustentável



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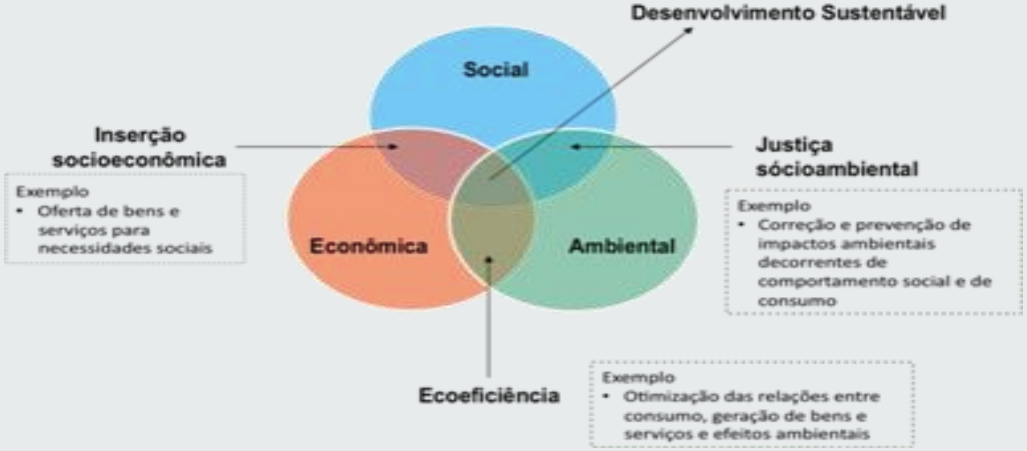

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Análise de Sustentabilidade Ambiental

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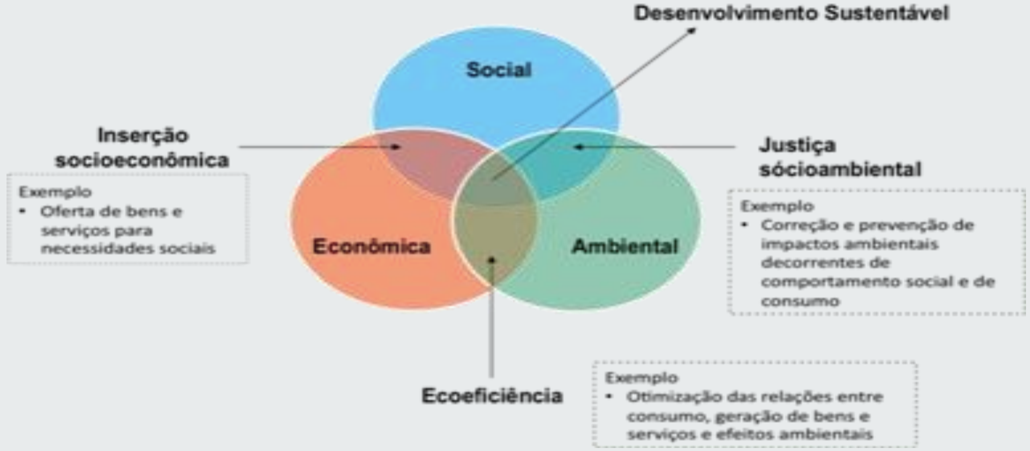

Análise de Sustentabilidade Ambiental

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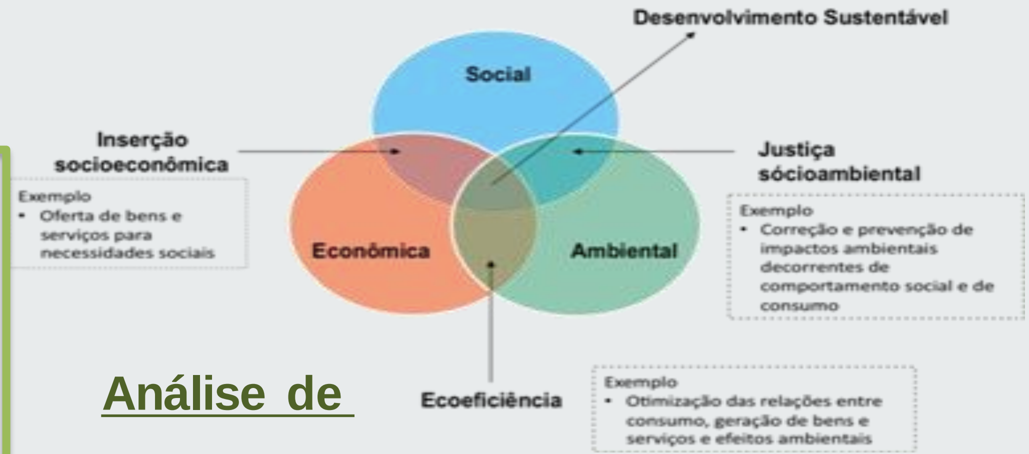
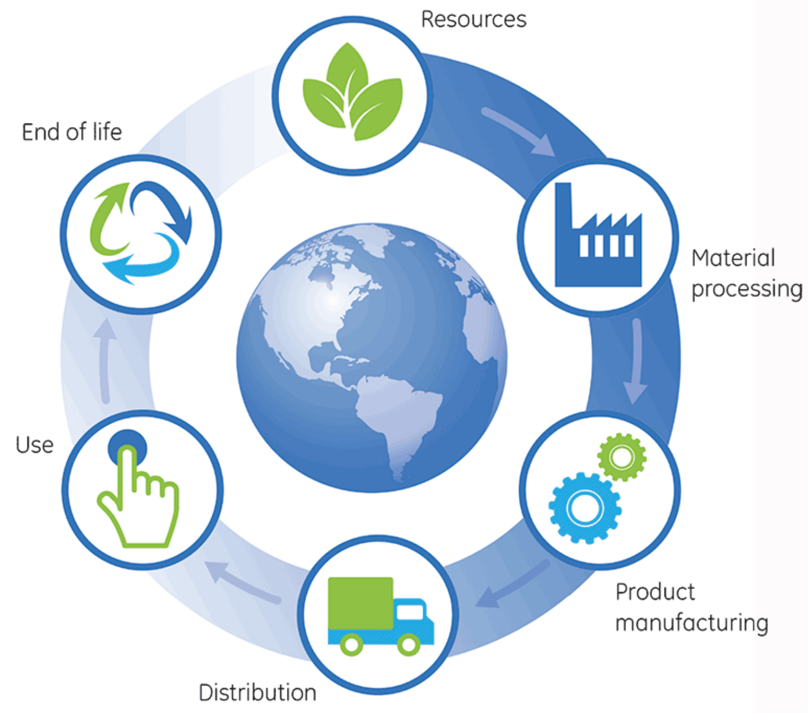


Análise de ciclo de vida (LCA)

Análise de Ciclo de Vida

Análise de ciclo de vida (LCA)

- Técnica para avaliar o impacte ambiental associado a todas as fases da vida de um produto desde a sua produção ao seu fim de vida



- Permite construir um inventário de inputs materiais e energéticos e de outputs ambientais

Análise de Ciclo de Vida

Análise de ciclo de vida (LCA)

- Permite avaliar os impactes potenciais associados a diferentes inputs e outputs

- Permite a comparação de processos o que ajuda na tomada de decisões mais informadas

- Metodologias reguladas pelas ISO 14040:2006 e14044:2006.

Análise de Ciclo de Vida

Análise de ciclo de vida (LCA)

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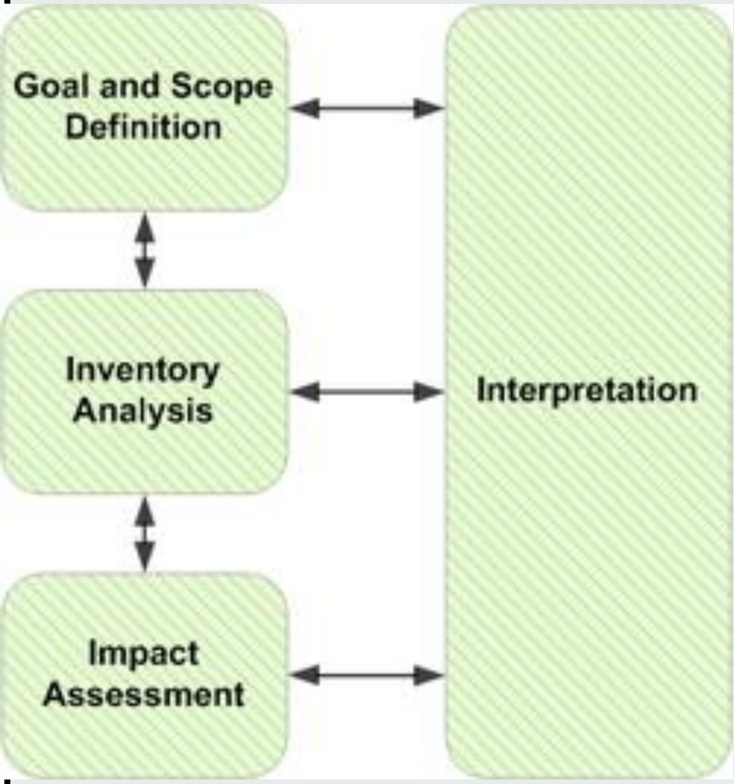
Análise de Ciclo de Vida

Passos para definição de LCA:

- **Definição da unidade functional**, define o que está a ser estudado e quantifica o serviço a ser disponiiblizado, sendo a referência à qual inputs e outputs se relacionam **(1 unidade?, 1kg, 1L???)**
- **Definição das fronteiras do Sistema**, define quais os processo que devem ou não ser incluídos na análise **(país, EU, mundo?)**
- **Outros pressupostos ou limitações**

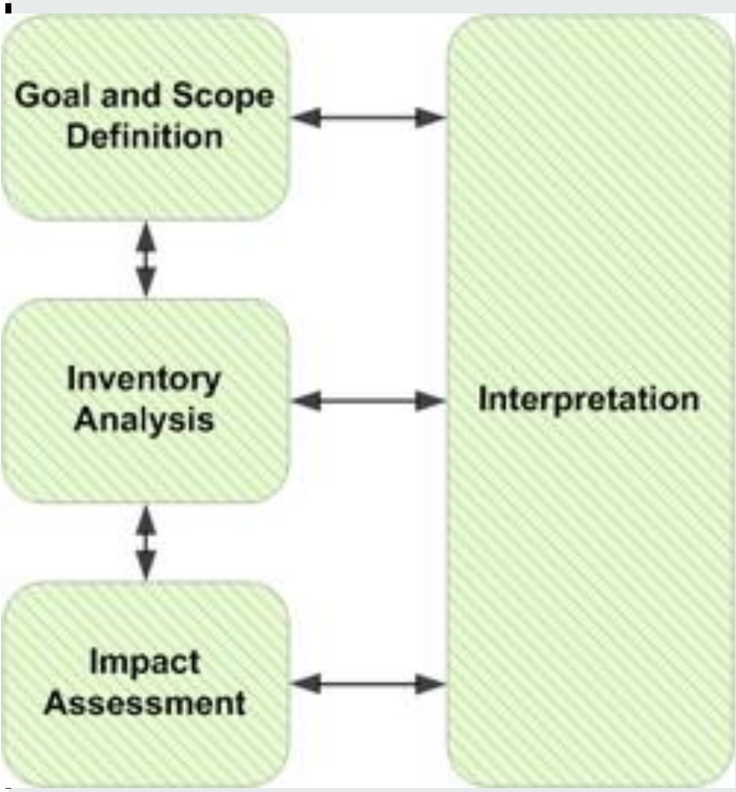


Análise de Ciclo de Vida

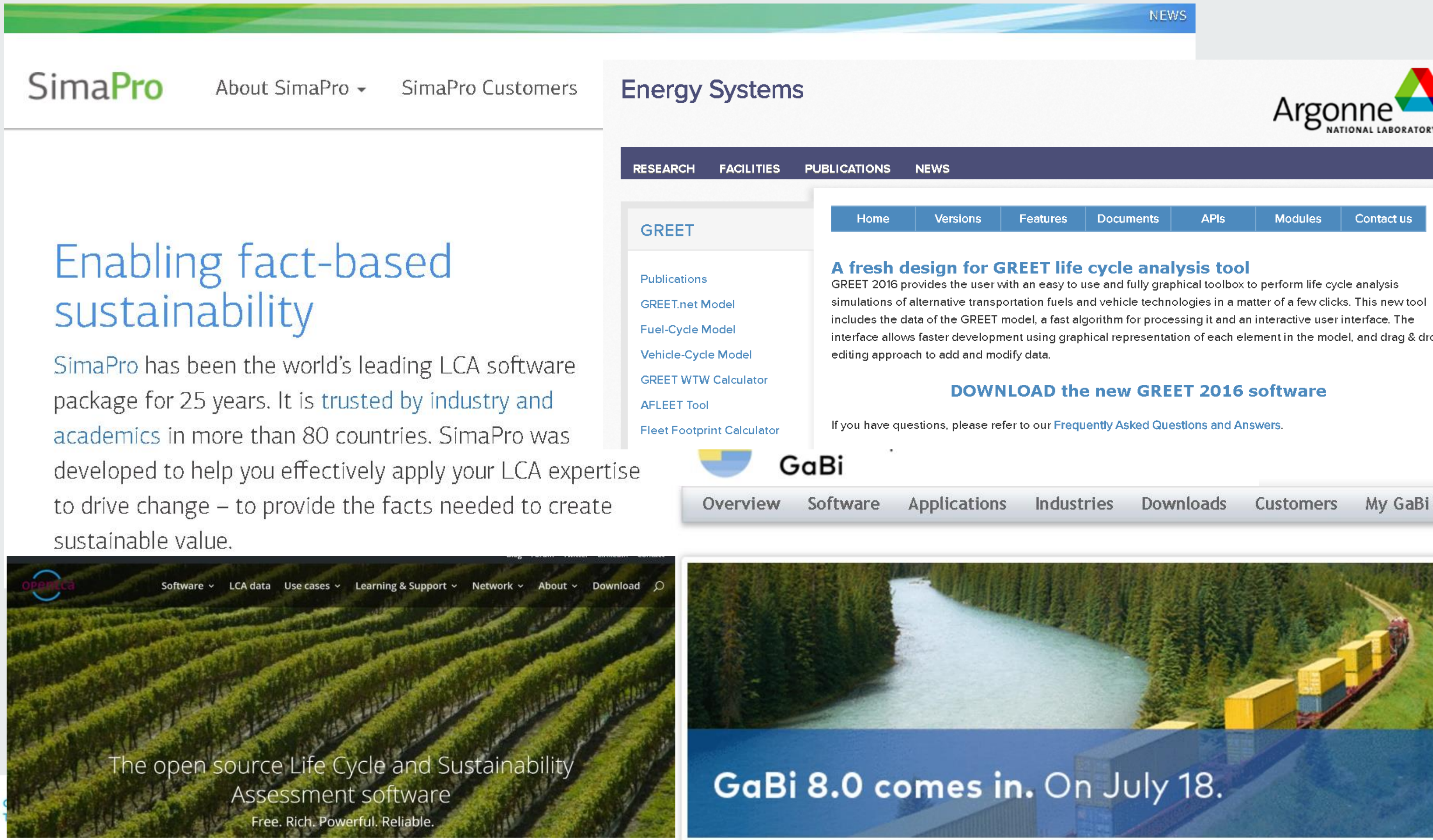
Passos para definição de LCA:

