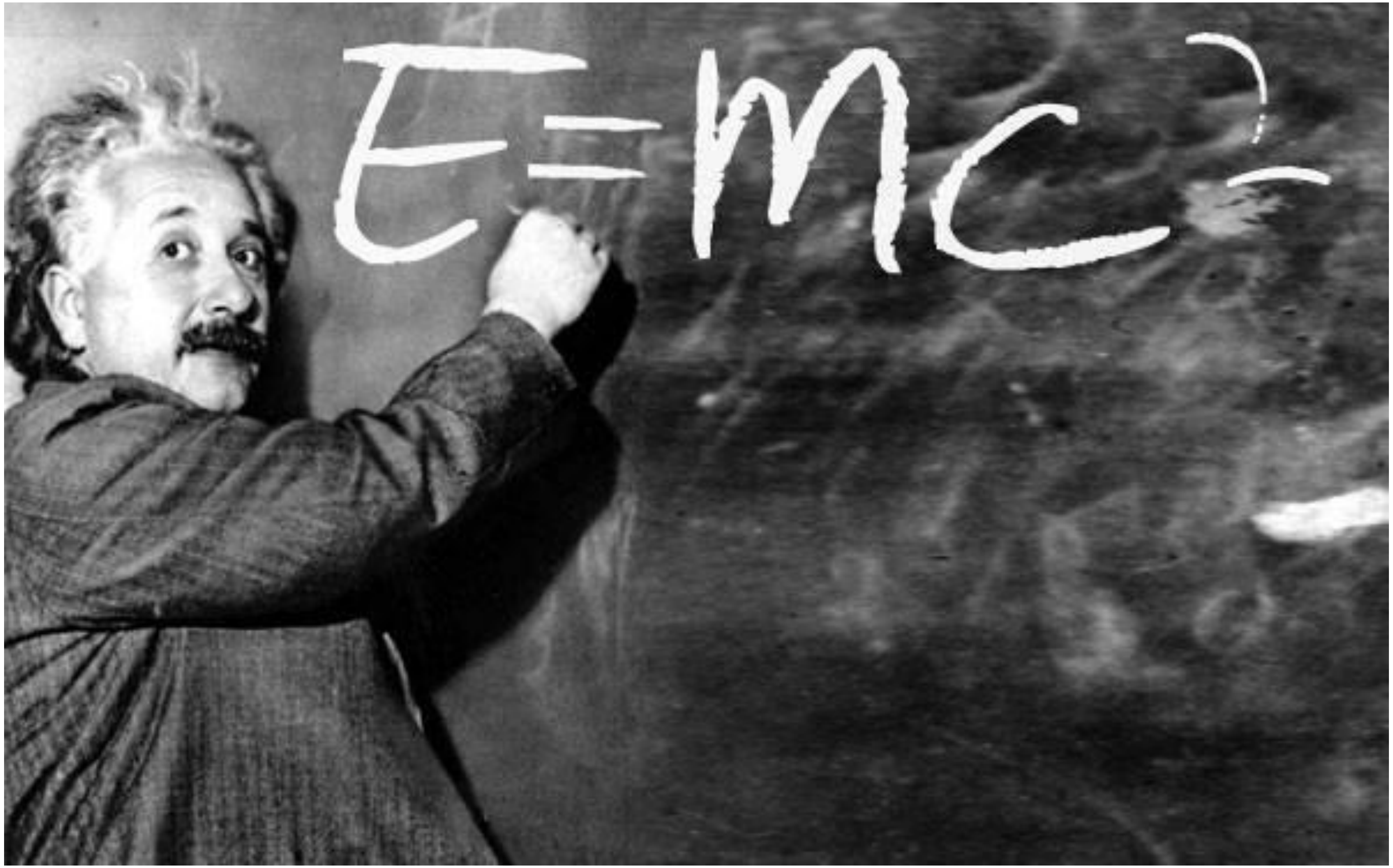
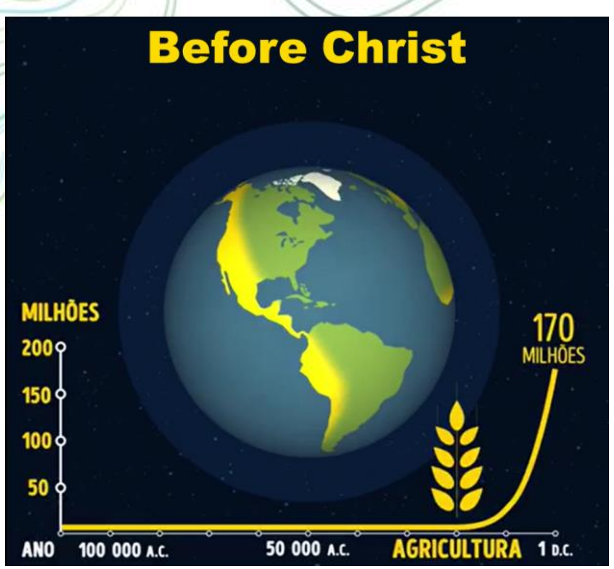
Ethanol: A Conceptual RoadMap

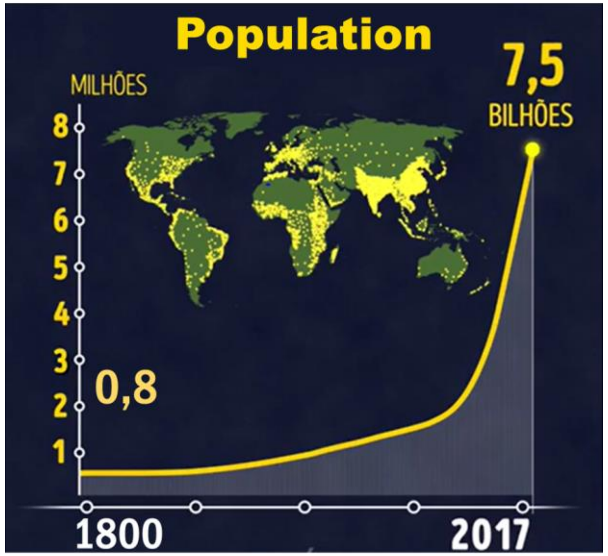
Prof. Gonçalo Pereira
UNICAMP

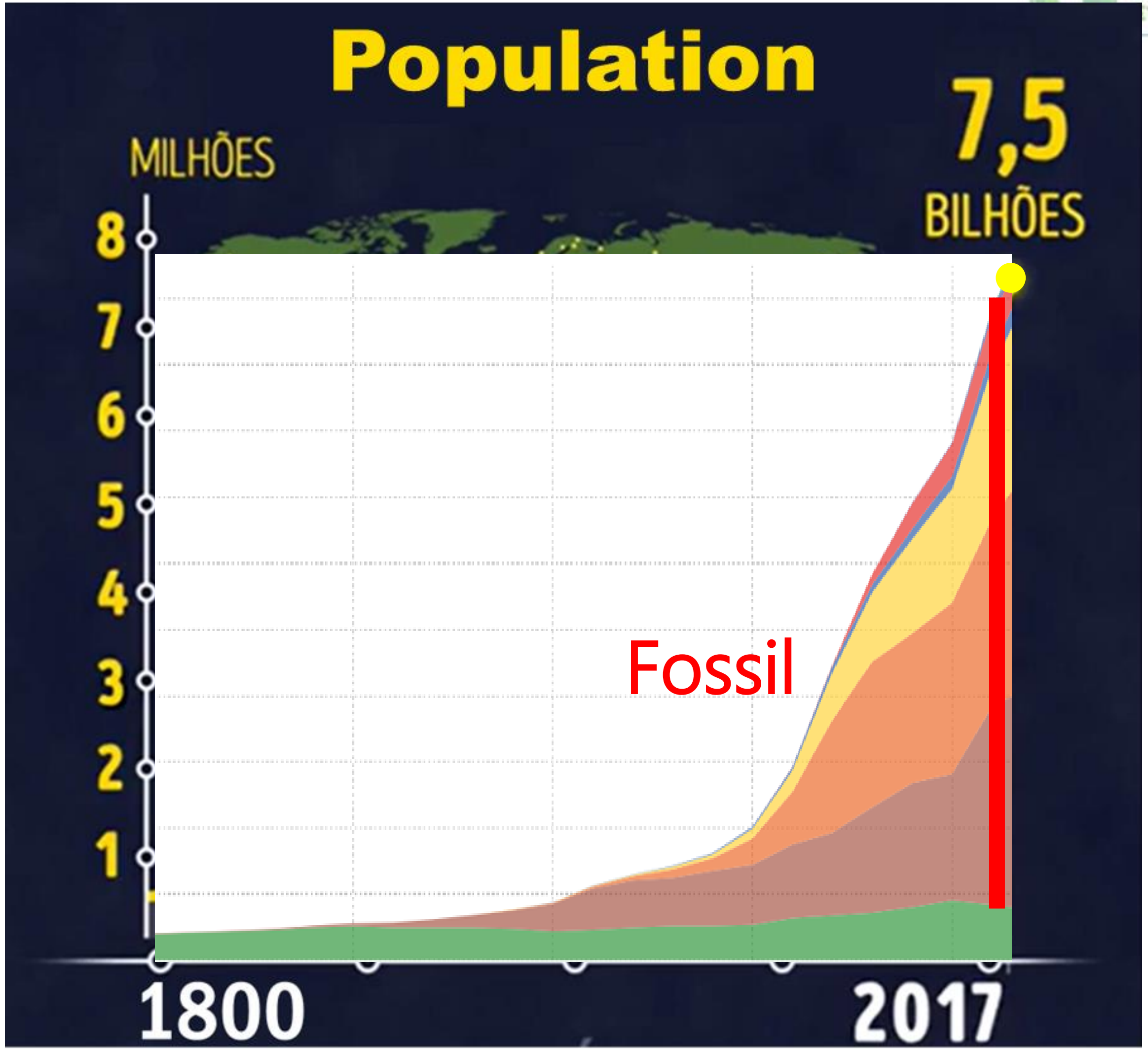
SUSTAINABLE MOBILITY: ETHANOL TALKS
THAILAND

Energy

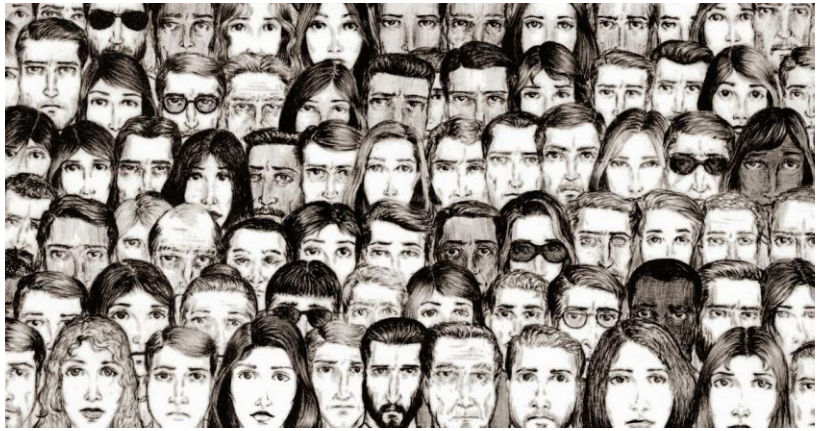

E=mc²


Before Christ
MILHÕES
200
150
100
50
170
MILHÕES
ANO
100 000 A.C.
50 000 A.C.
AGRICULTURA
1 D.C.