• **Definição de método de alocação**, usado para alocar diversos produtos dentro do mesmo processo **(co-produtos: massa, volume, energia?)**

• **Definição das categorias de impacte**, por exemplo toxicidade humana, smog, aquecimento global, eutrofização **(o que queremos avaliar?)**



Ferramentas de quantificação de impactes



Fontes energéticas alternativas

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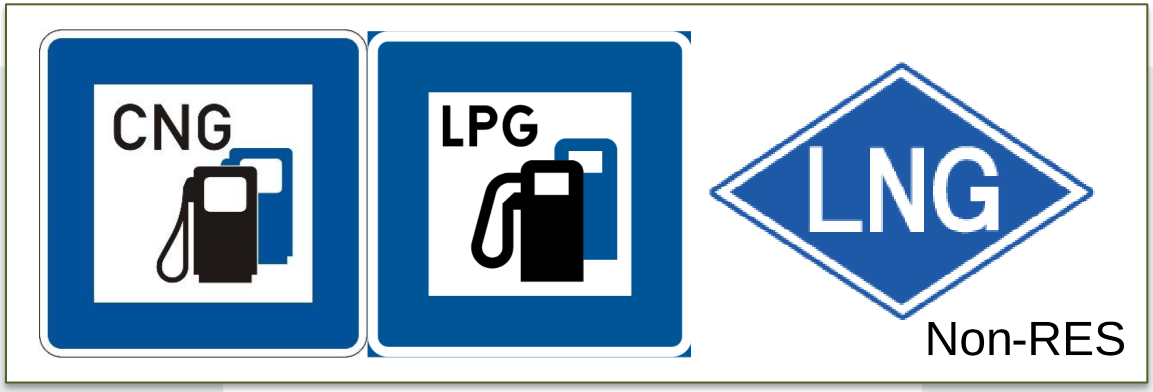

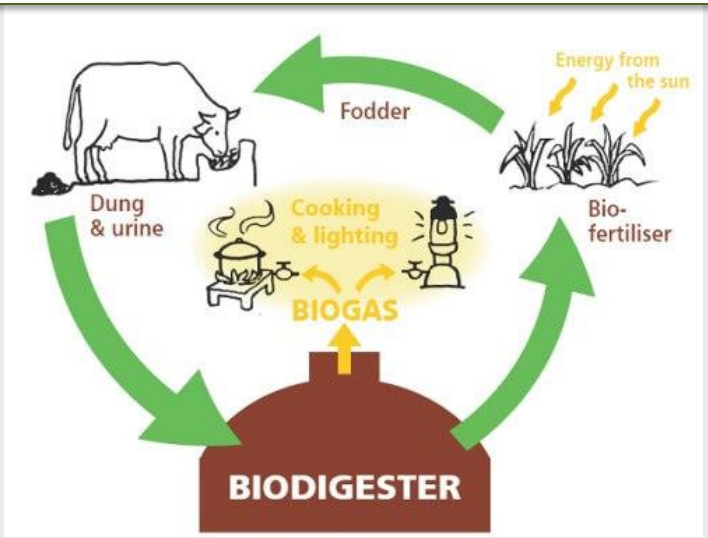

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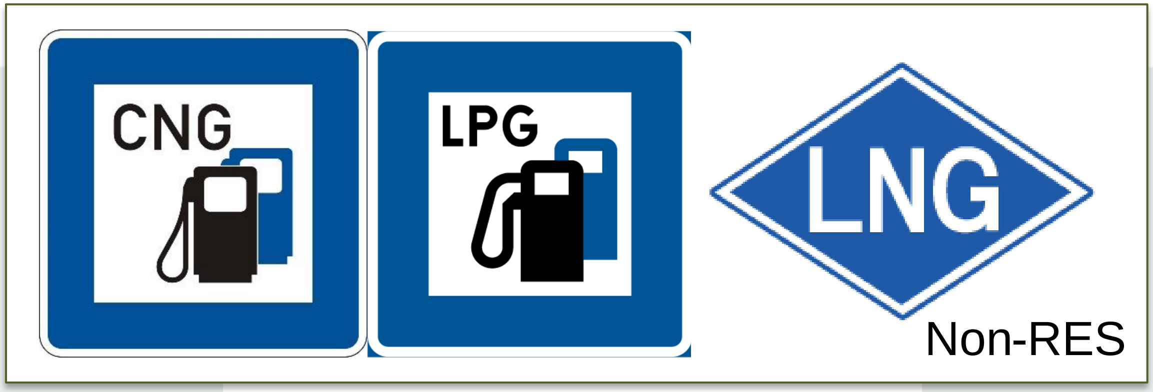

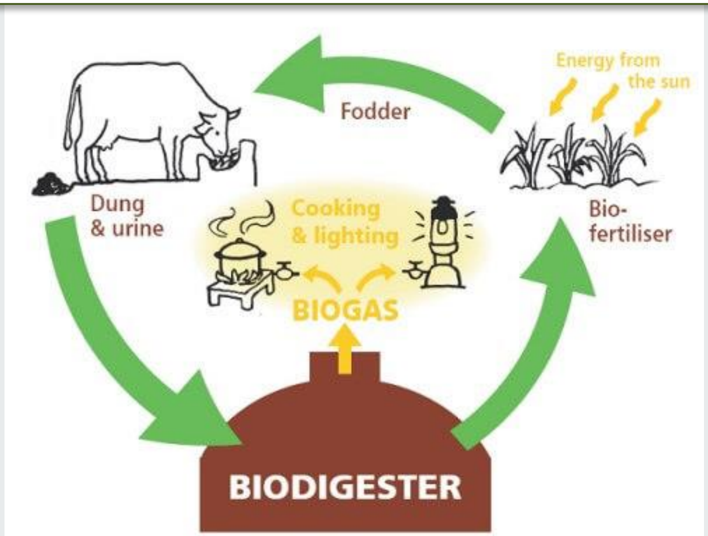

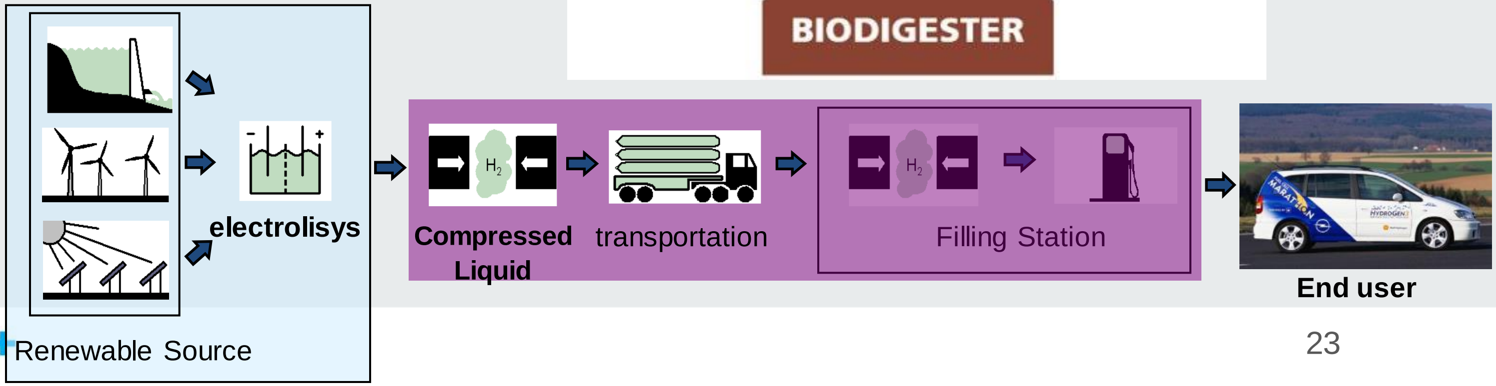

Fontes energéticas alternativas

Que fontes energéticas alternativas já utilizamos?

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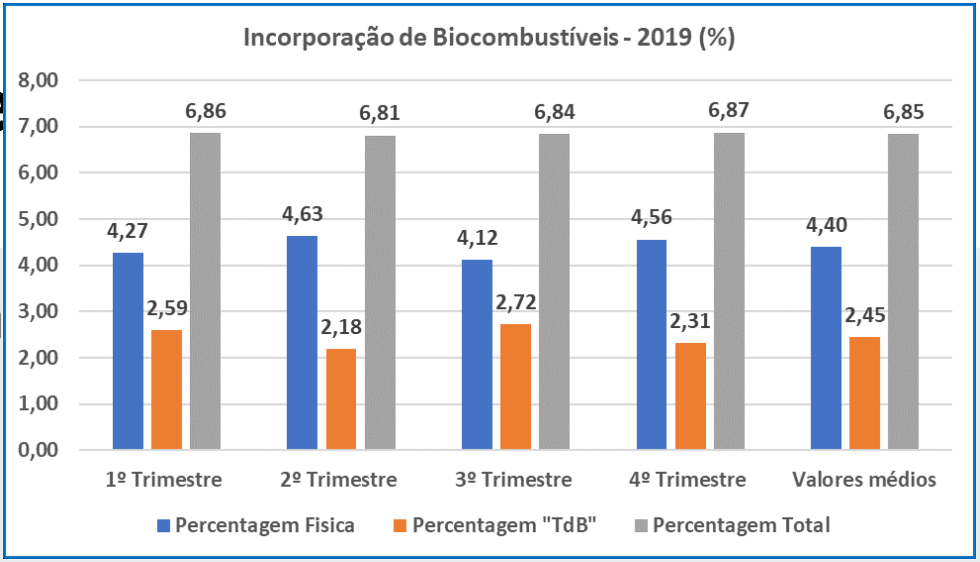
Fontes e

Que fontes energéticas altern



Emissão de títulos de Biocombustíveis – 2019

Tdb	Jan	Fev	Mar	Abr	Mai	Jun	Jul	Ago	Set	Out	Nov	Dez
TdB-D	20 610	19 267	17 646	22 001	25 045	26 575	21 766	27 330	20 159	25 432	24 318	17 210
TdB-G	531	600	537	706	332	523	480	337	582	338	468	256
TdB Importação[1]	797	797	779	1 034	730	761	707	595	1 415	586	697	698
TdB Dupla Contagem	12 584	12 195	11 944	13 987	13 796	17 556	15 296	17 004	11 745	16 944	13 266	8 726
Total	**33 725**	**32 062**	**30 127**	**36 694**	**39 173**	**44 664**	**42 698**	**44 671**	**32 486**	**42 714**	**38 052**	**26 192**

Legenda:

- TdB: Título de Biocombustível
- TdB-D: TdB emitido para biocombustível substituto do gasóleo
- TdB-G: TdB emitido para biocombustível substituto de gasolina
- TdB Dupla Contagem: Biocombustível de origem residual

[1] Os TdB de Importação estão incluídos nos valores de TdB-D e TdB-G, não sendo contabilizados para o total de TdB emitidos.

Fontes energéticas alternativas

Que fontes energéticas alternativas já utilizamos?

Transport	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Ren. electricity in road transport	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,1	0,2	0,5	0,5
Ren. electricity in rail transport	10,9	11,1	12,0	11,9	12,7	13,4	13,9	12,6	13,5	11,5	12,0	12,7	19,0	21,6	22,3	22,2	18,6
Ren. electricity in all other transport modes	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,4	0,5	0,4	0,3	0,3	0,3	0,3	0,3	0,3	0,3
Compliant biofuels*	0,0	0,0	71,6	121,9	125,6	208,1	309,1	4,0	4,2	9,4	151,5	327,7	259,7	242,1	281,5	283,8	262,1
Annex IX	×	×	×	×	×	×	×	4,0	4,2	9,4	10,1	35,7	107,2	139,5	165,6	177,5	160,1
3(4)d first paragraph	×	×	×	×	×	×	×	0,0	0,0	0,0	0,0	249,4	137,9	102,6	115,8	106,3	102,1
3(4)d third paragraph subsection (i) and (ii)	×	×	×	×	×	×	×	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
other compliant biofuels	×	×	×	×	×	×	×	0,0	0,0	0,0	141,4	42,5	14,7	0,0	0,0	0,0	0,0
Non-compliant biofuels	0,0	0,0	0,0	0,0	0,0	0,0	0,0	289,1	269,1	252,0	109,7	0,0	0,0	0,0	0,0	0,0	0,0
Other renewable energies	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Total (RES-T numerator with multiplicators)	**27,3**	**27,8**	**101,5**	**151,5**	**157,2**	**241,6**	**343,9**	**40,0**	**42,6**	**47,8**	**192,1**	**395,6**	**414,9**	**436,3**	**504,2**	**519,8**	**471,2**
* In period 2004-2010 all consumed biofuels are included in this category; as of 2011 only those compliant with Articles 17 and 18 of Directive 2009/28/EC.																	
Fuel used in transport (as defined in Article 3)																	
Total (RES-T denominator with multiplicators)	**6 448,7**	**6 170,3**	**6 226,8**	**6 228,7**	**6 250,4**	**6 219,4**	**6 198,3**	**5 752,1**	**5 277,4**	**5 172,7**	**5 238,2**	**5 323,5**	**5 425,6**	**5 513,6**	**5 579,5**	**5 719,1**	**4 857,7**
Note: All calculation provisions set out in Directive 2009/28/EC are applied to the total numerator and the total denominator																	
RES-T [%]	**0,42%**	**0,45%**	**1,63%**	**2,43%**	**2,51%**	**3,88%**	**5,55%**	**0,69%**	**0,81%**	**0,93%**	**3,67%**	**7,43%**	**7,65%**	**7,91%**	**9,04%**	**9,09%**	**9,70%**

Shares, 2021.