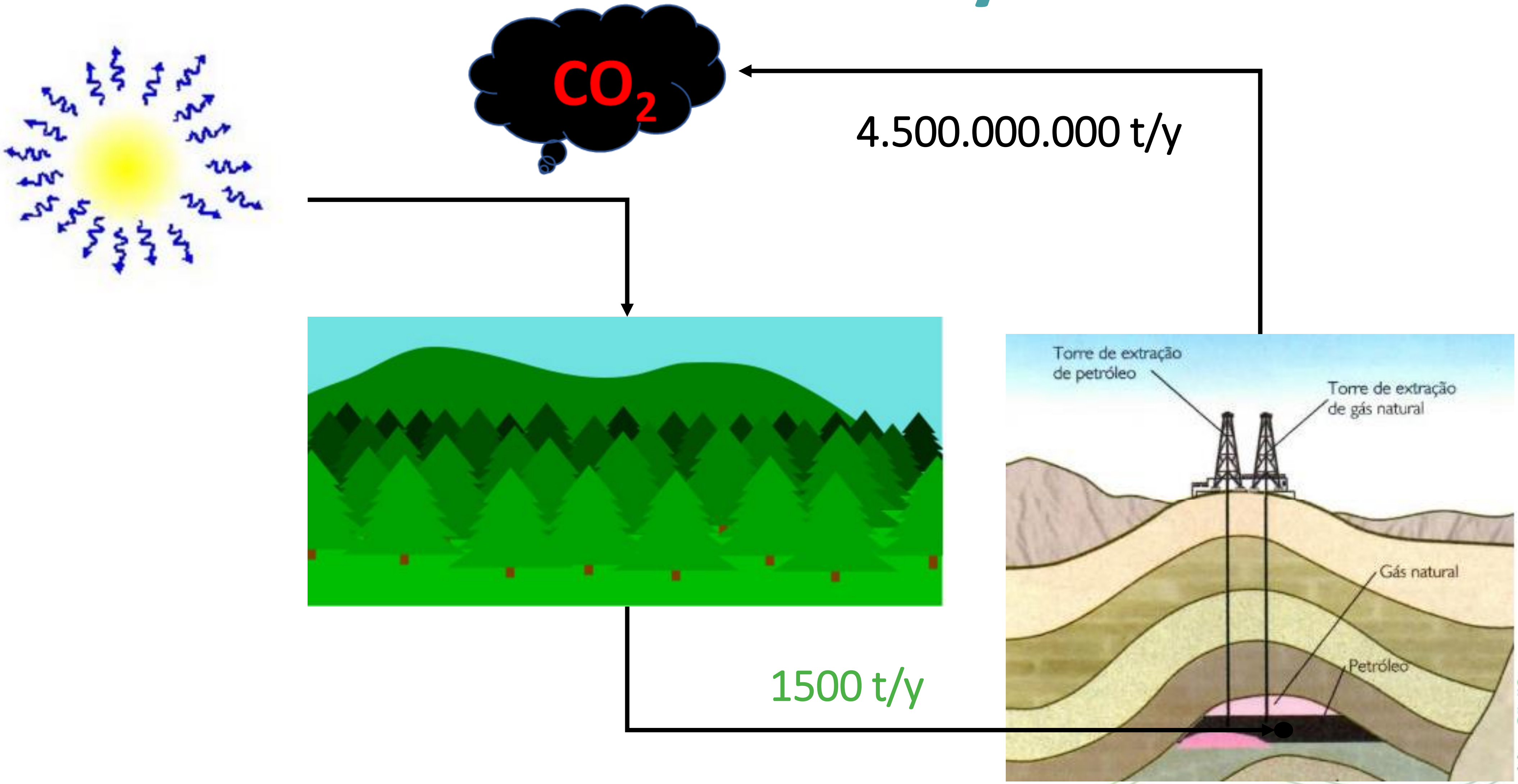

Population
MILHÕES
7,5
BILHÕES
8
7
6
5
4
3
2
1
0,8
1800
2017


Population
MILHÕES
7,5
BILHÕES
8
7
6
5
4
3
2
1
Fossil
1800
2017

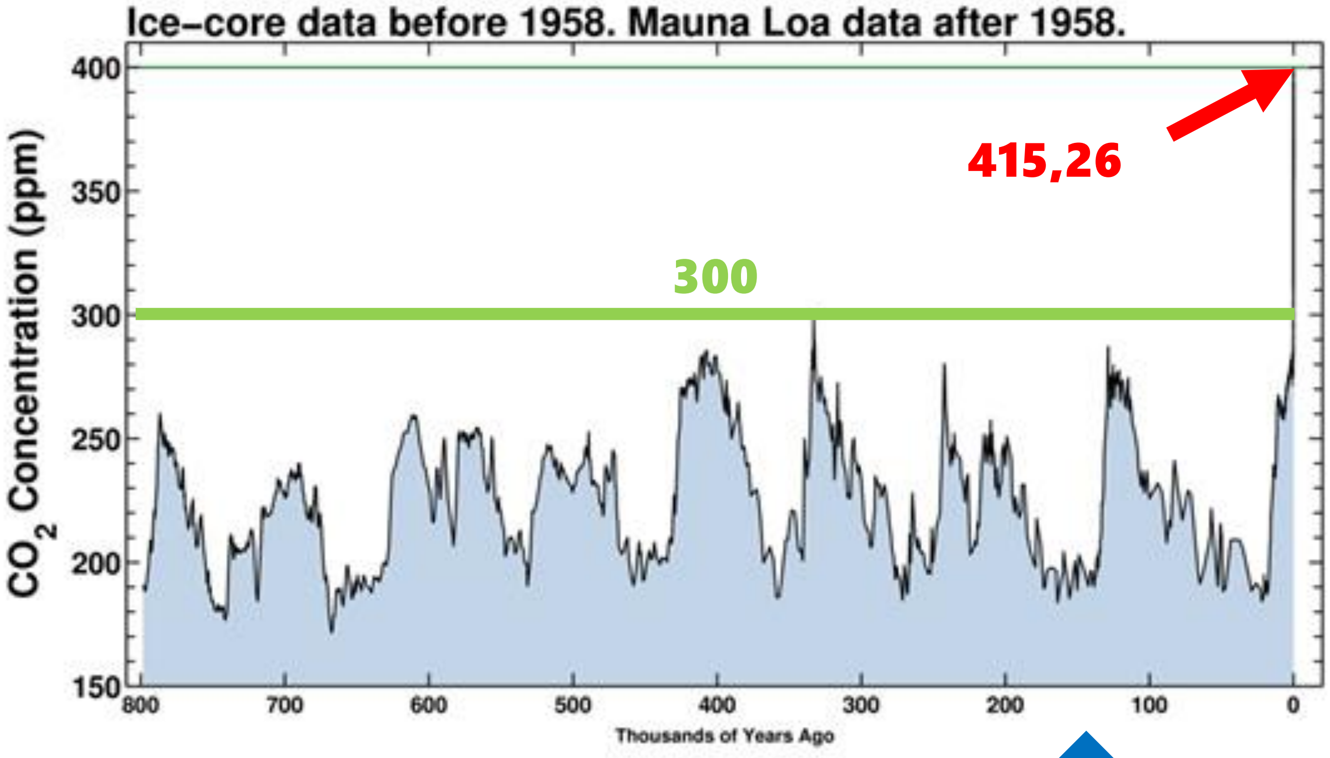

ТНК
eni
Mobil
elf
CAT
ЛУКОЙЛ
Castrol
ГАЗПРОМ
НЕФТЬ

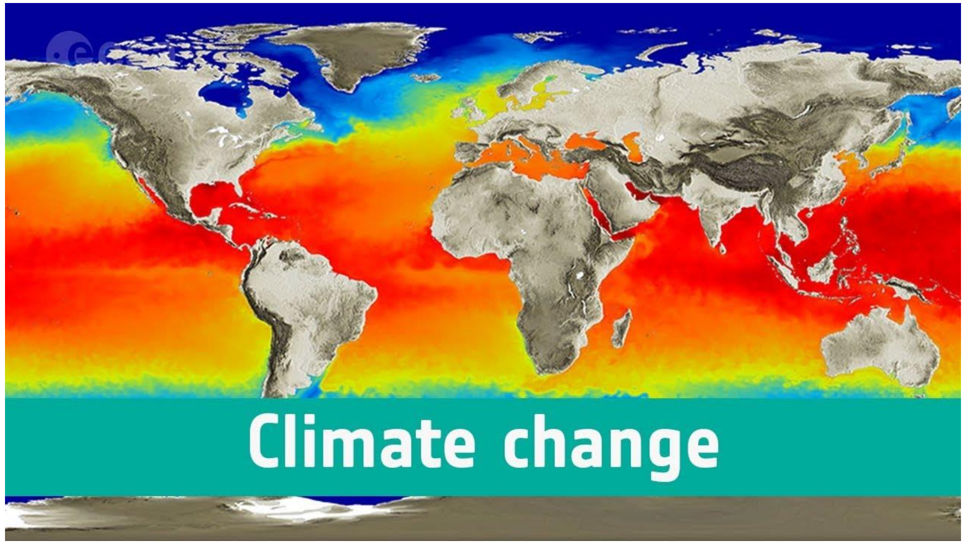


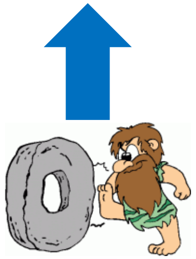
Fossil “Carbon Cycle”



CO2 is a Global Problem





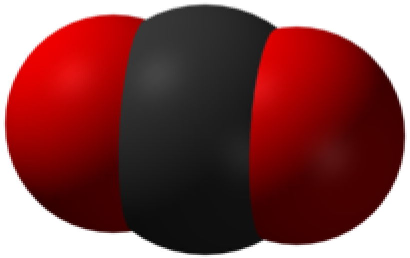


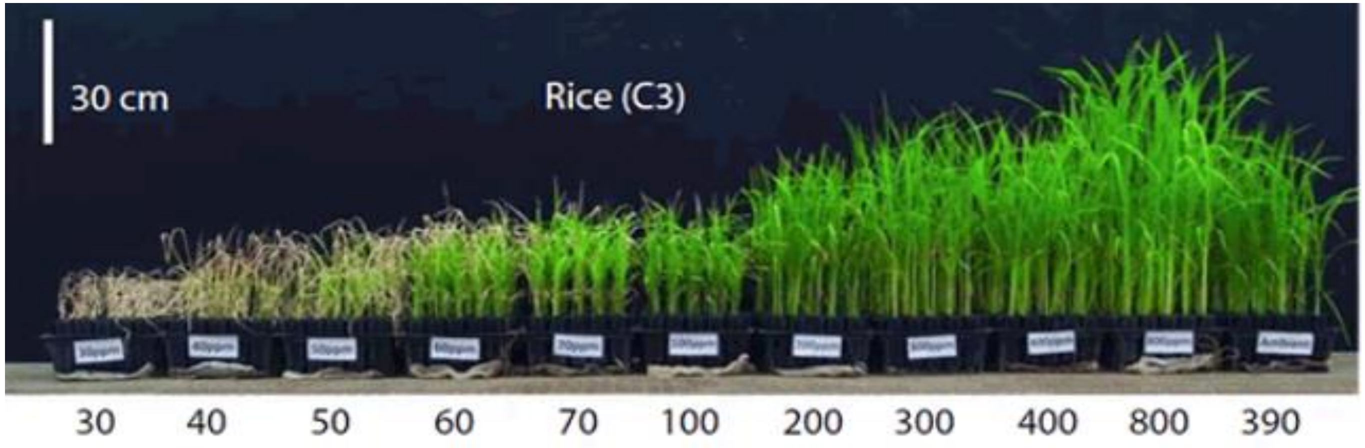
CO2 is NOT a LOCAL Problem

NOT TOXIC $\neq$ SO_2, NOX, 0_3, PM

Extremely Beneficial for Plants

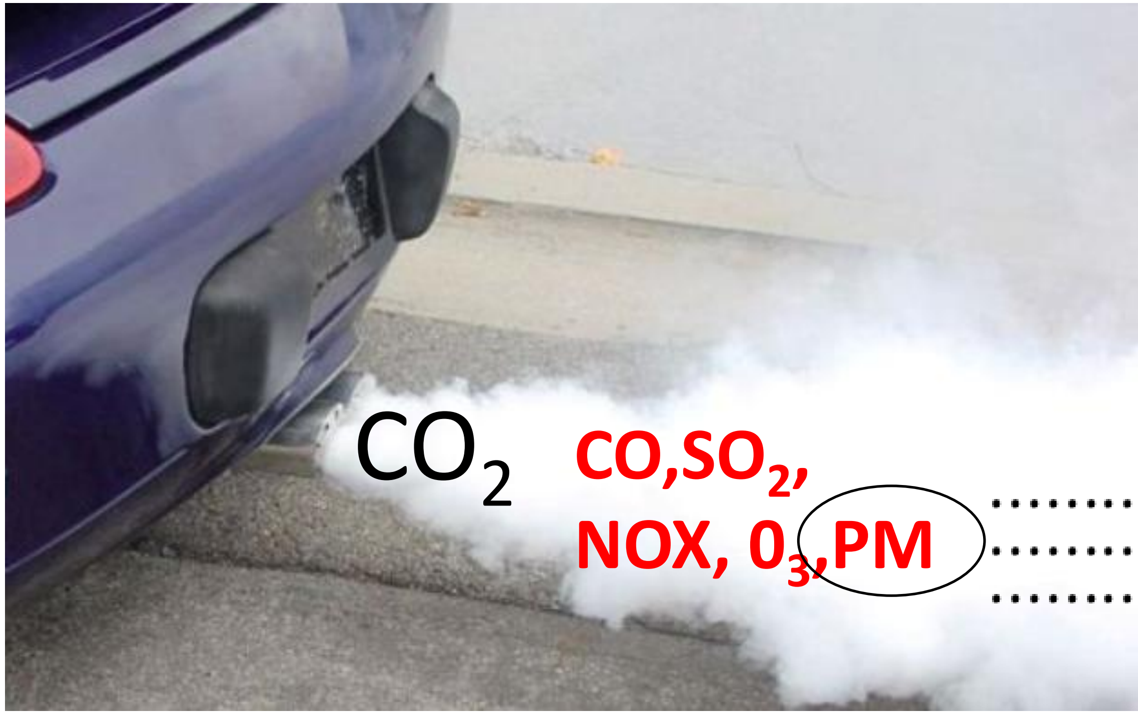
O=C=O



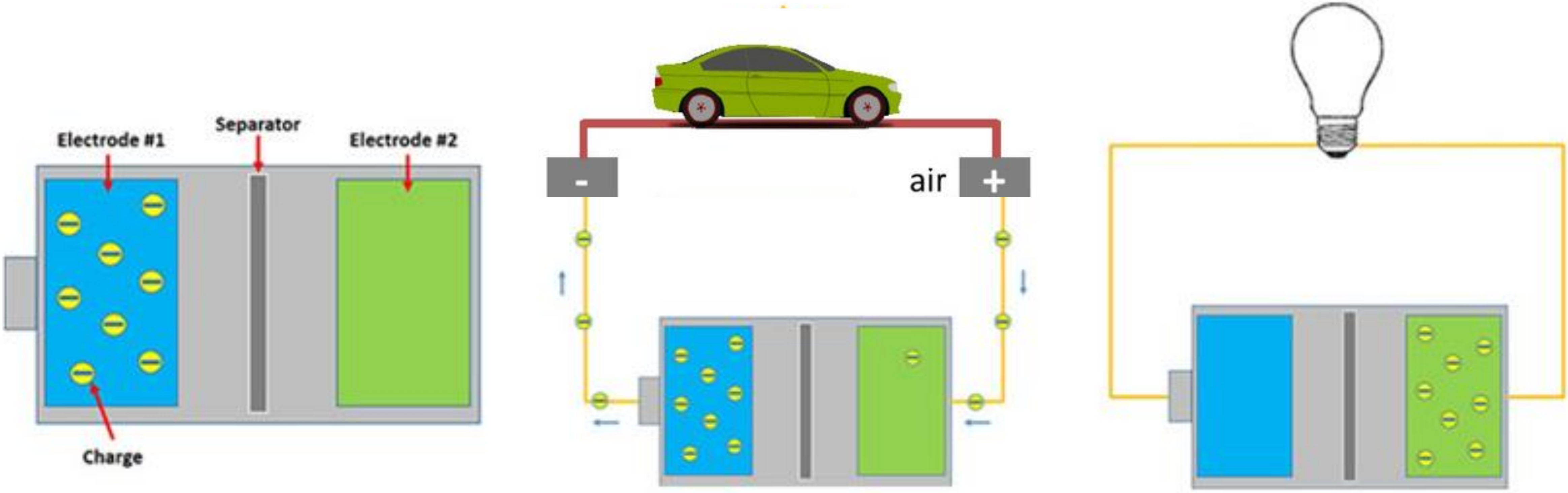


A Gaseous Fertilizer

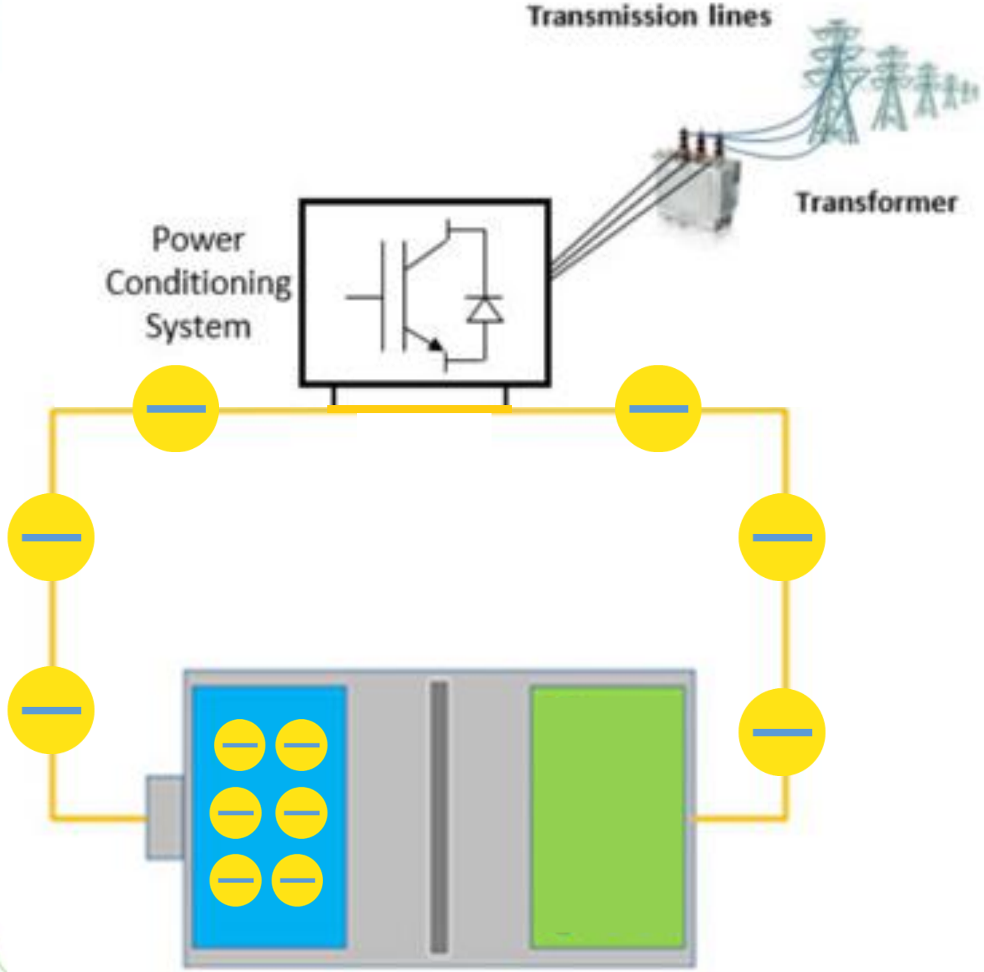
Fallacious Reasoning



How does a Battery work?

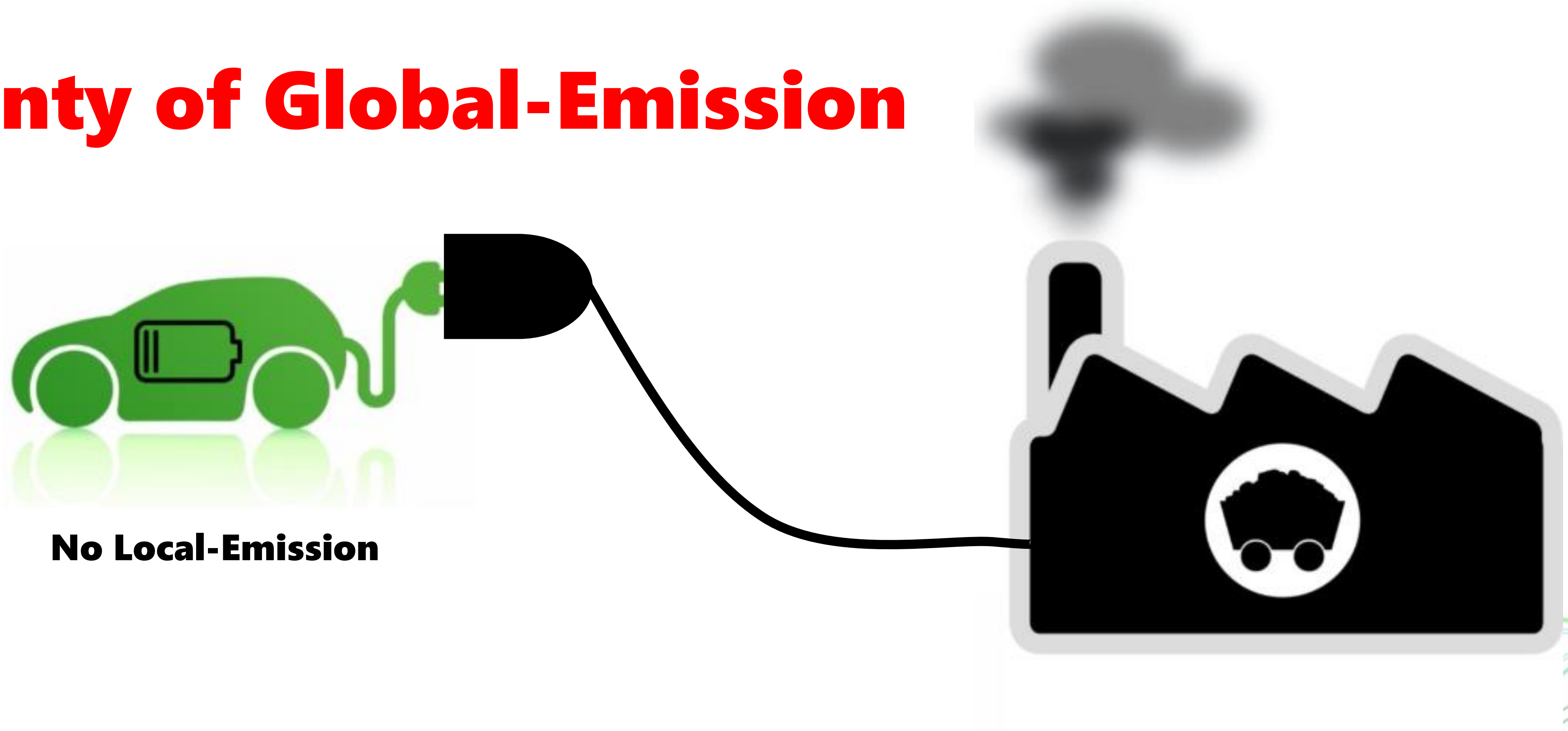


How to recharge a Battery?