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Fontes energéticas alternativas

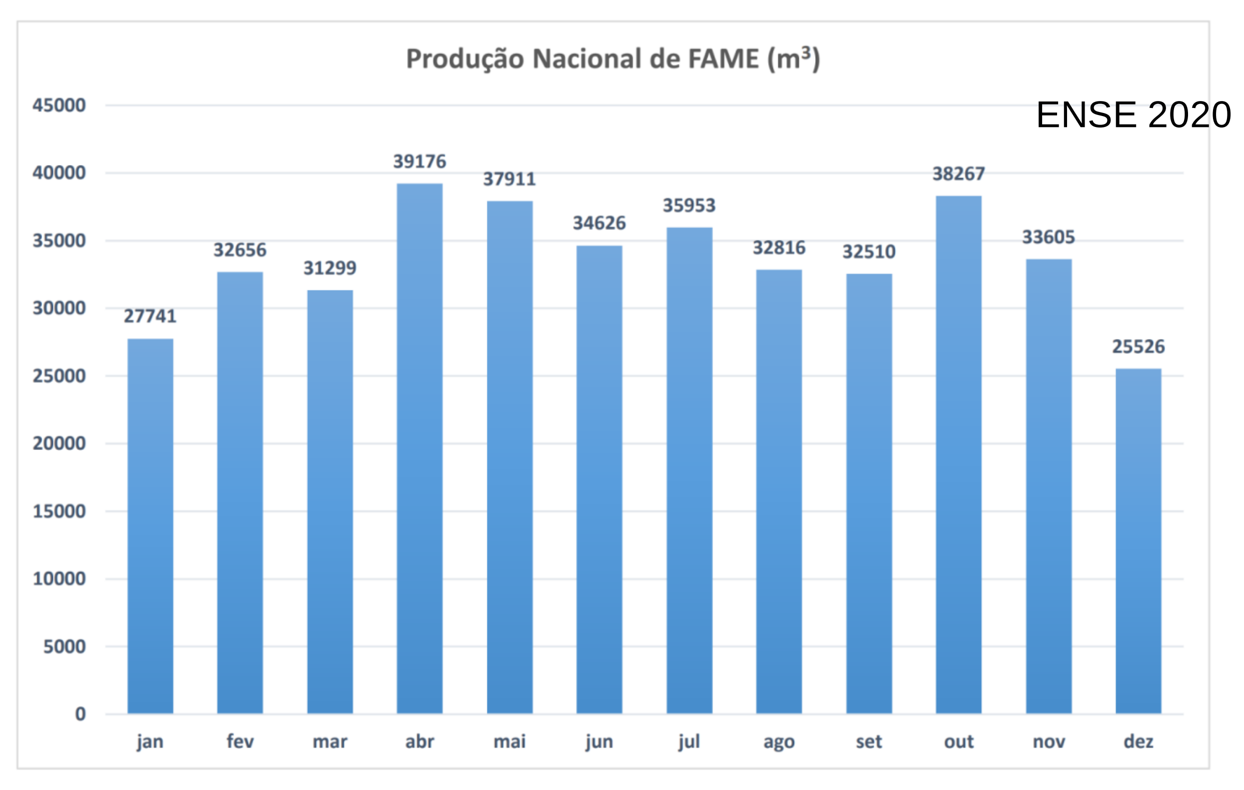
Que matérias primas são utilizadas para produzir essas fontes energéticas alternativas?

Fontes energéticas alternativas

Que matérias primas são utilizadas para produzir essas fontes energéticas alternativas?

- **Origem?**
- **Processos?**
- **Critérios de sustentabilidade?**

Economia circular



Fontes energéticas alternativas

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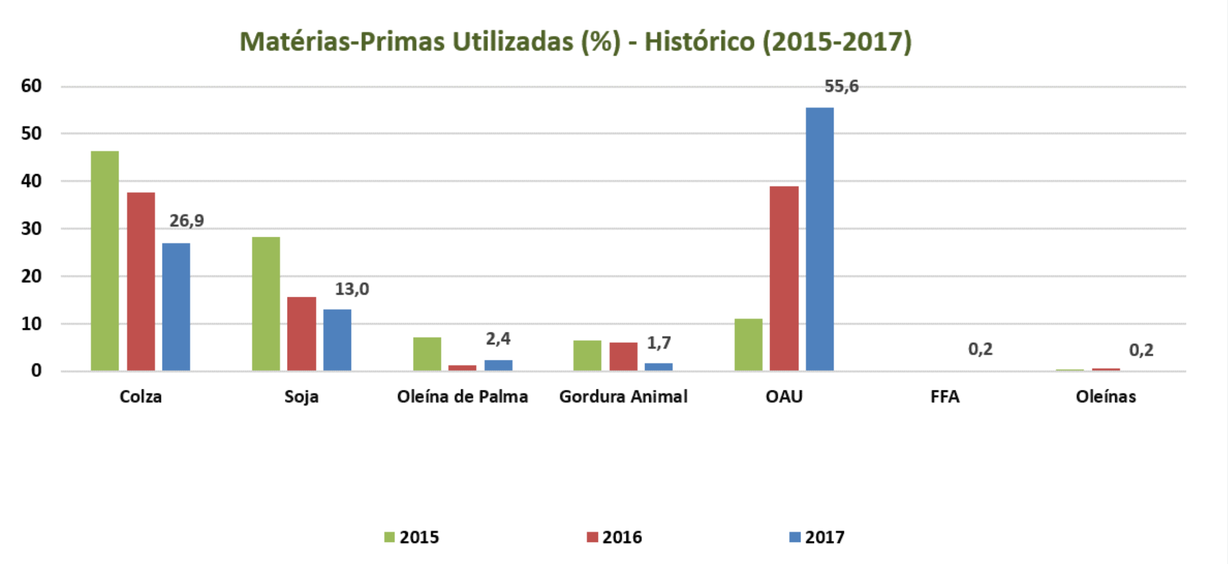
ENSE 2020

- **Origem?**
- **Processos?**
- **Critérios de sustentabilidade?**

Economia circular

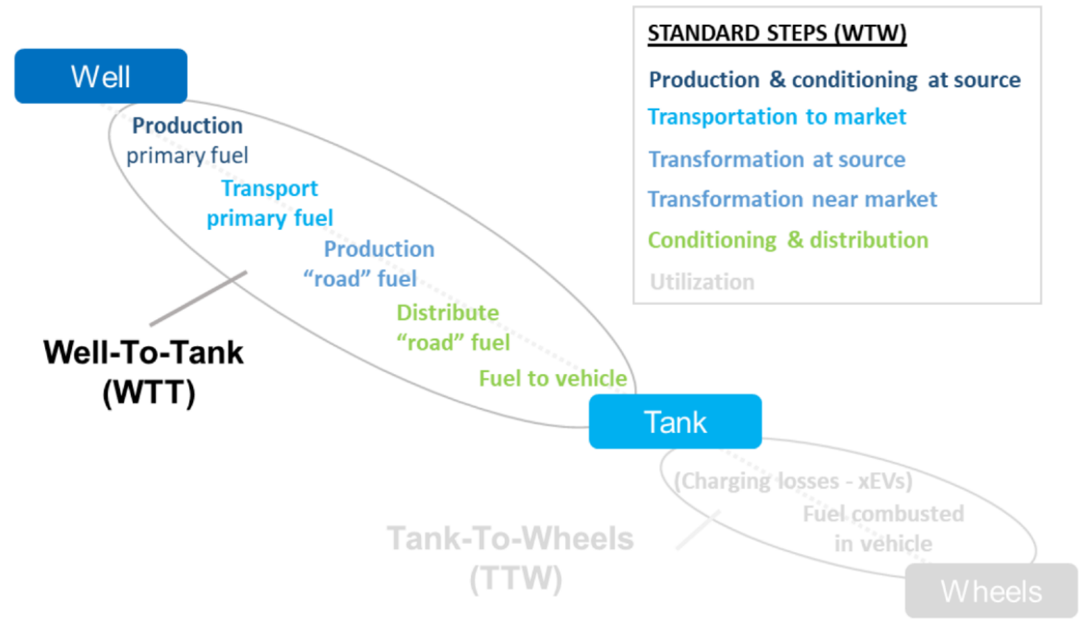


Ciclo de vida de fontes energéticas

Well-to-Tank (WTT)

Total expended energy (MJ_{ex}) along the extraction / production / transformation / transport of the energy source, excluding the energy content of the energy source/fuel produced (1MJ).

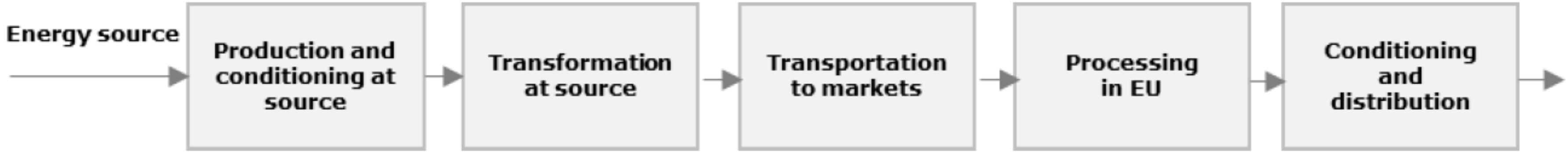
Figure 1. Well-To-Tank analysis (WTT) - Scope

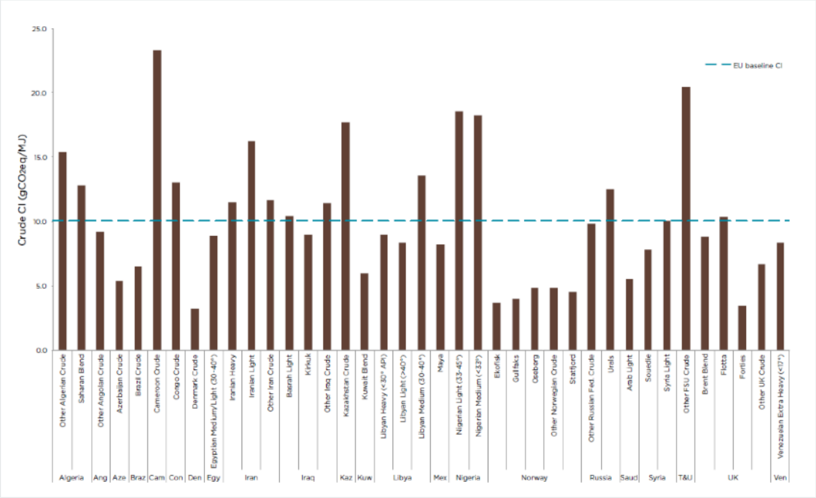


JRC, 2021.

Ciclo de vida de fontes energéticas

Well-to-Tank (WTT) – conventional fuels



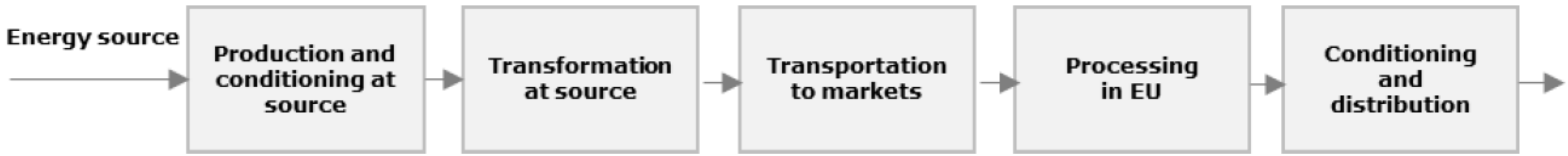


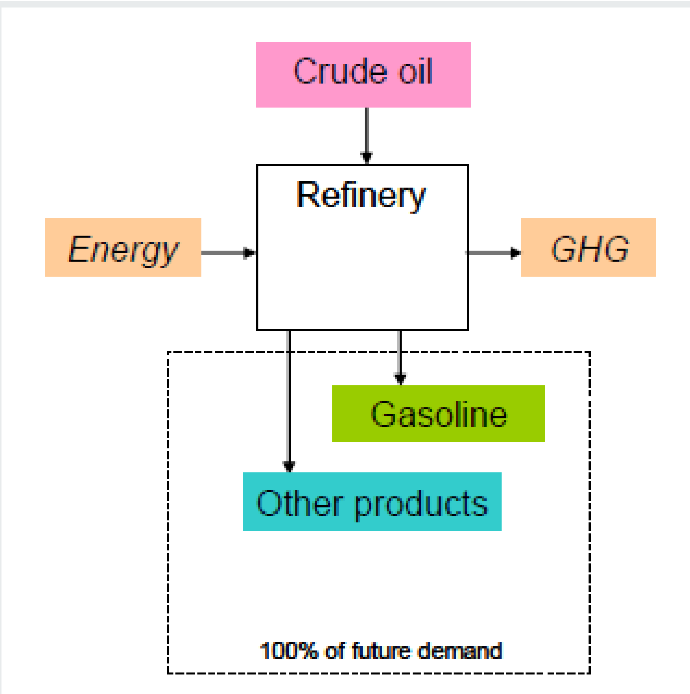
Para cada etapa do processo, inclusão de todos os inputs (materiais, energéticos, etc.) e de todos os outputs (materiais, emissões, etc) em cada um dos processos

Contabilização de todas as etapas desde a extracção, produção e disponibilização da fonte energética

Ciclo de vida de fontes energéticas

Well-to-Tank (WTT) – conventional fuels





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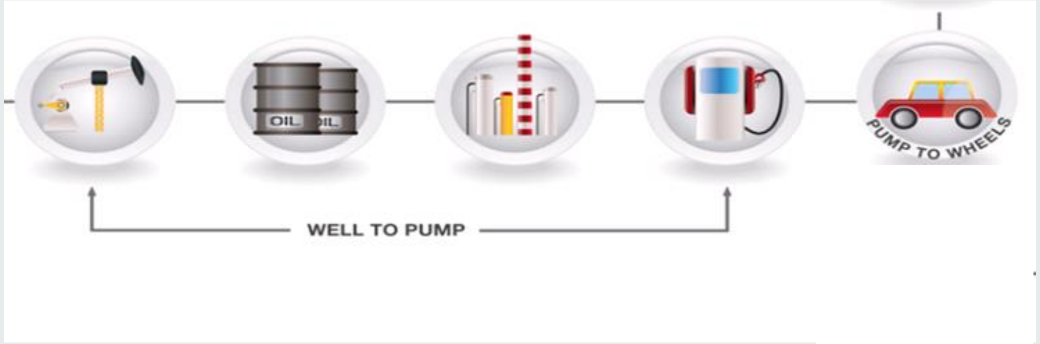
Ciclo de vida de fontes energéticas

Well-to-Tank (WTT)

Total expended energy (MJ_{ex}) along the extraction / production / transformation / transport of the energy source, excluding the energy content of the energy source/fuel produced (1MJ).

To obtain 1 MJ of fuel to be used in the vehicle

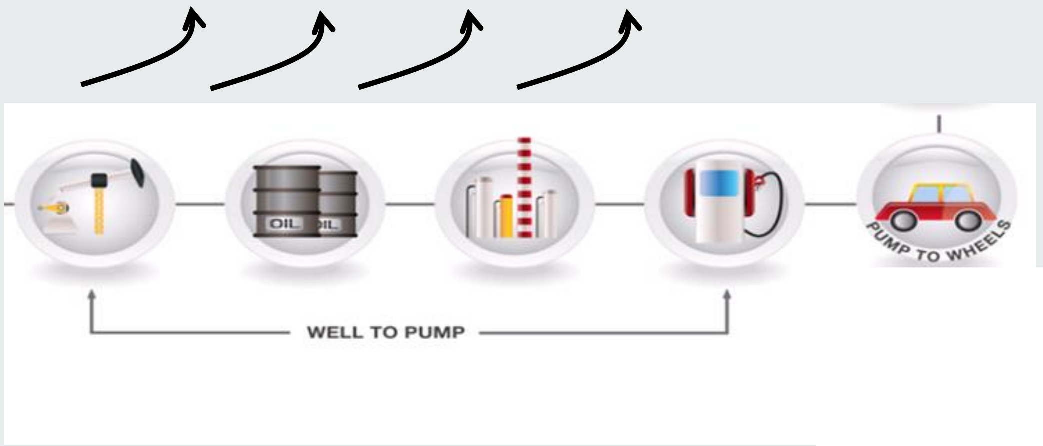


Ciclo de vida de fontes energéticas

Well-to-Tank (WTT)

... losses happened in the WTT stage:
Expended energy (MJ) + CO_2 emissions (g)

Total expended energy (MJ_{ex}) along the extraction / production / transformation / transport of the energy source, excluding the energy content of the energy source/fuel produced (1MJ).