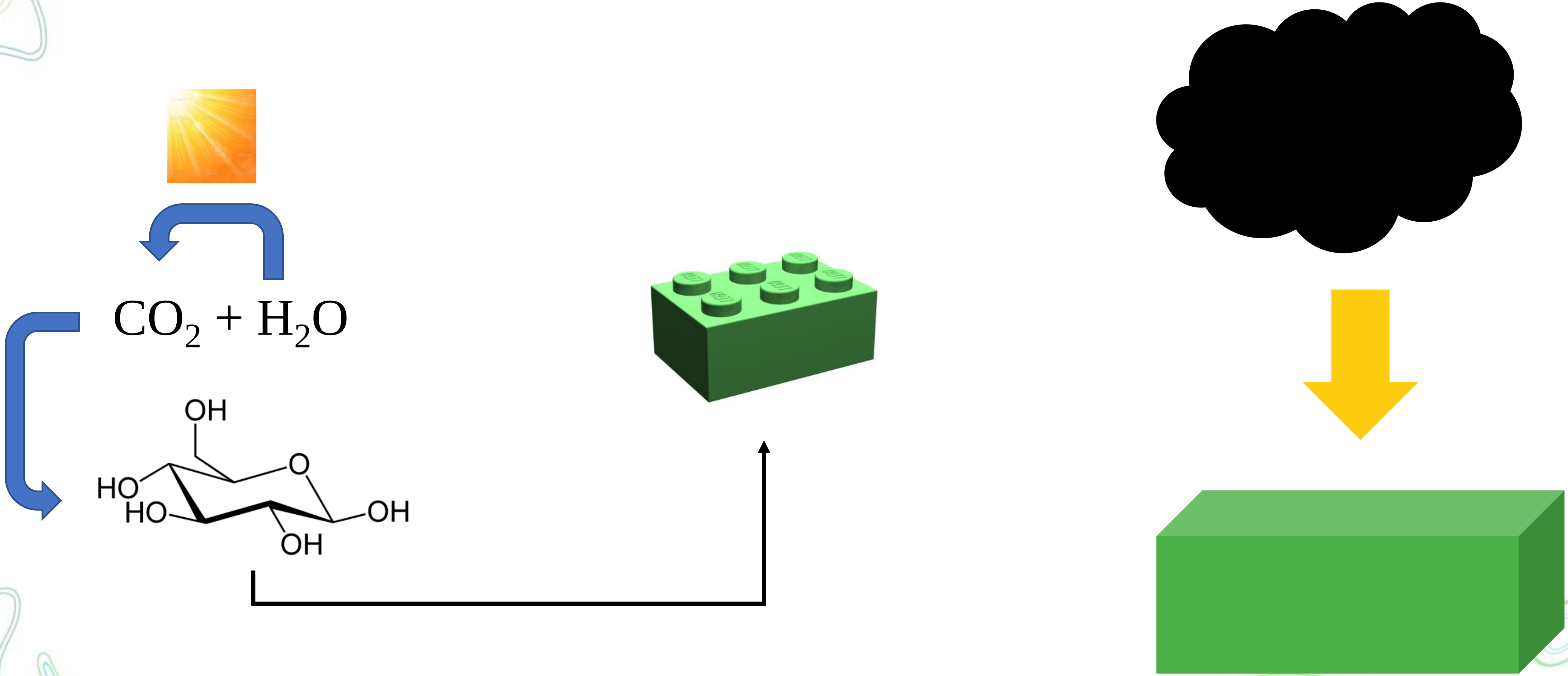
Metal Battery Cars

Plenty of Global-Emission

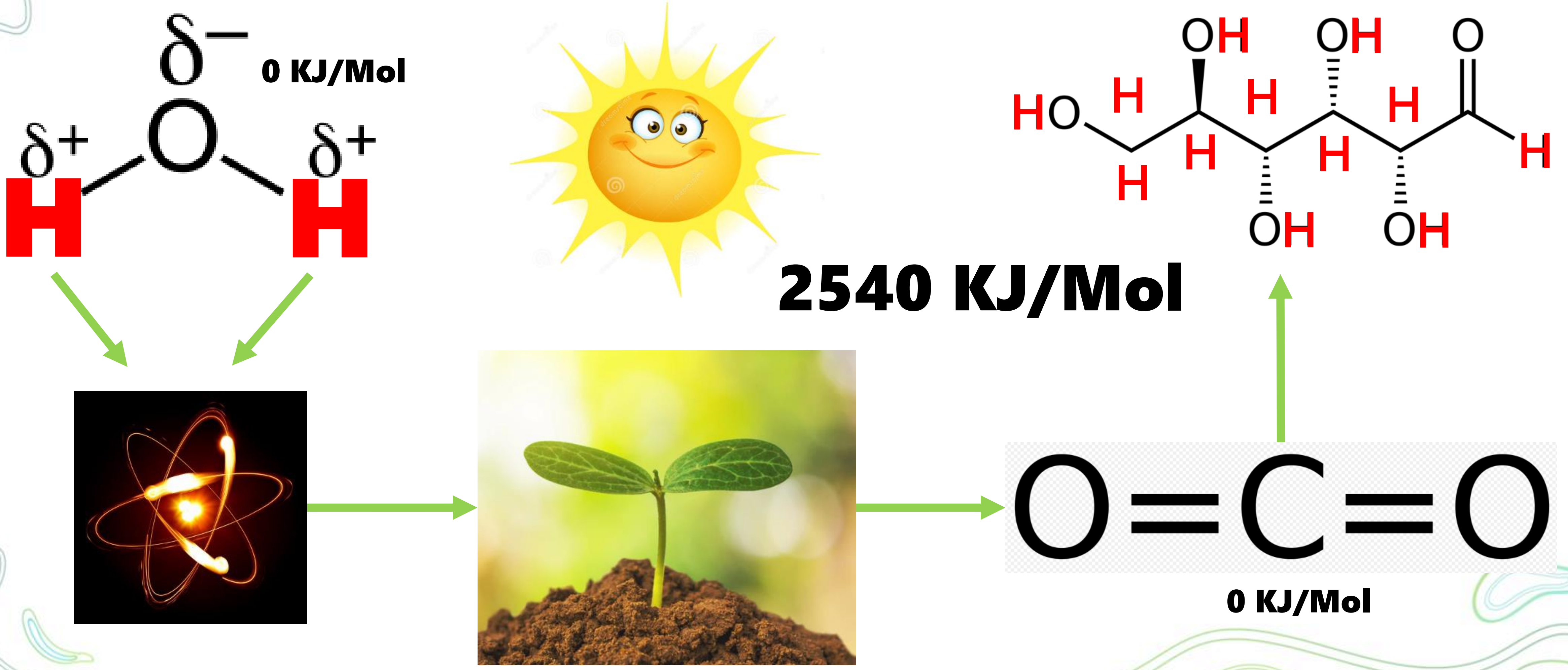


No Local-Emission

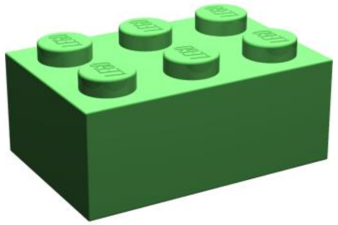
Carbon Fixation

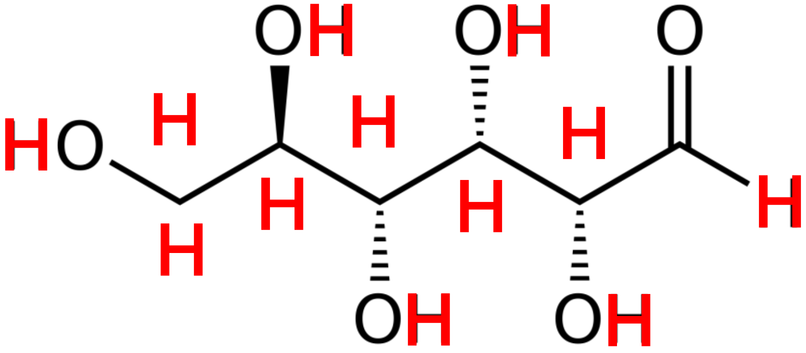


CO_2-Battery

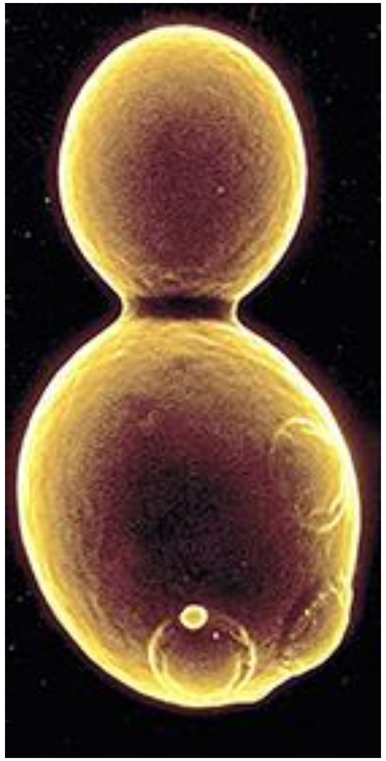


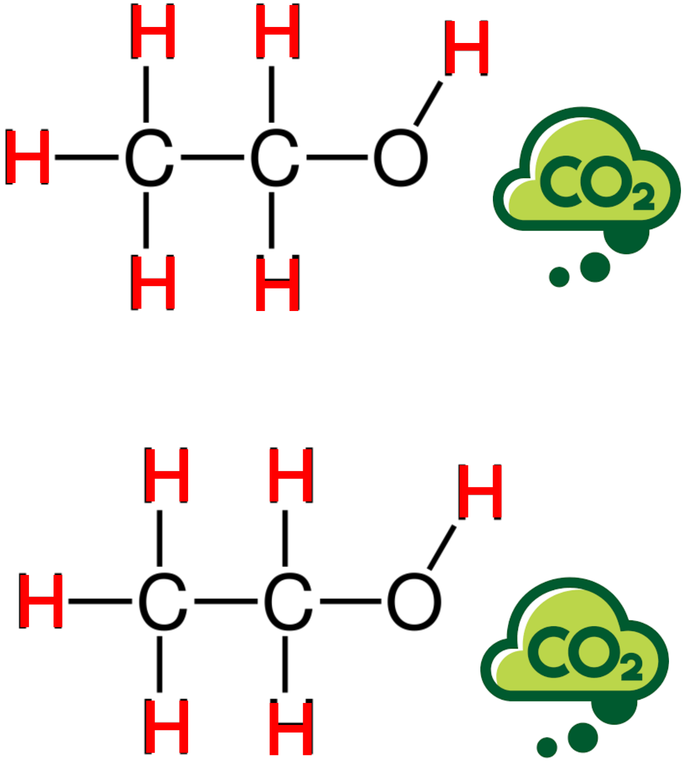
Battery Liquefaction





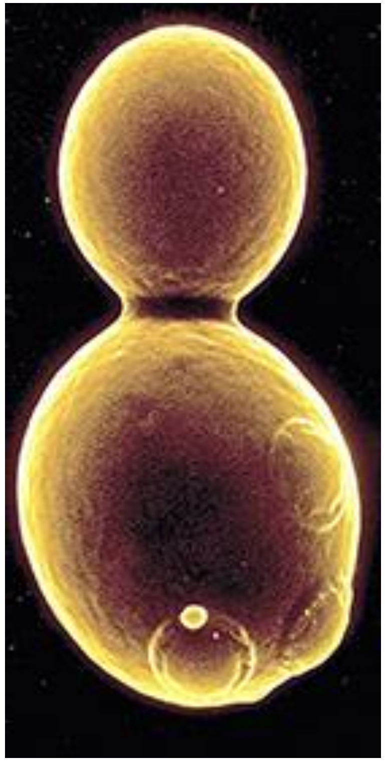
2540 KJ/Mol



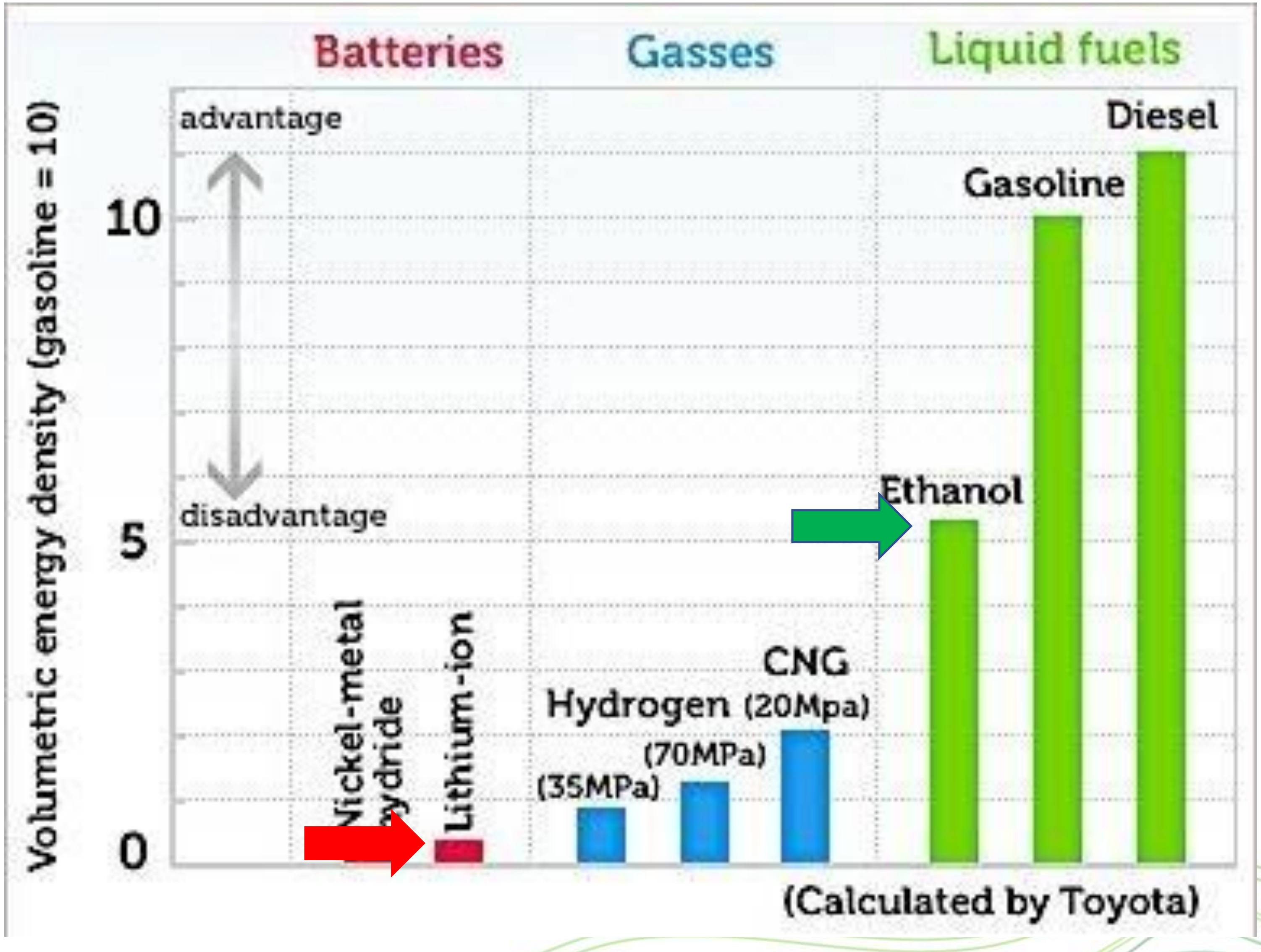


2470 KJ/Mol

Battery Liquefaction

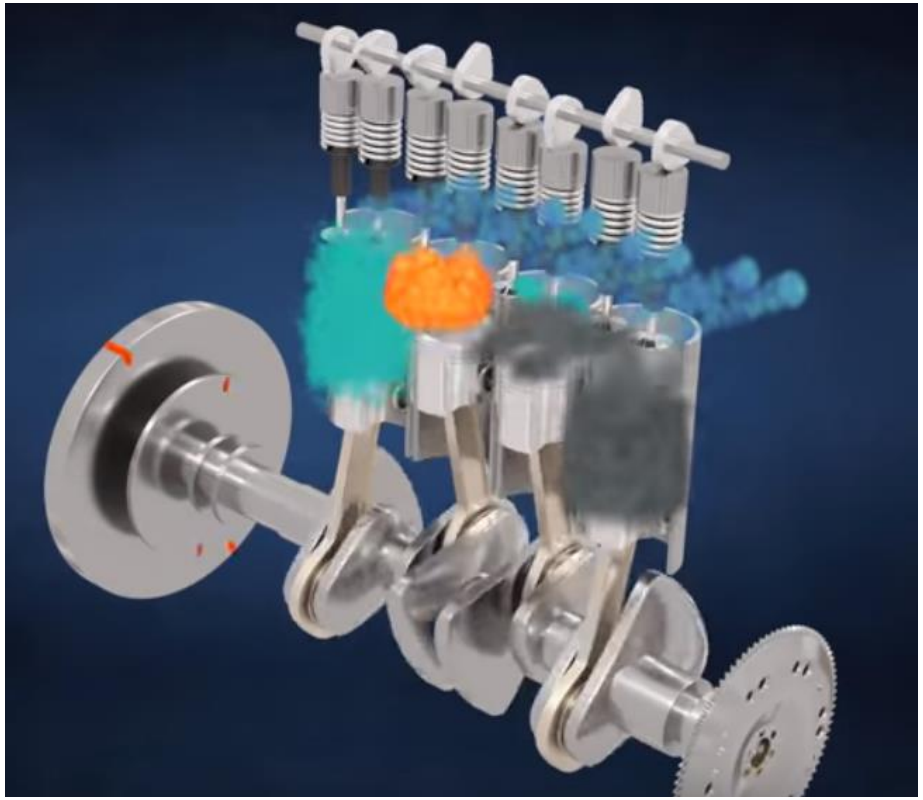


High Energy Density

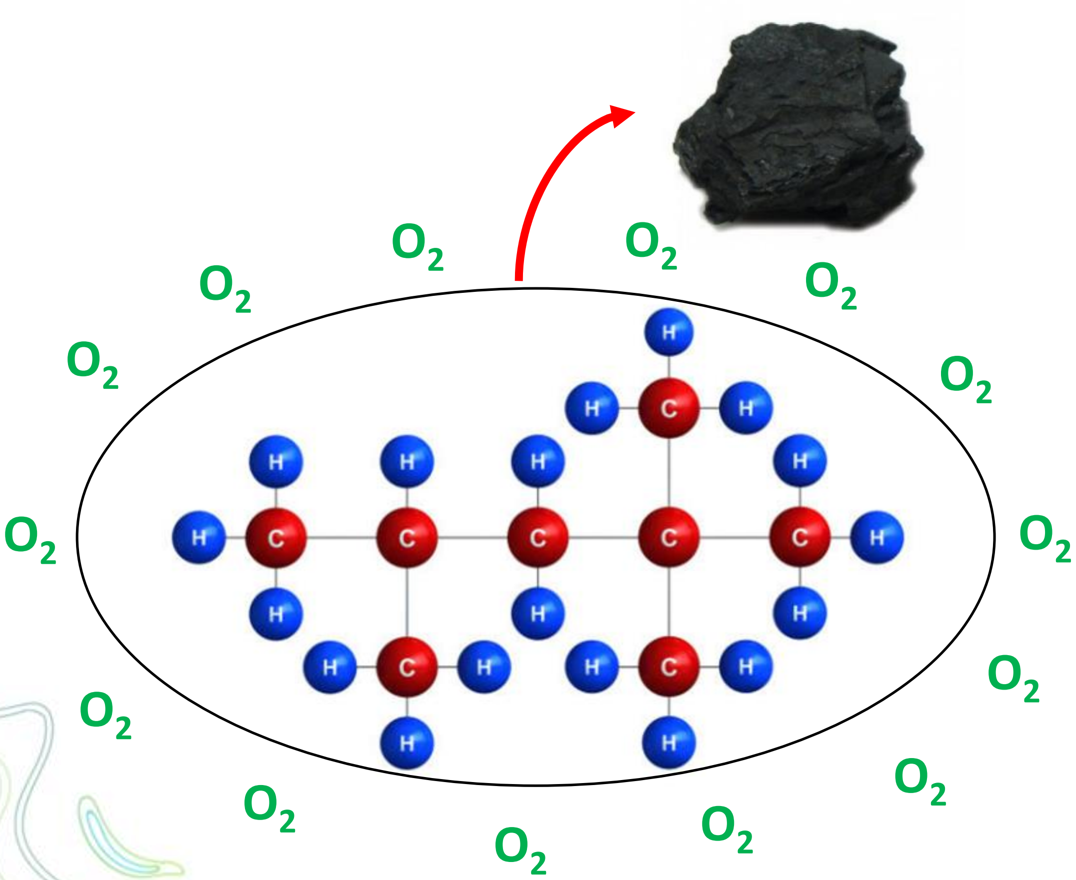


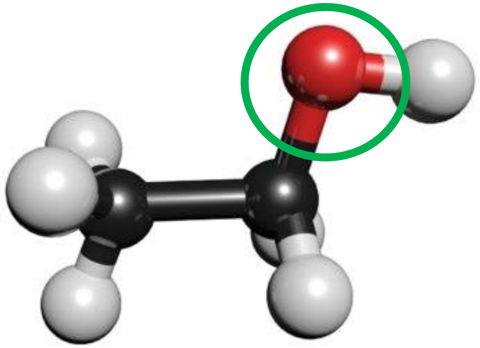
How to Discharge a Battery

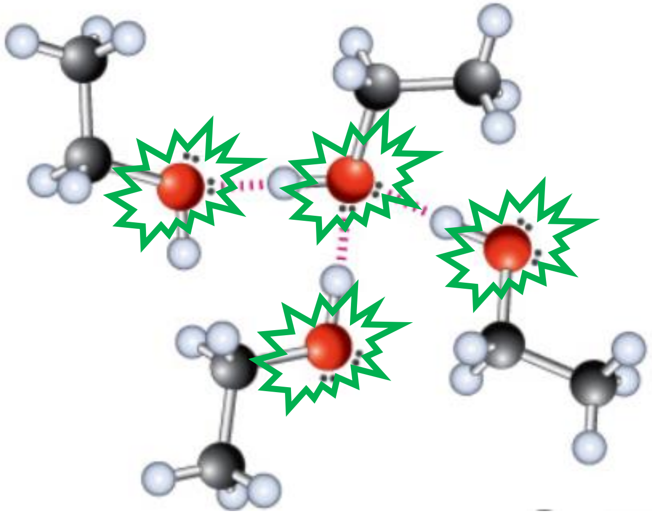
Combustion: The Traditional Way



Internal Molecular Combustion







Clean Combustion

THAILAND

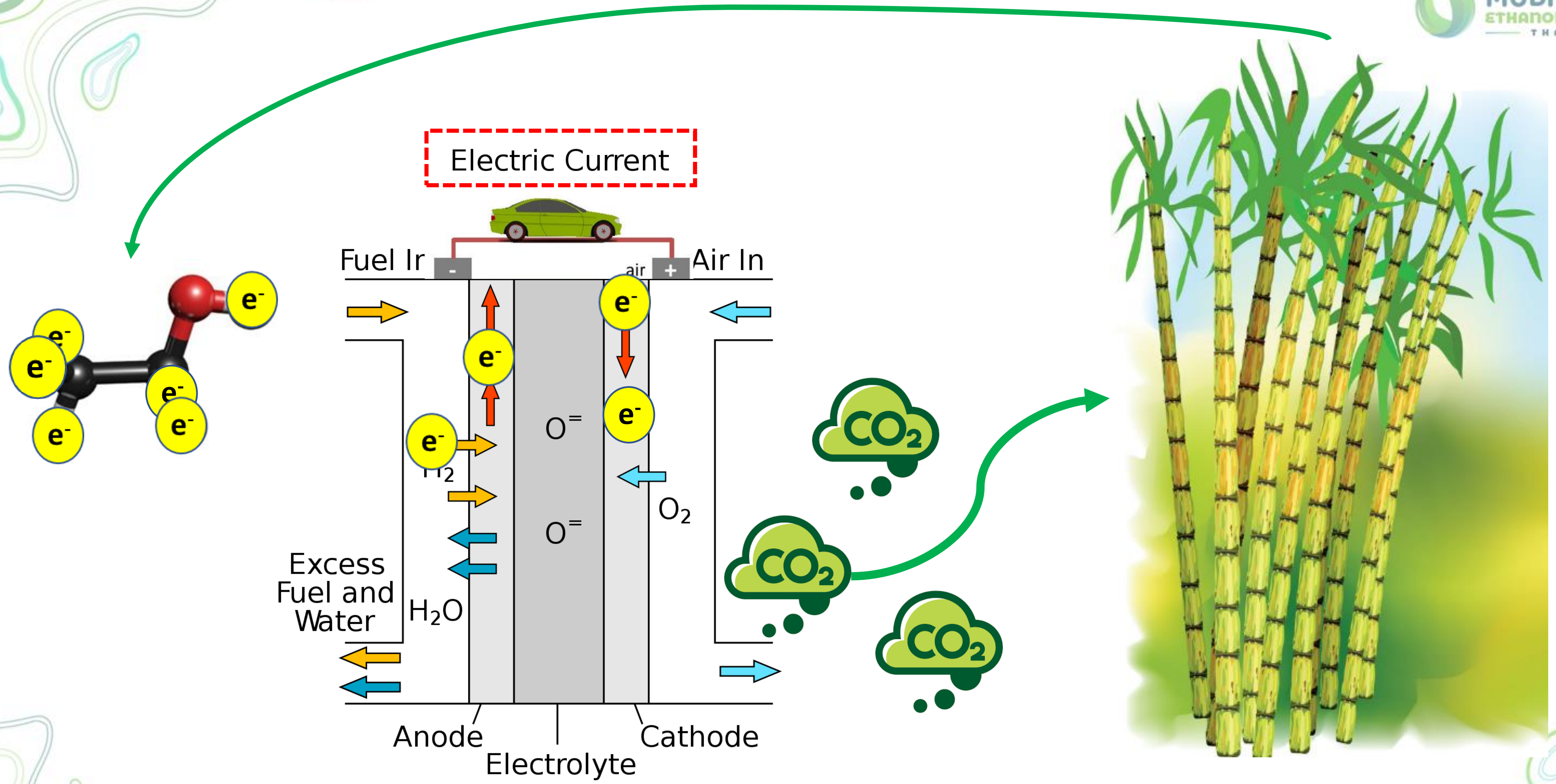
Energy Efficiency

25%

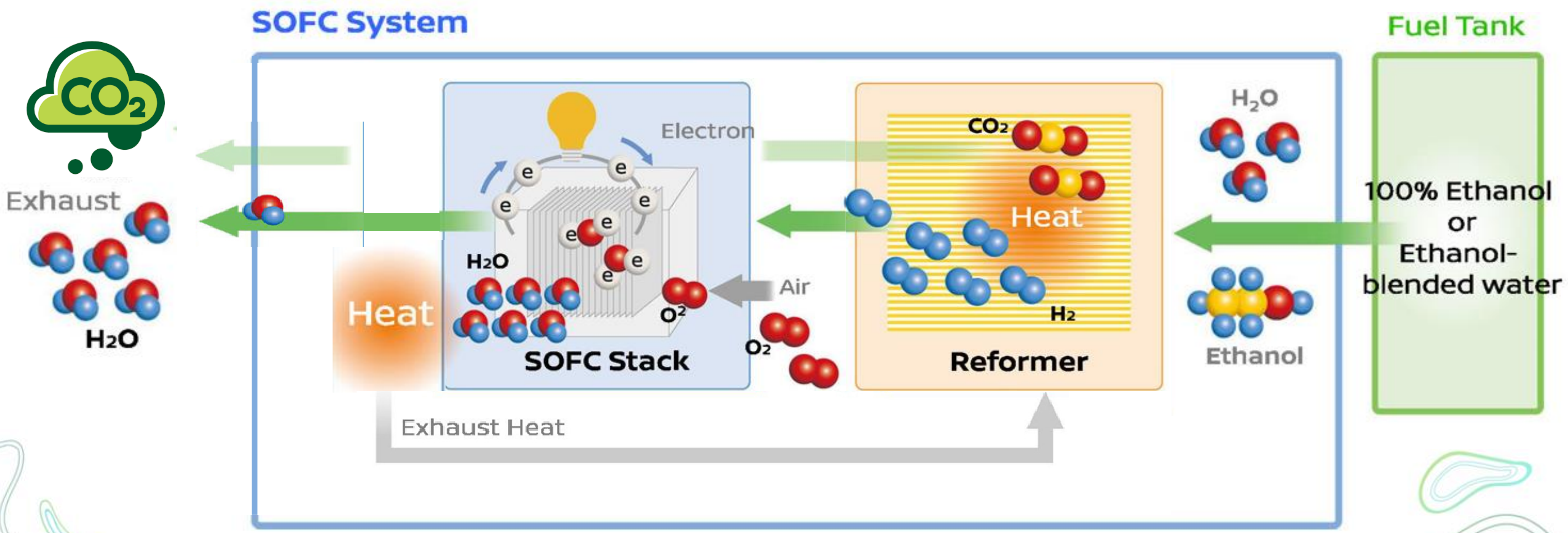
90%

Combining Advantages: The Fuel Cell Revolution

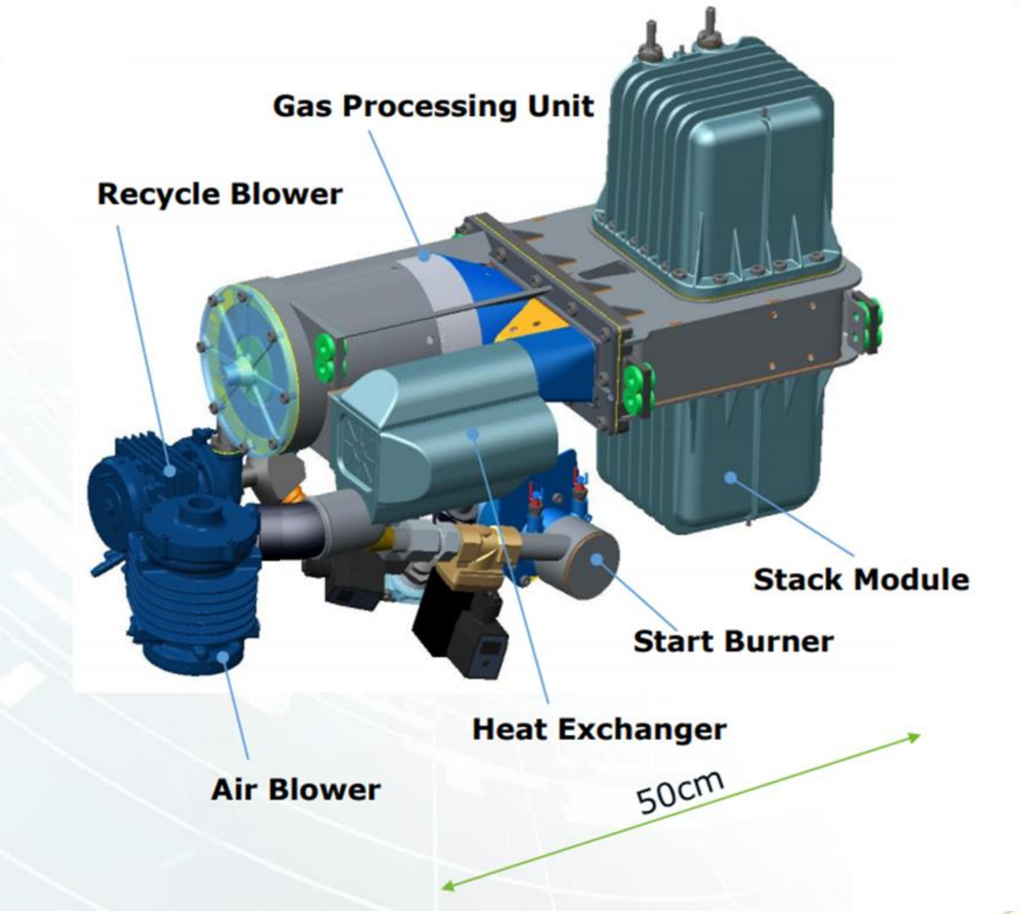
SUSTAINABLE MOBILITY: ETHANOL TALKS THAILAND



Solid Oxide Fuel Cell System



SOFC Design



Gas Processing Unit
Recycle Blower
Stack Module
Start Burner
Heat Exchanger
Air Blower
50cm

Nissan Disruption

Nissan unveils world's first Solid-Oxide Fuel Cell vehicle

YOKOHAMA, Japan (August 4, 2016) – In Brazil today, Nissan Motor Co., Ltd. today revealed the world's first Solid Oxide Fuel-Cell (SOFC)-powered prototype vehicle that runs on bio-ethanol electric power. The breakthrough model is an all-new light–commercial vehicle that can rely on multiple fuels – including ethanol and natural gas – to produce high-efficiency electricity as a power source.

1920 x 1080

1200 x 1200