Well-to-Tank factor (WTW) = 1 unit of energy (MJ) + expended energy (MJ)

Ciclo de vida de fontes energéticas

Well-to-Tank (WTT) – conventional fuels

Gasoline and Diesel WTT CO_2 emissions per unit of energy

- Transformation stages are the most energy/emission intensive
- Transport stages are very efficient

Code		**COG1**	*Description*
Final fuel		**Gasoline**	Crude oil from typical EU supply, transport by sea, refining in EU (marginal production), typical EU distribution and retail.

Results

		Energy expended MJ/$MJ_{gasoline}$	GHG emissions g CO_{2eq}/$MJ_{gasoline}$ Total	as CO_2	as CH_4	as N_2O
Standard steps	*Actual steps*					
Production & conditioning at source	Crude oil production	0.13	9.8	9.11	0.66	0.00
Transformation at source	*NA*					
Transportation to market	Crude oil transport	0.01	0.8	0.76	0.00	0.00
Transformation near market	Crude refining, marginal gasoline	0.08	5.5	5.51	0.00	0.00
Conditioning & distribution	Distribution	0.01	0.6	0.55	0.00	0.00
	Dispensing at retail site	0.01	0.4	0.43	0.00	0.00
Total WTT		**0.24**	**17.0**			

Code		**COD1**	*Description*
Final fuel		**Diesel fuel**	Crude oil from typical EU supply, transport by sea, refining in EU (marginal production), typical EU distribution and retail.

Results

		Energy expended MJ/MJ_{diesel}	GHG emissions g CO_{2eq}/MJ_{diesel} Total	as CO_2	as CH_4	as N_2O
Standard steps	*Actual steps*					
Production & conditioning at source	Crude oil production	0.13	10.0	9.31	0.68	0.00
Transformation at source	*NA*					
Transportation to market	Crude oil transport	0.01	0.8	0.77	0.00	0.00
Transformation near market	Crude refining, marginal diesel	0.11	7.2	7.20	0.00	0.00
Conditioning & distribution	Distribution	0.01	0.5	0.52	0.00	0.00
	Dispensing at retail site	0.01	0.4	0.37	0.00	0.00
Total WTT		**0.26**	**18.9**			

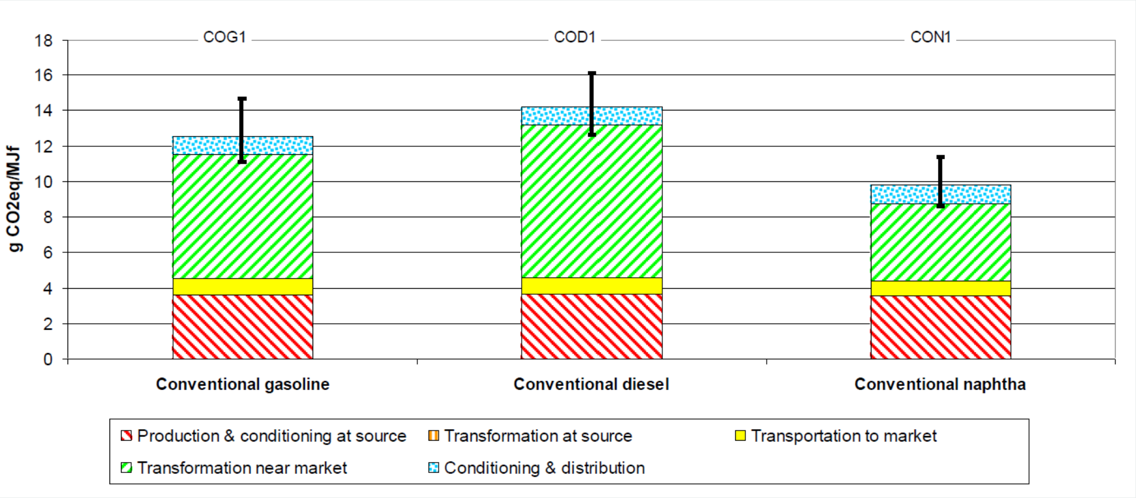
JRC, 2021.

Ciclo de vida de fontes energéticas

Well-to-Tank (WTT) – conventional fuels

Gasoline and Diesel WTT CO_2 emissions per unit of energy

- Transformation stages are the most energy/emission intensive
- Transport stages are very efficient



JRC, 2021.

Ciclo de vida de fontes energéticas

Well-to-Tank (WTT) – electricity

Combination of different factors:

- Electricity generation mix
- Efficiency of the processes
- Distribution and transmission losses (typical 7-10%)

Energy Source	Expended energy (MJ/MJfuel)	Primary energy (MJ/MJfuel)	Efficiency (%)
Coal	1.66	2.66	38%
NG	1.15	2.15	47%
Biogas	2.66	3.66	27%
Wood	2.01	3.01	33%
Nuclear	2.90	3.90	26%
Hydropower	0.11	1.11	90%
Solar	0.03	1.03	97%
Wind	0.07	1.07	93%

Ciclo de vida de fontes energéticas

Well-to-Tank (WTT) – electricity

Combination of different factors:

- Electricity generation mix
- Efficiency of the processes
- Distribution and transmission losses (typical 7-10%)

Energy Source	Expended energy (MJ/MJfuel)	Primary energy (MJ/MJfuel)	Efficiency (%)	GHG emissions (g CO2eq/MJfuel)	Electricity generation mix (%)
Coal	1.66	2.66	38%	200.3	12%
NG	1.15	2.15	47%	129.4	33%
Biogas	2.66	3.66	27%	19.2	2%
Wood	2.01	3.01	33%	15.1	4%
Nuclear	2.90	3.90	26%	3.9	0%
Hydropower	0.11	1.11	90%	0.0	20%
Solar	0.03	1.03	97%	0.0	2%
Wind	0.07	1.07	93%	0.0	27%

Ciclo de vida de fontes energéticas

Well-to-Tank (WTT) – electricity

Combination of different factors:

- Electricity generation mix
- Efficiency of the processes
- Distribution and transmission losses (typical 7-10%)

Energy Source	Expended energy (MJ/MJfuel)	Primary energy (MJ/MJfuel)	Efficiency (%)	GHG emissions (g CO2eq/MJfuel)	Electricity generation mix (%)
Coal	1.66	2.66	38%	200.3	12%
NG	1.15	2.15	47%	129.4	33%
Biogas	2.66	3.66	27%	19.2	2%
Wood	2.01	3.01	33%	15.1	4%
Nuclear	2.90	3.90	26%	3.9	0%
Hydropower	0.11	1.11	90%	0.0	20%
Solar	0.03	1.03	97%	0.0	2%
Wind	0.07	1.07	93%	0.0	27%
					100%
Weighted average without losses	**0.76**	**1.76**	**MJ/MJ**	**67 g/MJ**	
Weighted average with 7% losses	**0.81**	**1.88**	**MJ/MJ**	**72 MJ/MJ**	

Ciclo de vida de fontes energéticas

Well-to-Tank (WTT) – alternative energy sources

Ethanol

Ethanol	
SBET1a	Sugar beet, pulp to AF, slops not used
SBET1b	Sugar beet, pulp to AF, slops to biogas
SBET1c	Sugar beet, pulp to fuel, slops to biogas
WTET1a	Wheat, conv NG boiler, DDGS as AF
WTET1b	Wheat, conv NG boiler, DDGS as fuel
WTET2a	Wheat, NG GT+CHP, DDGS as AF
WTET2b	Wheat, NG GT+CHP, DDGS as fuel
WTET3a	Wheat, Lignite CHP, DDGS as AF
WTET3b	Wheat, Lignite CHP, DDGS as fuel
WTET4a	Wheat, Straw CHP, DDGS as AF
WTET4b	Wheat, Straw CHP, DDGS as fuel
WTET5	Wheat, DDGS to biogas
BRET2a	Barley/Rye, NG GT+CHP, DDGS as AF
CRET2a	Maize, NG GT+CHP, DDGS as AF
CRETus	Corn US, DDGS as AF
SCET1	Sugar cane (Brazil)
WFET1	F wood
WWET1	W wood
STET1	Wheat straw
ETBE	
LREB1	ETBE: imported C4 and wheat ethanol

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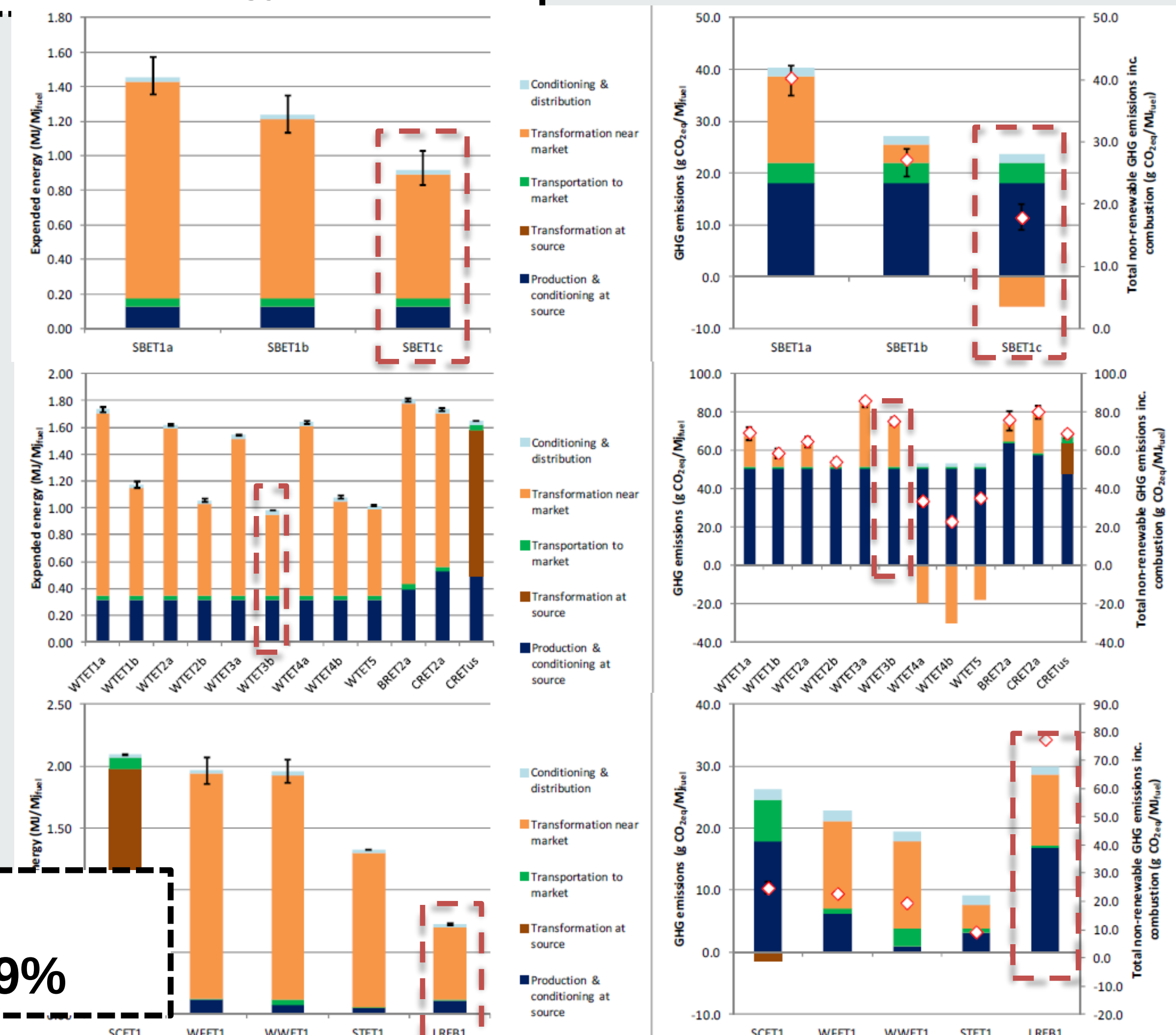
Ciclo de vida de fontes energéticas

Ethanol

Well-to-Tank (WTT) – alternative energy sources

Ethanol	
SBET1a	Sugar beet, pulp to AF, slops not used
SBET1b	Sugar beet, pulp to AF, slops to biogas
SBET1c	Sugar beet, pulp to fuel, slops to biogas
WTET1a	Wheat, conv NG boiler, DDGS as AF
WTET1b	Wheat, conv NG boiler, DDGS as fuel
WTET2a	Wheat, NG GT+CHP, DDGS as AF
WTET2b	Wheat, NG GT+CHP, DDGS as fuel
WTET3a	Wheat, Lignite CHP, DDGS as AF
WTET3b	Wheat, Lignite CHP, DDGS as fuel
WTET4a	Wheat, Straw CHP, DDGS as AF
WTET4b	Wheat, Straw CHP, DDGS as fuel
WTET5	Wheat, DDGS to biogas
BRET2a	Barley/Rye, NG GT+CHP, DDGS as AF
CRET2a	Maize, NG GT+CHP, DDGS as AF
CRETus	Corn US, DDGS as AF
SCET1	Sugar cane (Brazil)
WFET1	F wood
WWET1	W wood
STET1	Wheat straw
ETBE	
LREB1	ETBE: imported C4 and wheat ethanol



Conversion yields?

WTT ethanol = 1/1.70 = **59%**

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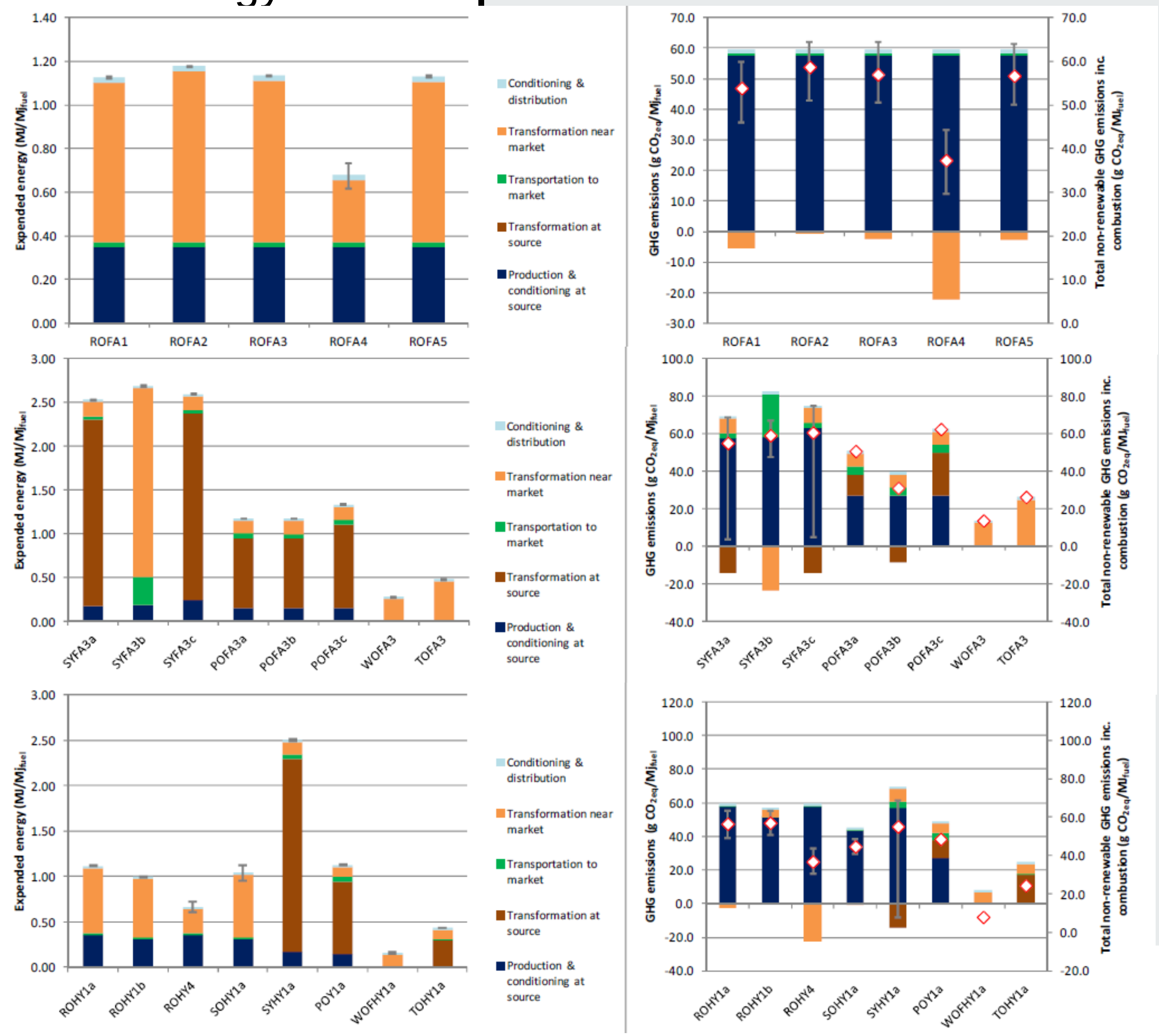
Ciclo de vida de fontes energéticas

Biodiesel

2. Well-to-Tank (WTT) – alternative energy sources

Conventional fossil fuels	
COD1	Diesel
Biodiesel	
ROFA1	RME: Meal as AF, glycerine as chem.
ROFA2	RME: Meal and glycerine as AF
ROFA3	RME: Meal as AF, glycerine to biogas
ROFA4	RME: Meal and glycerine to biogas
ROFA5	RME: Meal as AF, Glycerine to hydrogen
ROFE3	REE: Meal as AF, glycerine to biogas
SOFA3	RME: Meal as AF, glycerine to biogas
SYFA3a	SYME: No till, oil import, meal as AF, glycerine to biogas
SYFA3b	SYME: No till, beans import, meal as AF, glycerine to biogas
SYFA3c	SYME: Conv. culture, oil import, meal as AF, glycerine to biogas
POFA3a	POME: Meal as AF, no CH4 rec., heat credit, glycerine to biogas
POFA3b	POME: Meal as AF, CH4 rec., heat credit, glycerine to biogas
POFA3c	POME: Meal as AF, no CH4 rec., no heat credit, glycerine to biogas
WOFA3a	FAME: waste cooking oil
TOFA3a	FAME: tallow oil
HVO	
ROHY1a	HRO (NExBTL), meal as AF
ROHY1b	HRO (UOP), meal as AF
ROHY4	HRO (NExBTL), meal to biogas
SOHY1a	HSO (NExBTL), meal as AF
SYHY1a	HSO (NExBTL), oil imported
POY1a	HPO (NExBTL), no CH4 rec.
WOHY1a	HWO (NExBTL), waste cooking oil
TOHY1a	HTO (NExBTL), tallow oil



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Ciclo de v

Conversion yields?

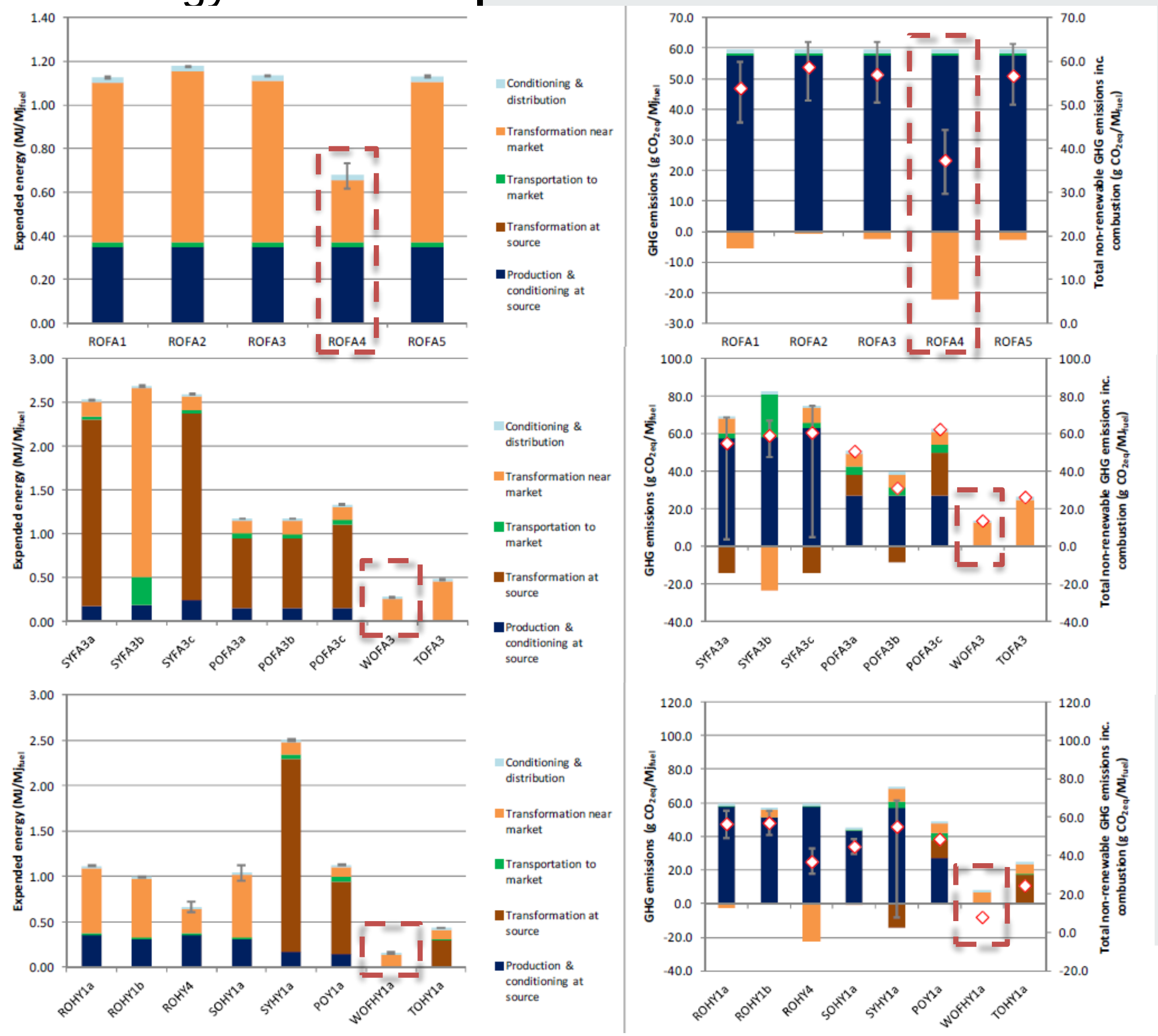
WTT biodiesel FAME = 1/1.68 = **35%**

WTT biodiesel OAU = 1/1.28 = **78%**

WTT biodiesel HVO = 1/1.16 = **86%**

Well-to-Tank (WTT) – alternative energy sources

Conventional fossil fuels	
COD1	Diesel
Biodiesel	
ROFA1	RME: Meal as AF, glycerine as chem.
ROFA2	RME: Meal and glycerine as AF
ROFA3	RME: Meal as AF, glycerine to biogas
ROFA4	RME: Meal and glycerine to biogas
ROFA5	RME: Meal as AF, Glycerine to hydrogen
ROFE3	REE: Meal as AF, glycerine to biogas
SOFA3	RME: Meal as AF, glycerine to biogas
SYFA3a	SYME: No till, oil import, meal as AF, glycerine to biogas
SYFA3b	SYME: No till, beans import, meal as AF, glycerine to biogas
SYFA3c	SYME: Conv. culture, oil import, meal as AF, glycerine to biogas
POFA3a	POME: Meal as AF, no CH4 rec., heat credit, glycerine to biogas
POFA3b	POME: Meal as AF, CH4 rec., heat credit, glycerine to biogas
POFA3c	POME: Meal as AF, no CH4 rec., no heat credit, glycerine to biogas
WOFA3a	FAME: waste cooking oil
TOFA3a	FAME: tallow oil
HVO	
ROHY1a	HRO (NExBTL), meal as AF
ROHY1b	HRO (UOP), meal as AF
ROHY4	HRO (NExBTL), meal to biogas
SOHY1a	HSO (NExBTL), meal as AF
SYHY1a	HSO (NExBTL), oil imported
POY1a	HPO (NExBTL), no CH4 rec.
WOHY1a	HWO (NExBTL), waste cooking oil
TOHY1a	HTO (NExBTL), tallow oil



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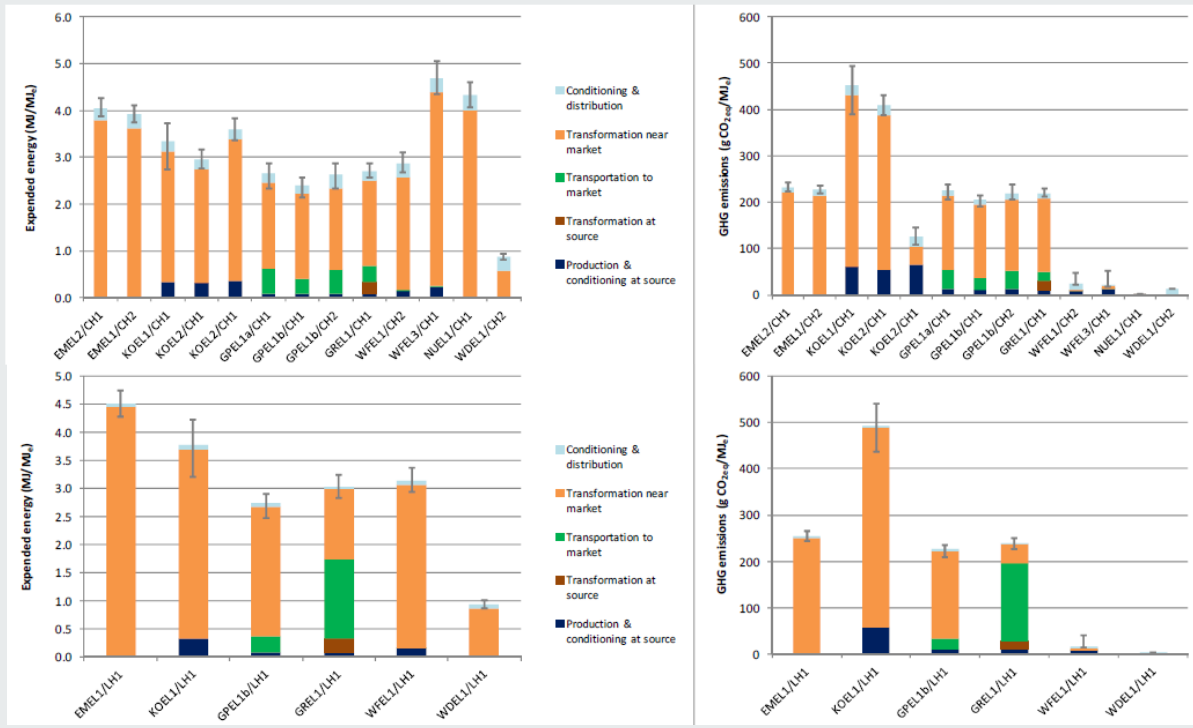
Ciclo de vida de fontes energéticas

Bio-H_2

Well-to-Tank (WTT) – alternative energy sources

Hydrogen (electrolysis)	
GPEL1a/CH1	C-H2: NG 7000 km, CCGT, O/S Ely
GPEL1b/CH1	C-H2: NG 4000 km, CCGT, O/S Ely
GPEL1b/CH2	C-H2: NG 4000 km, CCGT, Cen Ely, Pipe
GREL1/CH1	C-H2: LNG, O/S Ely
WFEL1/CH2	C-H2: F Wood, 200 MW gasif, CCGT, Cen ely, Pipe
WFEL3/CH1	C-H2: F Wood, Conv power, O/S Ely
EMEL2/CH1	C-H2: Elec EU-mix, O/S Ely
EMEL1/CH2	C-H2: Elec EU-mix, Cen ely, Pipe
EMEL1/LH1	Cc-H2: Elec EU-mix, Cen ely, Liq, Road
KOEL1/CH1	C-H2: Elec coal EU-mix conv., O/S Ely
KOEL2/CH1	C-H2: Elec coal EU-mix IGCC, O/S Ely
KOEL2C/CH1	C-H2: Elec coal EU-mix IGCC + CCS, O/S Ely
NUEL1/CH1	C-H2: Elec nuclear, O/S Ely
WDEL1/CH2	C-H2: Wind, Cen Ely, Pipe
GPEL1b/LH1	Cc-H2: NG 4000 km, CCGT, Cen Ely, Liq, Road
GREL1/LH1	Cc-H2: LNG, Ely
WFEL1/LH1	Cc-H2: F Wood, 200 MW gasif, CCGT, Cen Ely, Liq, Road
EMEL1/LH1	Cc-H2: Elec EU-mix, Cen Ely, Liq, Road
KOEL1/LH1	Cc-H2: Elec coal EU-mix, Cen Ely, Liq, Road
WDEL1/LH1	Cc-H2: Wind, Cen Ely, Liq, Road