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Nissan shows in Japan technology initially developed for Brazil

Nissan mostra no Japão tecnologia de etanol de 2ª geração criada no Brasil

Carmaker presented at the japan auto show, a project that allows the use of cane fuel to generate hydrogen for fuel cells

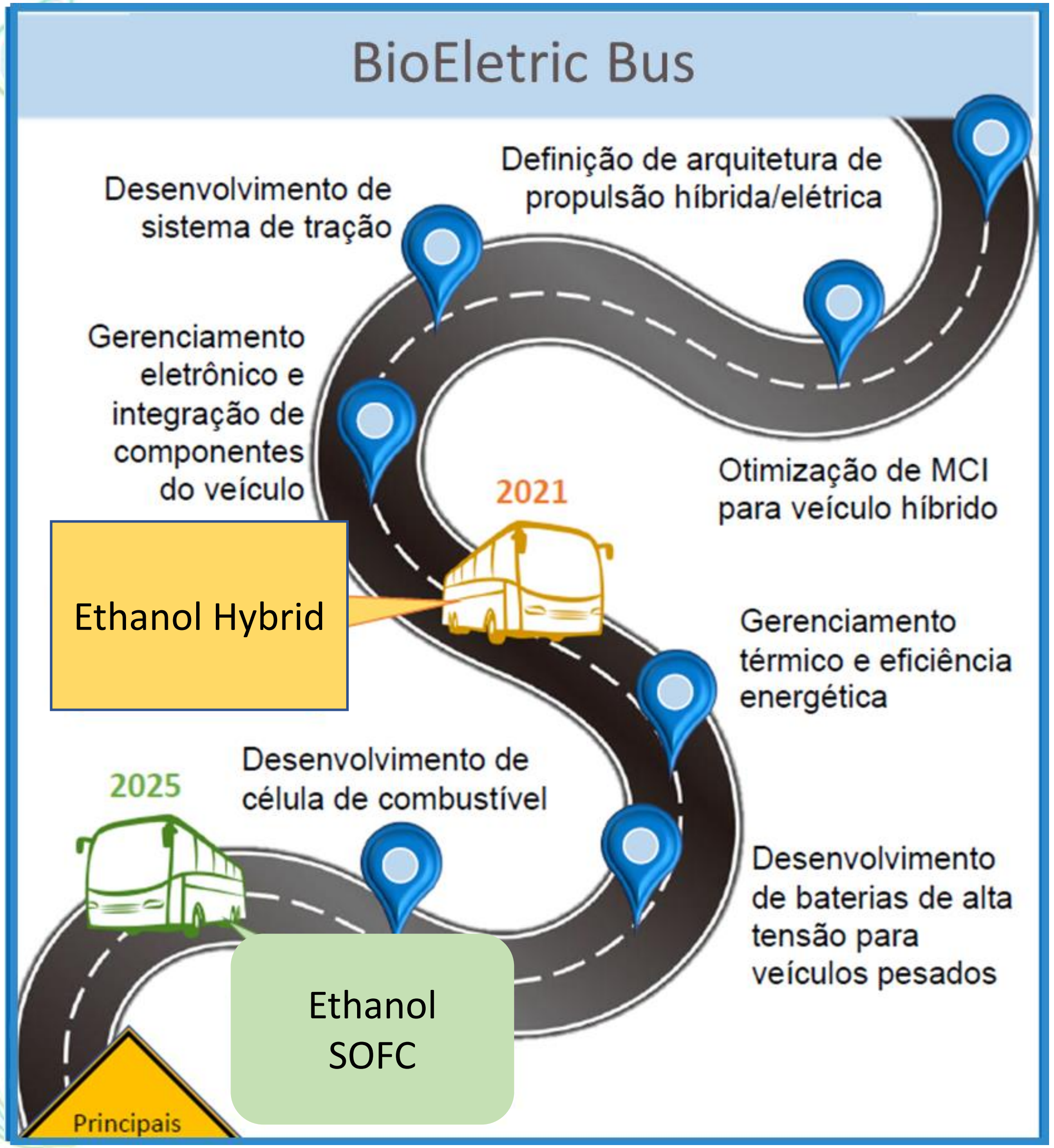
Cleide Silva*, O Estado de S.Paulo
23 de outubro de 2019 | 14h34

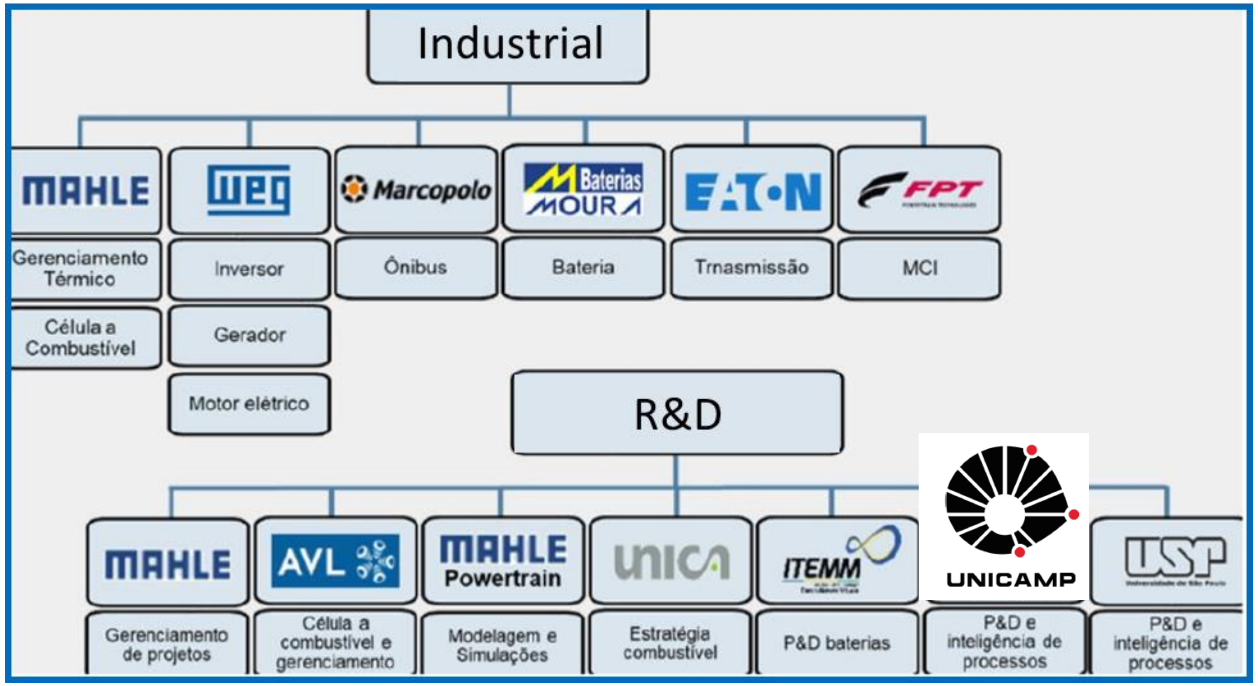
UNICAMP

Agora em sua segunda fase de testes em conjunto com a **Universidade de Campinas (Unicamp)** e o Instituto de Pesquisas Energéticas e Nucleares (Ipen), ligado à USP, o projeto começa a se mostrar viável comercialmente e, segundo Silva, poderá ser adotado de forma global. "Esse já não é um projeto só do Brasil."

This is not a project just for Brazil

BioEletric Bus





Is this Possible?

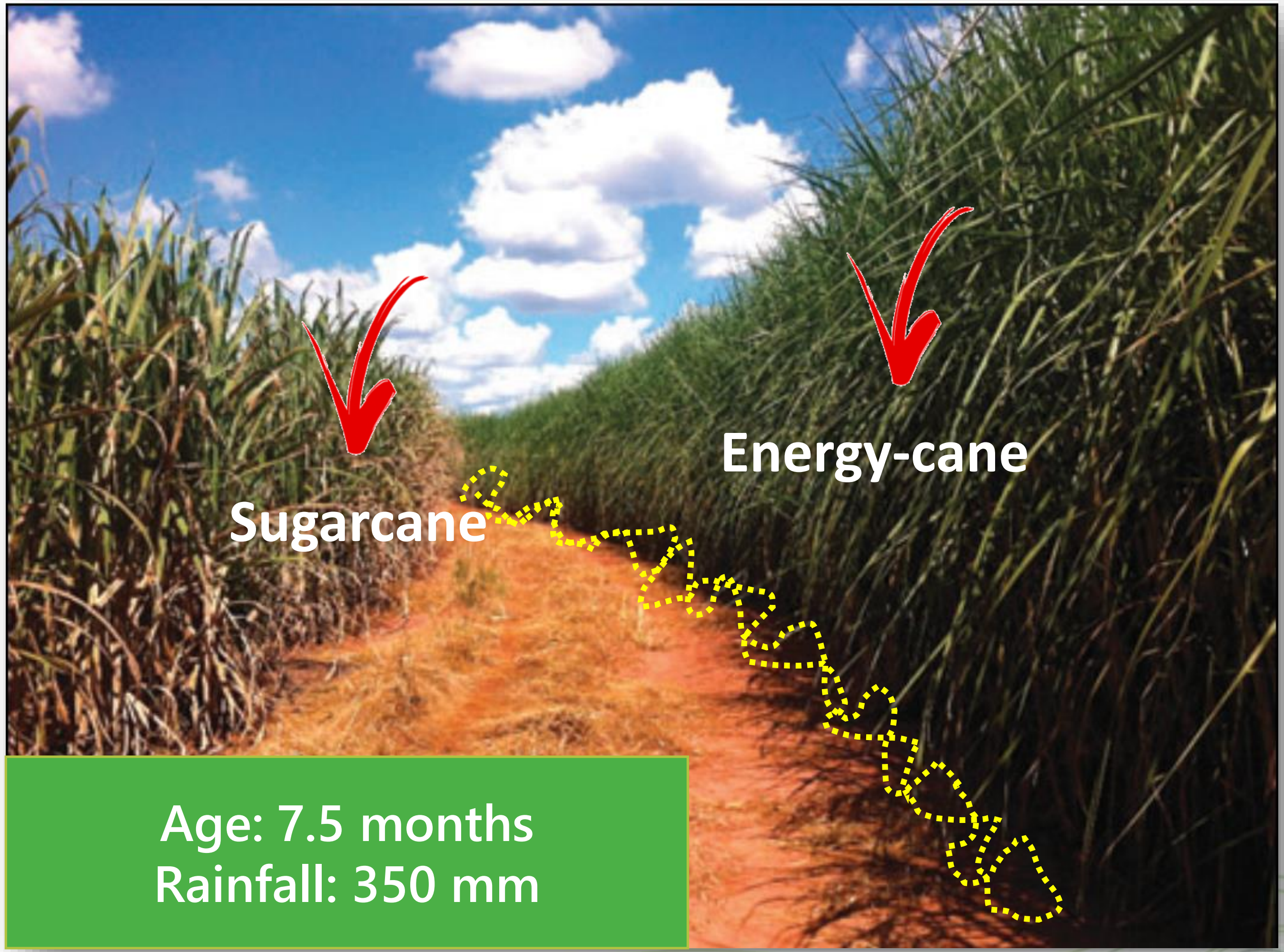
New Biomasses

Energy-cane I

Sugarcane

Energy-cane II

Resistance, Productivity and Biofertilizers

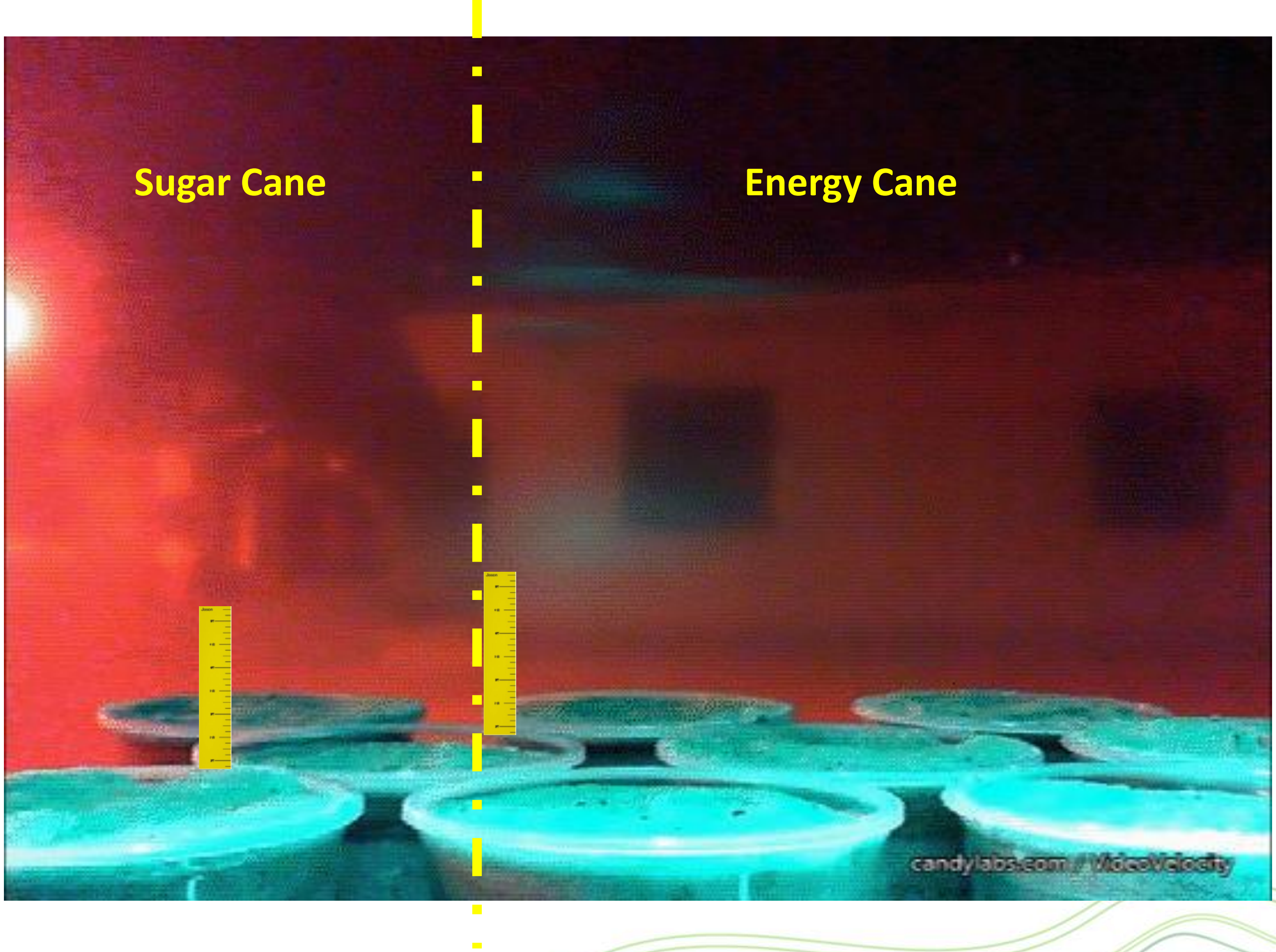


Root System

Sugarcane

Energy-cane

SUSTAINABLE MOBILITY: ETHANOL TALKS THAILAND



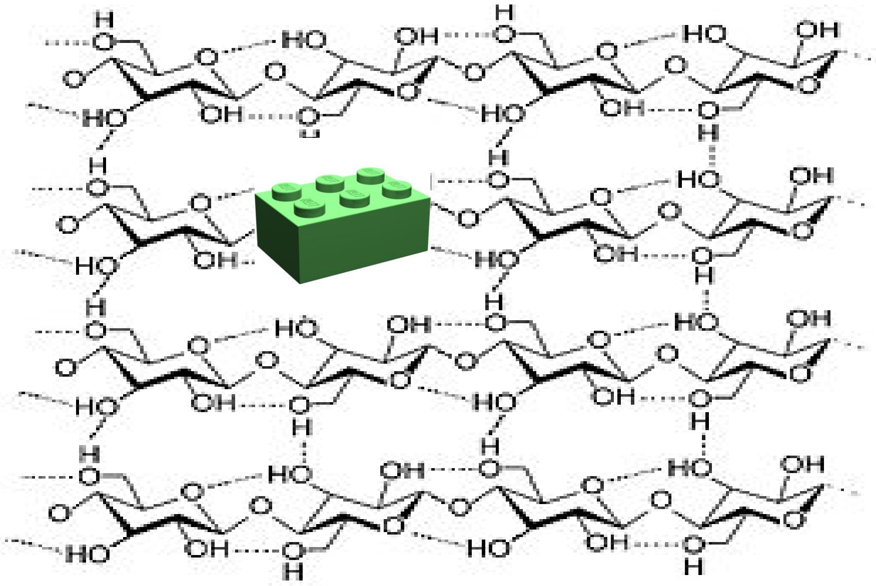
Agave for Arid Areas

Solube or Insoluble: Everything is Sugar

Second Generation

Sugar Cane – Typical Composition

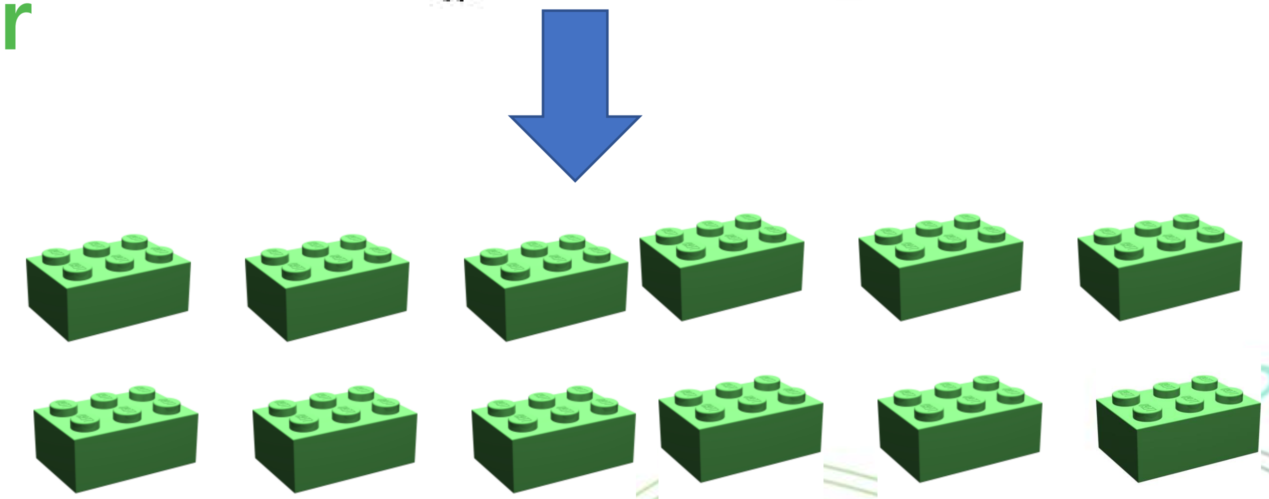
1 Ton Sugar Cane
>> 140 kg Sugar
>> 140 kg Bagasse (FIBER)
>> 140 kg Straw and Tip (FIBER)