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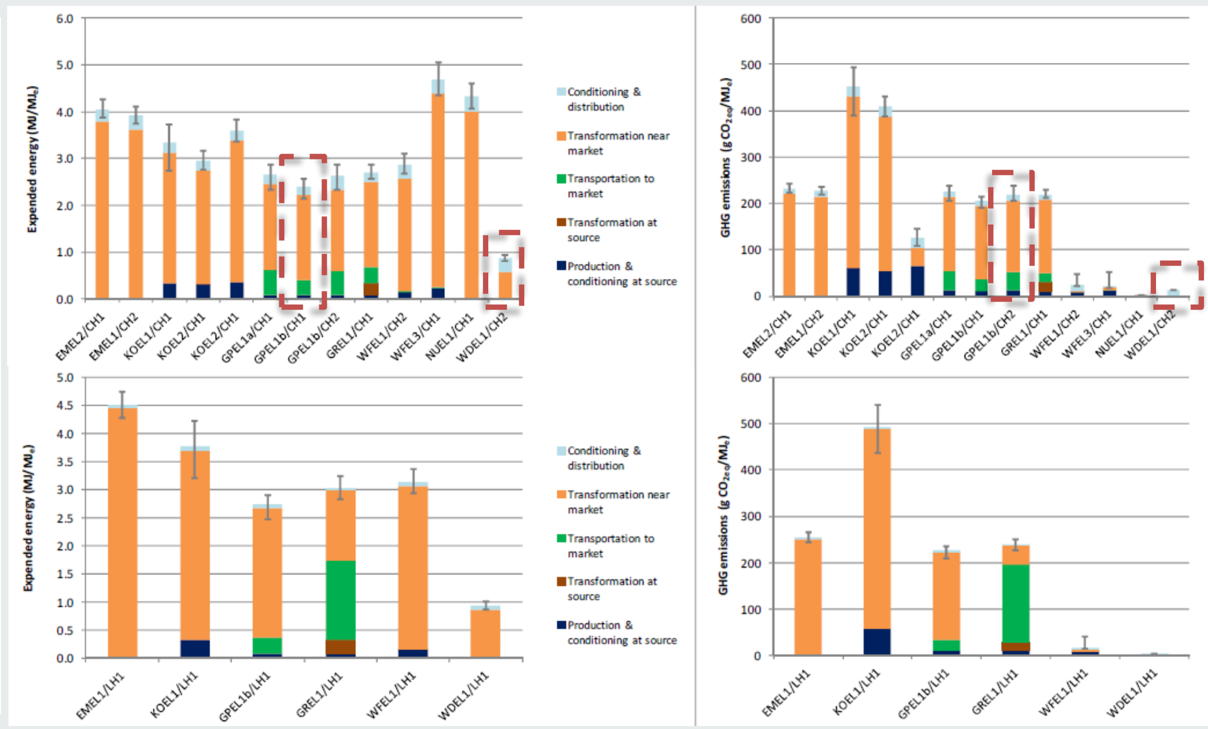
Ciclo de vida de fontes energéticas

Well-to-Tank (WTT) – alternative energy sources

Bio-H_2

Hydrogen (electrolysis)	
GPEL1a/CH1	C-H2: NG 7000 km, CCGT, O/S Ely
GPEL1b/CH1	C-H2: NG 4000 km, CCGT, O/S Ely
GPEL1b/CH2	C-H2: NG 4000 km, CCGT, Cen Ely, Pipe
GREL1/CH1	C-H2: LNG, O/S Ely
WFEL1/CH2	C-H2: F Wood, 200 MW gasif, CCGT, Cen ely, Pipe
WFEL3/CH1	C-H2: F Wood, Conv power, O/S Ely
EMEL2/CH1	C-H2: Elec EU-mix, O/S Ely
EMEL1/CH2	C-H2: Elec EU-mix, Cen ely, Pipe
EMEL1/LH1	Cc-H2: Elec EU-mix, Cen ely, Liq, Road
KOEL1/CH1	C-H2: Elec coal EU-mix conv., O/S Ely
KOEL2/CH1	C-H2: Elec coal EU-mix IGCC, O/S Ely
KOEL2C/CH1	C-H2: Elec coal EU-mix IGCC + CCS, O/S Ely
NUEL1/CH1	C-H2: Elec nuclear, O/S Ely
WDEL1/CH2	C-H2: Wind, Cen Ely, Pipe
GPEL1b/LH1	Cc-H2: NG 4000 km, CCGT, Cen Ely, Liq, Road
GREL1/LH1	Cc-H2: LNG, Ely
WFEL1/LH1	Cc-H2: F Wood, 200 MW gasif, CCGT, Cen Ely, Liq, Road
EMEL1/LH1	Cc-H2: Elec EU-mix, Cen Ely, Liq, Road
KOEL1/LH1	Cc-H2: Elec coal EU-mix, Cen Ely, Liq, Road
WDEL1/LH1	Cc-H2: Wind, Cen Ely, Liq, Road



Conversion yields?

WTT H_2 = 1/3.40 = **29%**

WTT H_2 = 1/1.94 = **52%**

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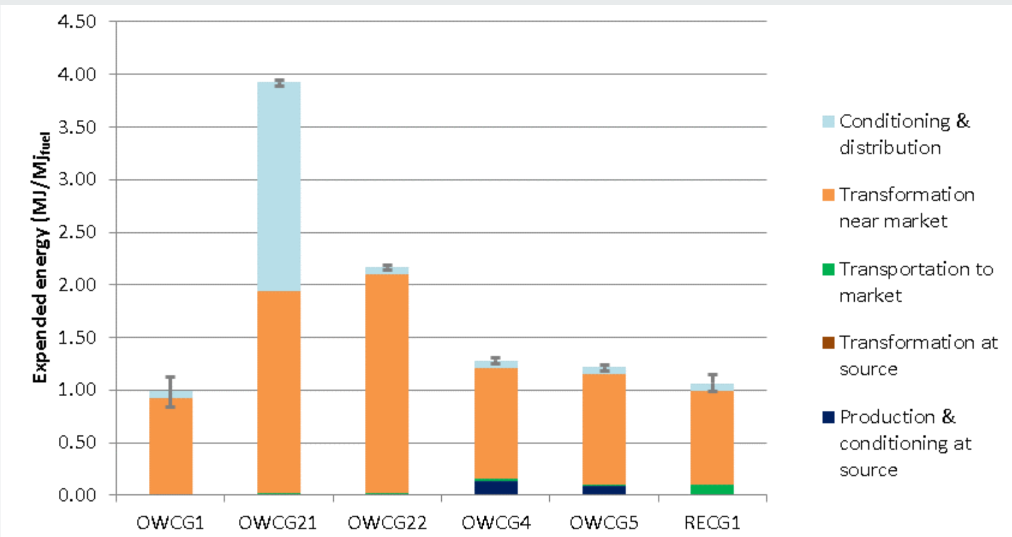
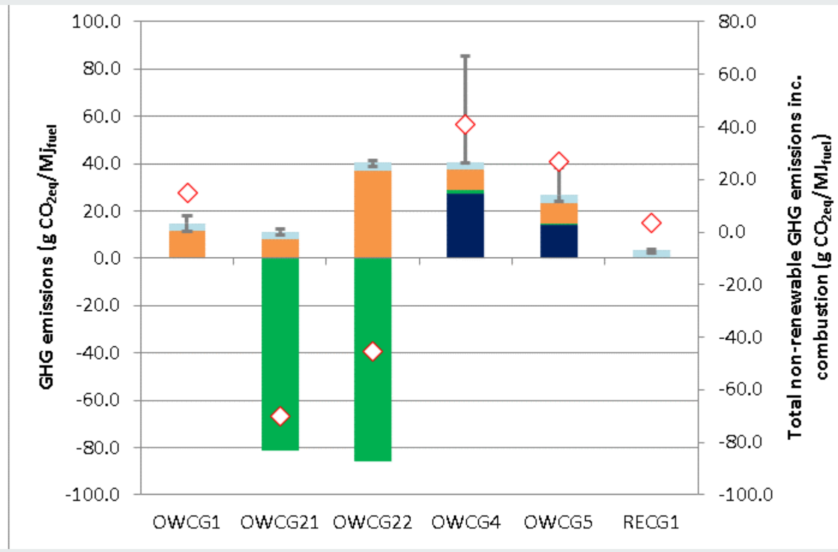
Ciclo de vida de fontes energéticas

Biogas

Well-to-Tank (WTT) – alternative energy sources





OWCG1	CBG	Upgraded biogas from municipal organic waste as CBG. Closed digestate storage.
OWCG21/2	CBG	Upgraded biogas from wet manure as CBG Digestate storage closed (21) or open (22)
OWCG4	CBG	Upgraded biogas from maize (wole plant) as CBG. Closed digestate storage.
OWCG5	CBG	Upgraded biogas from double cropping (barley/maize) as CBG. Closed digestate storage.
RECG1	SNG	Synthetic methane (as CNG) from renewable electricity and CO_2 from flue gases

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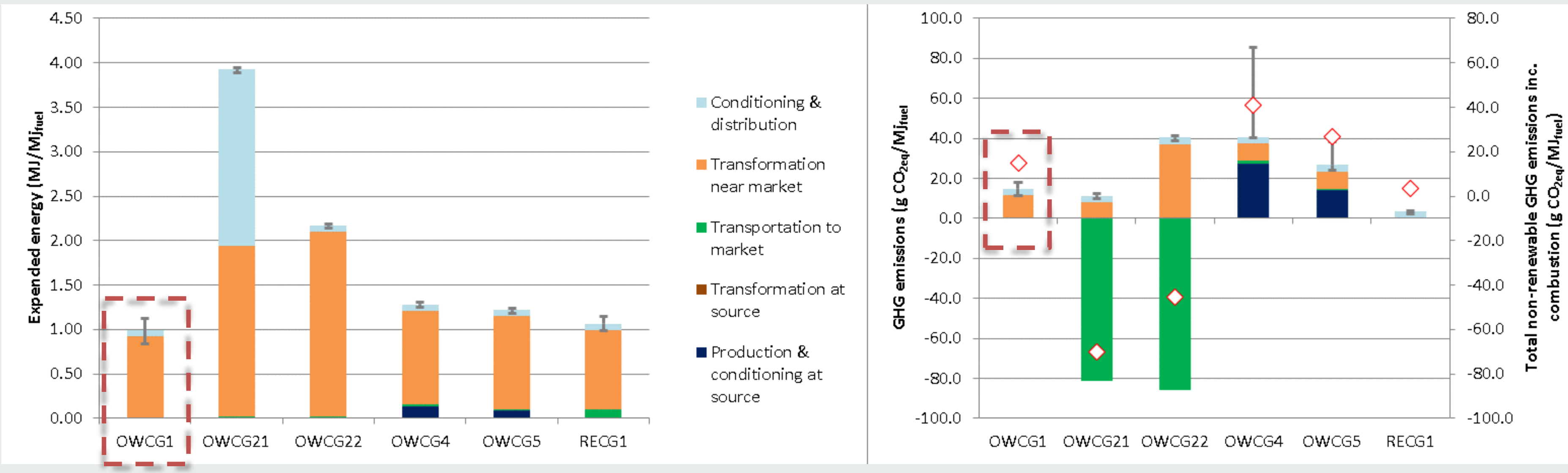
Ciclo de vida de fontes energéticas

Well-to-Tank (WTT) – alternative energy sources

Biogas



OWCG1	CBG	Upgraded biogas from municipal organic waste as CBG. Closed digestate storage.
OWCG21/2	CBG	Upgraded biogas from wet manure as CBG Digestate storage closed (21) or open (22)
OWCG4	CBG	Upgraded biogas from maize (wole plant) as CBG. Closed digestate storage.
OWCG5	CBG	Upgraded biogas from double cropping (barley/maize) as CBG. Closed digestate storage.
RECG1	SNG	Synthetic methane (as CNG) from renewable electricity and CO_2 from flue gases

Conversion yields?

WTT biogas = 1/1.99 = **50%**

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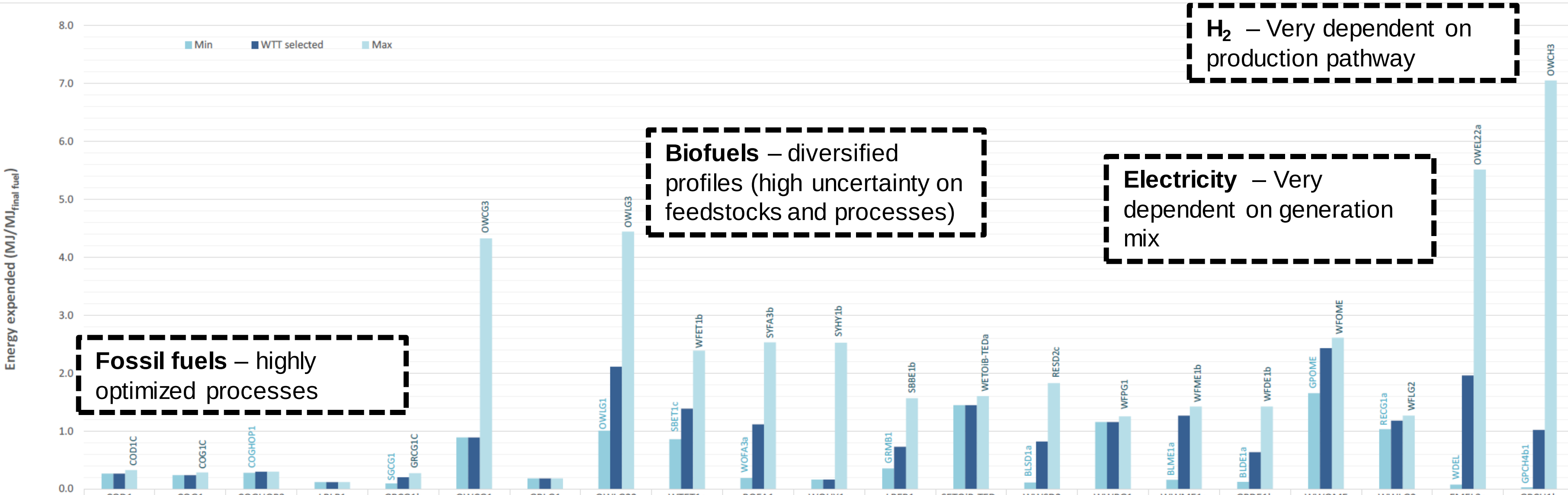
Ciclo de vida de fontes energéticas

Well-to-Tank (WTT) – alternative energy sources

Figure 132. WTT energy expended per type of fuel. Summary



Fossil fuels – highly optimized processes

Biofuels – diversified profiles (high uncertainty on feedstocks and processes)

Electricity – Very dependent on generation mix

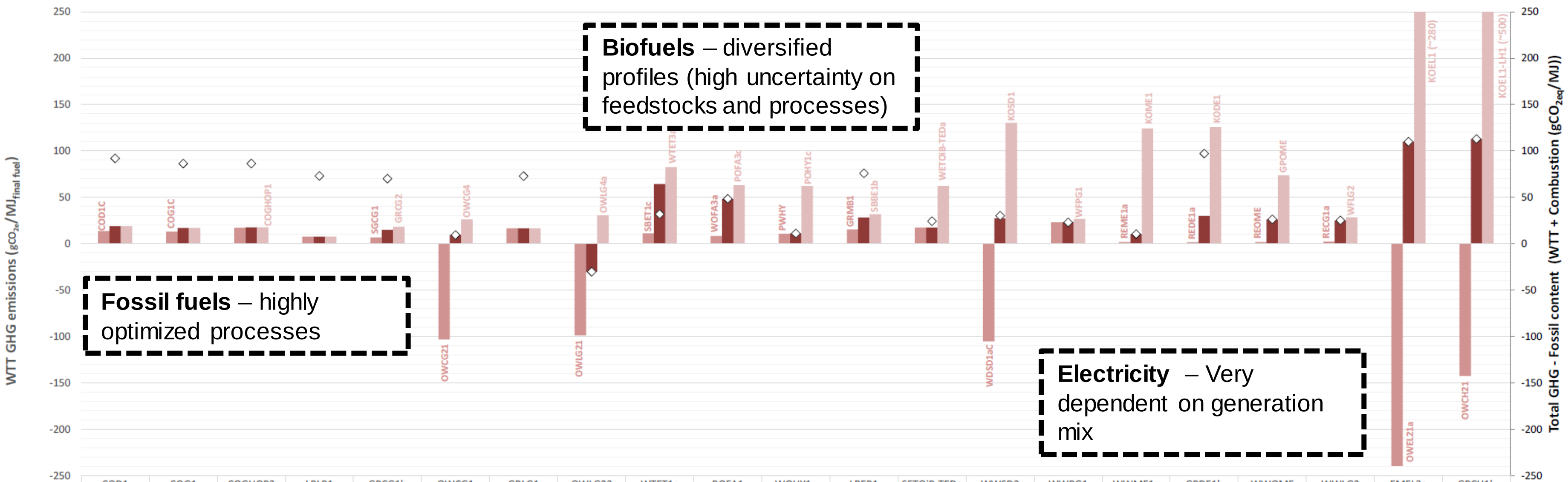
H_2 – Very dependent on production pathway

	COD1	COG1	COGHOP3	LRLP1	GPCG1b	OWCG1	GRLG1	OWLG22	WTET1a	ROFA1	WOHY1a	LREB1	SETOiB-TEDa	WWSD2	WWPG1	WWME1a	GPDE1b	WWOME	WWLG2	EMEL3a	GPCH1b
	Diesel	Gasoline	High octane gasoline	LPG	CNG	CBM	LNG	LBM	Ethanol	Biodiesel	HVO	ETBE/MTBE	ED95	Syn_diesel	Syn_gasoline	Syn_methanol	Syn_DME	Syn_OME	Syn_NG	Electricity	H2
Min	0.26	0.24	0.28	0.12	0.09	0.89	0.18	1.00	0.86	0.19	0.16	0.355	1.44	0.11	1.16	0.16	0.12	1.65	1.03	0.07	0.03
WTT selected	0.26	0.24	0.30	0.12	0.20	0.89	0.18	2.11	1.39	1.11	0.16	0.728	1.44	0.82	1.16	1.26	0.63	2.43	1.18	1.96	1.02
Max	0.32	0.28	0.30	0.12	0.27	4.33	0.18	4.44	2.39	2.53	2.52	1.57	1.60	1.83	1.25	1.42	1.42	2.61	1.27	5.51	7.05

Ciclo de vida de fontes energéticas

Well-to-Tank (WTT) – alternative energy sources

Figure 133. WTT GHG emissions. Summary

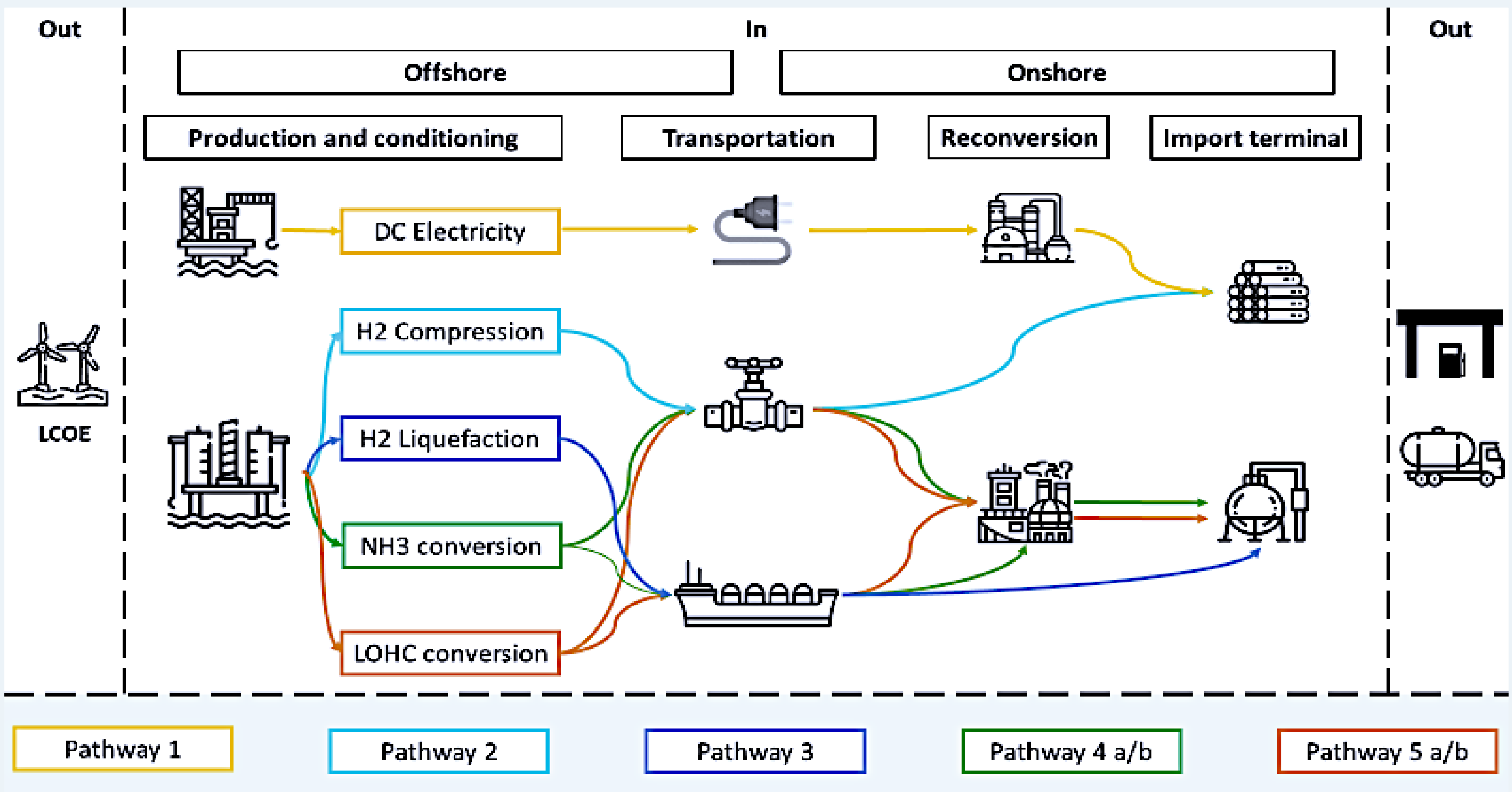


	COD1 Diesel	COG1 Gasoline	COGHOP3 High octane gasoline	LRLP1 LPG	GPCG1b CNG	OWCG1 CBM	GRLG1 LNG	OWLG22 LBM	WTET1a Ethanol	ROFA1 Biodiesel
Min	13.7	13.1	17.3	7.8	6.8	-102.9	16.6	-98.7	11.3	8.3
WTT selected	18.9	17.0	17.6	7.8	15.1	9.5	16.6	-30.1	64.5	48.4
Max	18.9	17.0	17.6	7.8	18.3	26.3	16.6	30.5	82.7	63.3

	WOHY1a HVO	LREB1 ETBE/MTBE	SETOiB-TEDa ED95	WWSD2 Syn_diesel	WWPG1 Syn_gasoline	WWME1a Syn_methanol	GPDE1b Syn_DME	WWOME Syn_OME	WWLG2 Syn_NG	EMEL3a Electricity	GPCH1b H2
Min	10.8	15.3	17.6	-105.1	23.1	1.8	1.7	1.8	2.4	-239.3	-142.4
WTT selected	11.1	28.38	17.6	27.5	23.1	10.5	30.0	26.3	25.3	110.1	113.0
Max	62.4	31.9	62.4	130.3	26.8	124.3	125.7	73.7	28.6	280.5	499.6

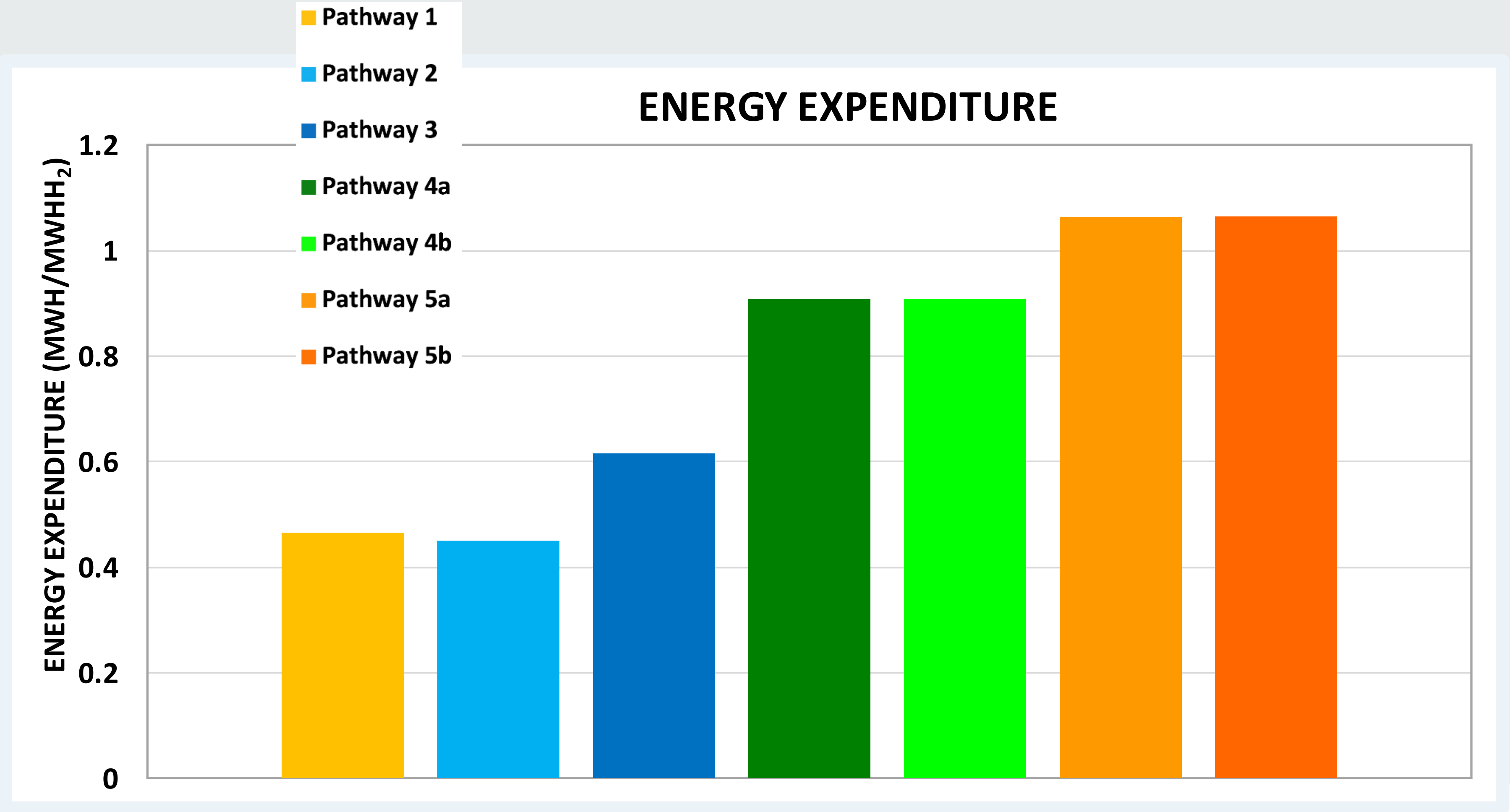
Ciclo de vida de fontes energéticas

Exemplos de aplicação: 1) Produção de H_2



Ciclo de vida de fontes energéticas

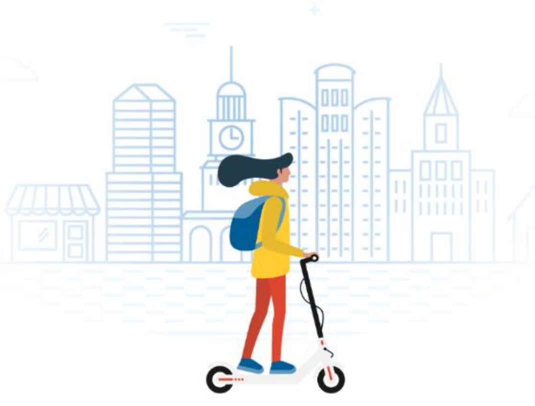
Exemplos de aplicação: 1) Produção de H_2



Ciclo de vida de fontes energéticas

Exemplos de aplicação: 2) Ciclo de vida completo (trotinetes)

- **Context**: recent emergence of shared e-scooters systems, with associated safety issues and urban space conflicts
- **Objective**: quantify the lifecycle environmental impacts of shared e-scooters: production, use, and end-of-life



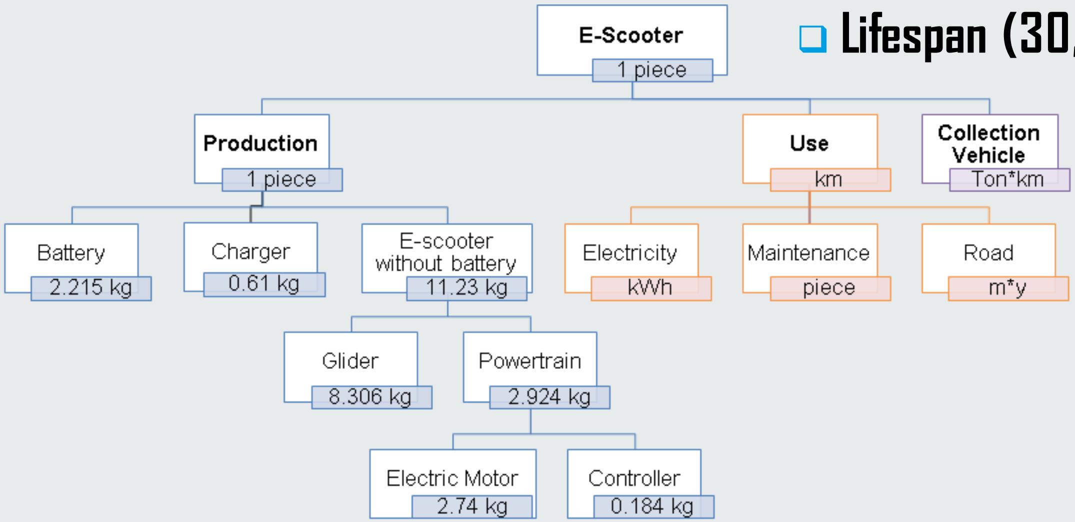
Ana Filipa Reis, Patrícia Baptista, Filipe Moura, Assessing the environmental sustainability of shared e-scooters: case study from Lisbon, Portugal, submitted to Transportation Research Part D, 2021.

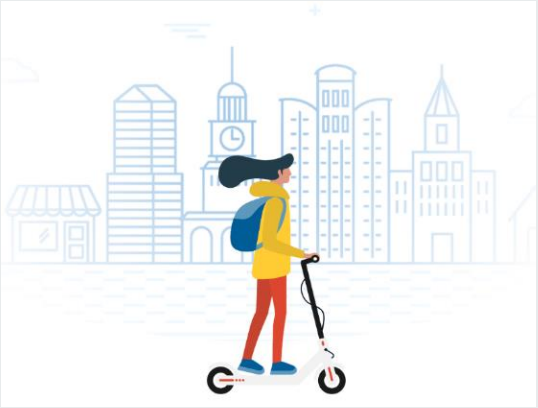
Ciclo de vida de fontes energéticas

Exemplos de aplicação: 2) Ciclo de vida completo (trotinetes)

High uncertainty on:

- Distance per day (1, 2, 5 km)
- e-scooter collection frequency (everyday, every 3 days)
- Lifespan (30, 45, 90, 180 days)





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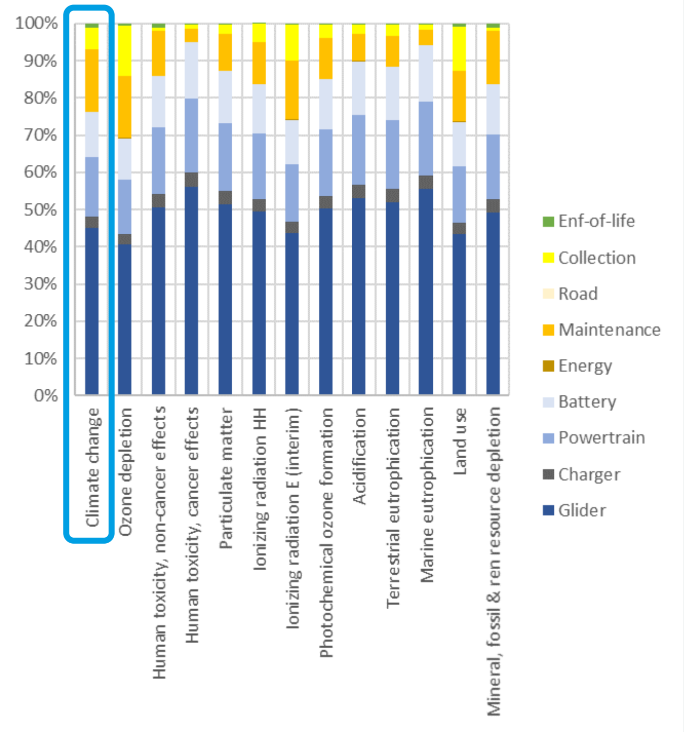
Ciclo de vida de fontes energéticas

Exemplos de aplicação: 2) Ciclo de vida completo (trotinetes)

Climate change:

- Production is responsible for more than 70% of the total impacts,
- Usage corresponds to 17% of impacts, of which 16.9% corresponds to maintenance,
- Collection operations are responsible for 5.8% of impacts
- Similar trend in remaining categories



Ana Filipa Reis, Patrícia Baptista, Filipe Moura, Assessing the environmental sustainability of shared e-scooters: case study from Lisbon, Portugal, submitted to Transportation Research Part D, 2021.

Ciclo de vida de fontes energéticas

Exemplos de aplicação: 2) Ciclo de vida completo (trotinetes)

Impact per km:

- Best scenario - 112 g CO_{2eq}/km, with a life span of 180 days and daily use of 5 km for scenario 3 (with recycling);
- Worst scenario - 5325 g CO_{2eq}/km, for a lifetime of 30 days, daily use of 1 km, and daily collection for Scenario 1 (without recycling).

Lifespan	km/day / Collection	Scenario 1 1km	Scenario 1 2km	Scenario 1 5km	Scenario 3 1km	Scenario 3 2km	Scenario 3 5km
30	1 in 1 days	5325	2665	1067	2699	1352	542
	3 in 3 days	4932	2469	988	2306	1156	463
45	1 in 1 days	3746	1875	751	1995	1000	401
	3 in 3 days	3353	**1679**	673	1602	**804**	323
90	1 in 1 days	2169	1086	436	1294	648	260
	3 in 3 days	1778	890	357	902	452	182
180	1 in 1 days	1380	691	278	942	472	190
	3 in 3 days	988	495	200	550	276	112

Ana Filipa Reis, Patrícia Baptista, Filipe Moura, Assessing the environmental sustainability of shared e-scooters: case study from Lisbon, Portugal, submitted to Transportation Research Part D, 2021.

Ciclo de vida de fontes energéticas

Exemplos de aplicação: 2) Ciclo de vida completo (trotinetes)

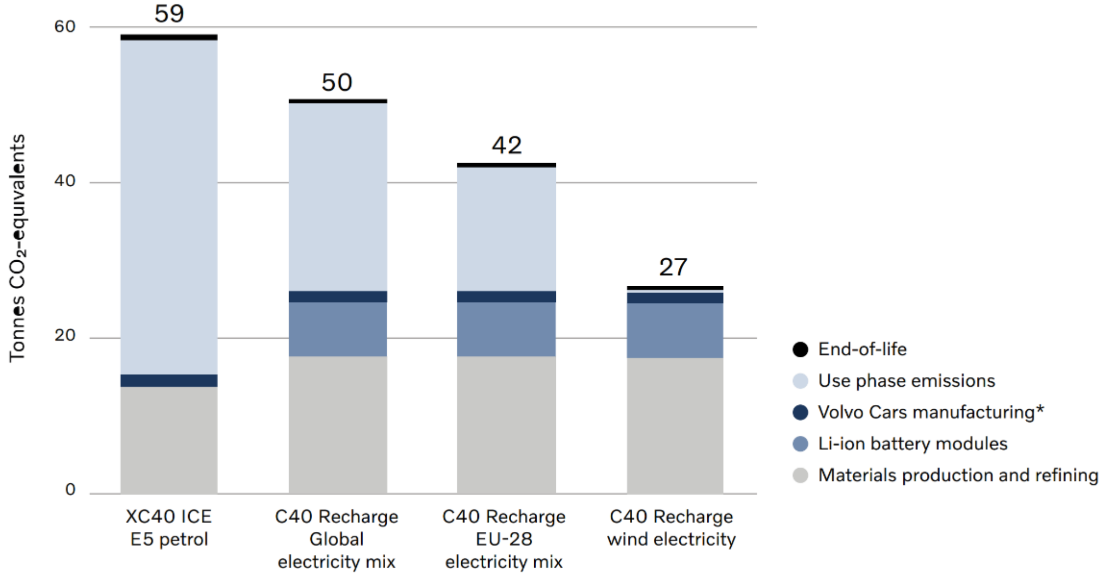
- Operators' system design and Policy recommendations for shared e-scooters to have a place in the competitive urban environment:
- Define strategies to ensure that they make more trips per day and operate longer distances per day (e.g. integrated ticketing); and
- Ensure that the physical structure and materials of e-scooters are stronger and more resistant to vandalism and to pavement characteristics, including its degradation.

Ana Filipa Reis, Patrícia Baptista, Filipe Moura, Assessing the environmental sustainability of shared e-scooters: case study from Lisbon, Portugal, submitted to Transportation Research Part D, 2021.

Ciclo de vida de fontes energéticas

Exemplos de aplicação: 3) Influência do mix elétrico (EV)

- Volvo C40 Recharge



** Volvo Cars manufacturing includes both factories as well as inbound and outbound logistics.*

Figure ii. Carbon footprint for C40 Recharge and XC40 ICE, with different electricity mixes.
Results are shown in tonnes CO_2-equivalents per functional unit (200,000km total distance, rounded values).

Volvo, 2021.

Ciclo de vida de fontes energéticas

Exemplos de aplicação: 3) Influência do mix elétrico (EV)

- Volvo C40 Recharge

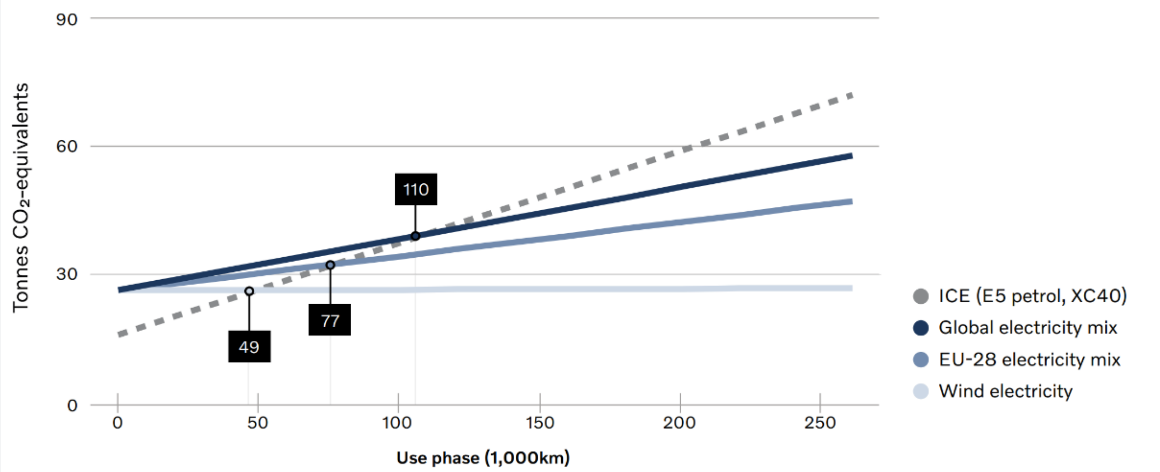


Figure iii. Break-even diagram: *Total amount of GHG emissions, depending on total kilometres driven, from XC40 ICE (dashed line) and C40 Recharge (with different electricity mixes in the use phase). Where the lines cross, break-even between the two vehicles occurs. All life cycle phases except use phase are summarized and set as the starting point for each line at zero distance.*

Volvo, 2021.

Ciclo de vida de fontes energéticas

Exemplos de aplicação: 3) Influência do mix elétrico (EV)

- Volvo C40 Recharge

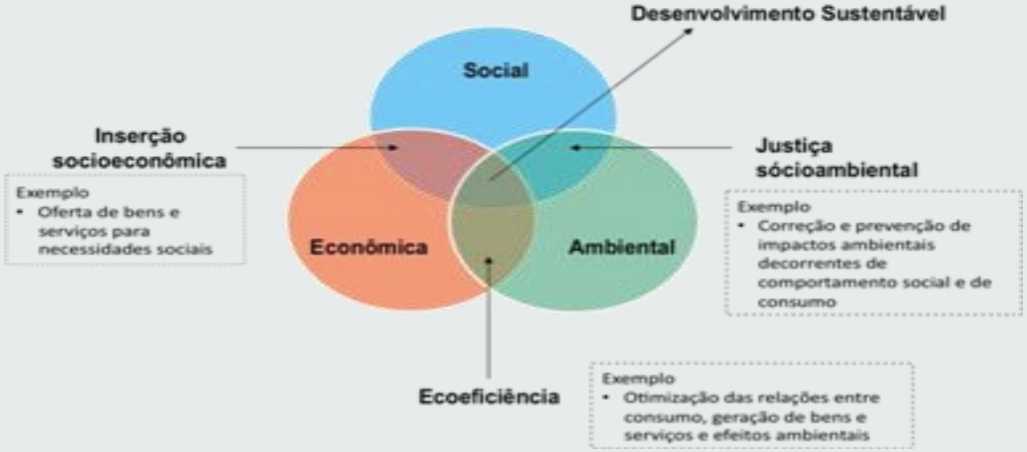
Key Findings

- The C40 Recharge has approximately 5 per cent lower total carbon footprint than XC40 Recharge when charged with EU-28 electricity mix in the use phase, which is mainly because of better aerodynamic properties.
- The C40 Recharge has a lower total carbon footprint than the XC40 ICE (E5 petrol) for all the analysed sources of electricity for the use phase.
- Materials production and refining, battery module production and manufacturing at Volvo Cars for a C40 Recharge results in nearly 70 per cent higher GHG emissions compared to an XC40 ICE (E5 petrol).
- The highly probable future reduction of carbon intensity of the EU-28 electricity mix will reduce the carbon footprint of C40 Recharge when using this mix for driving. However, a significantly lower carbon footprint is achieved when charging the car with renewable electricity, such as wind power.
- Production of aluminium and the Li-ion battery modules have relative high carbon footprints, with a contribution of approximately 30 per cent each to the total footprint of all materials and components in the C40 Recharge.
- Choice of methodology has a significant impact on the total carbon footprint. Therefore, care should be taken when comparing results from this report with those from other vehicle manufacturers.

Volvo, 2021.

Análise de Sustentabilidade Ambiental

Nem só energia, CO_2 e outros imapctes ambientais são contabilizados no contexto da sustentabilidade...



1. **Análise técnico/económica de fontes energéticas**
2. **Como é que a regulamentação pode ser utilizada na promoção de fontes energéticas alternativas?**
3. **Como atingir a viabilidade económica de forma mais sustentada?**

Conclusões

Viabilidade de fonte energética alternativa dependente de:

- **Factores operacionais**
- **Factores económicos**
- **Regulamentação**
- **...**

Conclusões

Viabilidade de fonte energética alternativa dependente de:

- **Factores operacionais**
- **Factores económicos**
- **Regulamentação**
- **...**

1) **Importância de fazer a caracterização mássica, energética e económica de todas as etapas da cadeia de valor da fonte energética**
2) **Tal permitirá avaliação energética e económica da cadeia de valor global** (mesmo que não chegue ao LCA)
3) **Identificar barreiras e oportunidades associadas a cada etapa** (e.g. comparação de custo de tecnologias, existe co-produto que pode ser valorizado, distância a redes de abastecimento/distribuição, etc.)
4) **Identificação de hipóteses de melhoria ou alternativas**

Análise de Sustentabilidade Ambiental (ASA) incluindo perspectiva de ciclo de vida de diferentes fontes energéticas

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