1 ha Sugar Cane 80

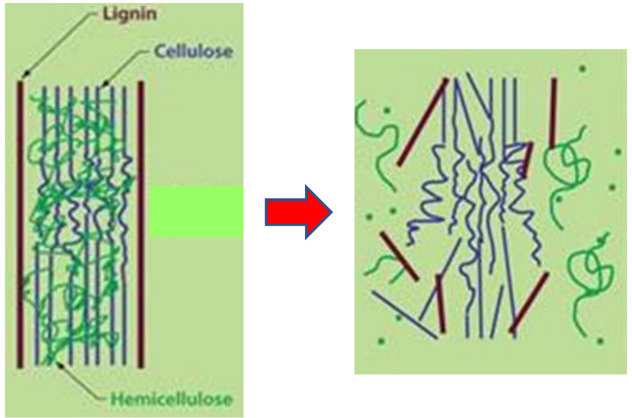
Per Year

1 ha Energy Cane 240

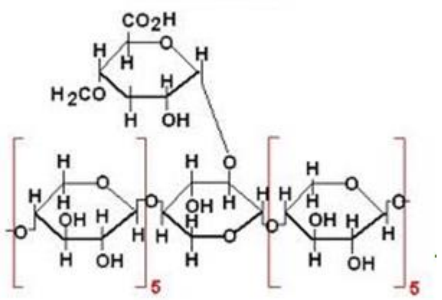


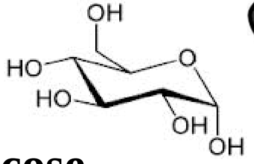
2G Technology

Pre-Treatment

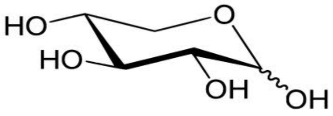


Hydrolysis



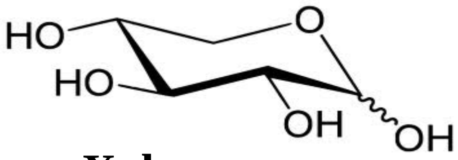


Glucose

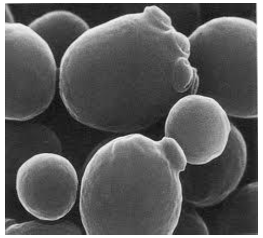


Xylose

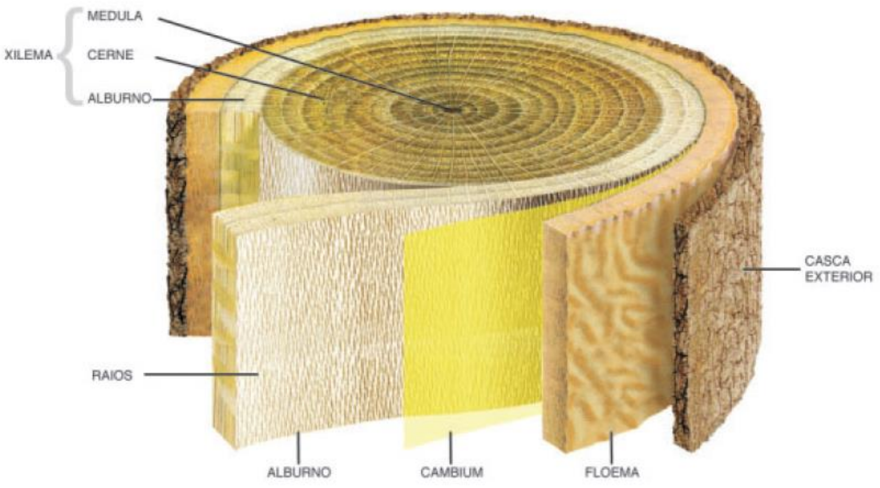
Fermentation

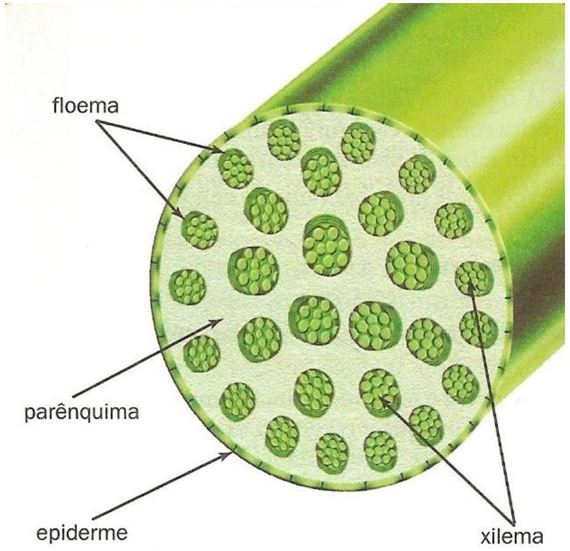


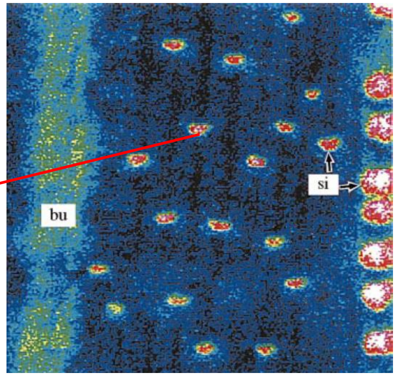
Xylose



Bagasse is not Wood



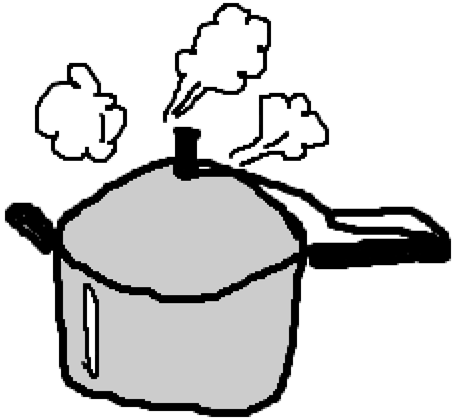




Abrasion and Erosion

Bagasse becomes a Porridge

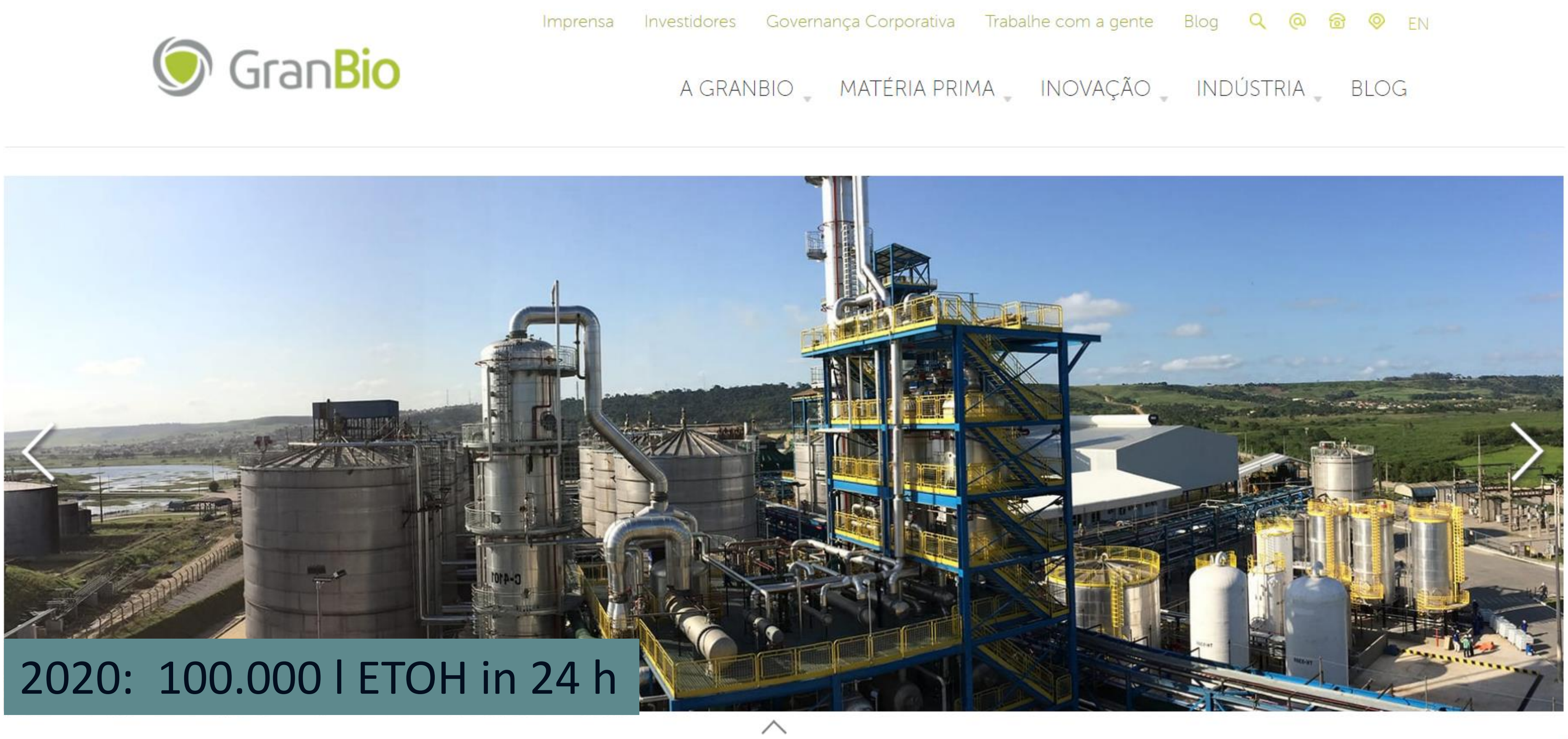
Wood



Bagasse

Adhesion

2G is Real



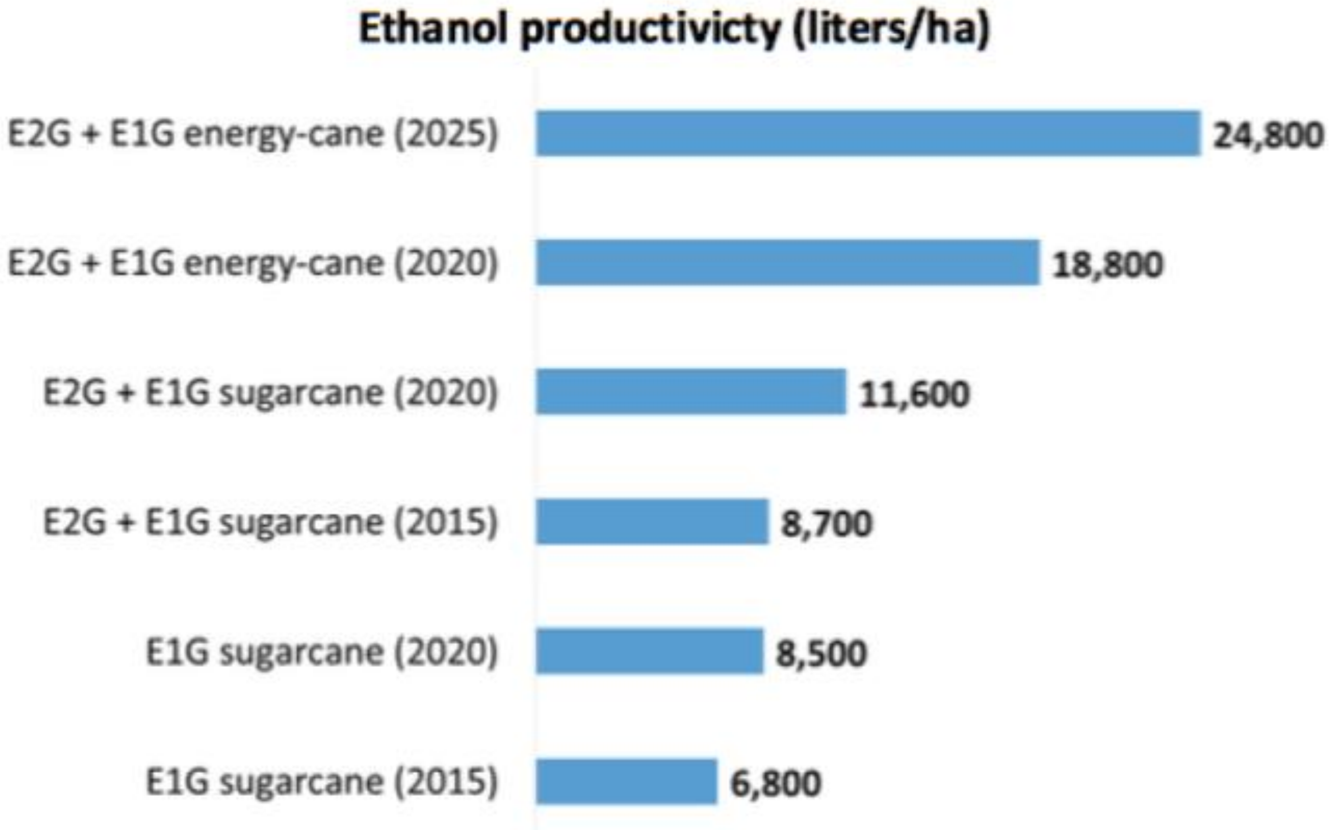
2020: 100.000 l ETOH in 24 h

Raizen

50 MM lit. produced
254 l/ton dry bagasse
10-11 months/year

“Sugar is the New Crude”

Soft Energy Transition



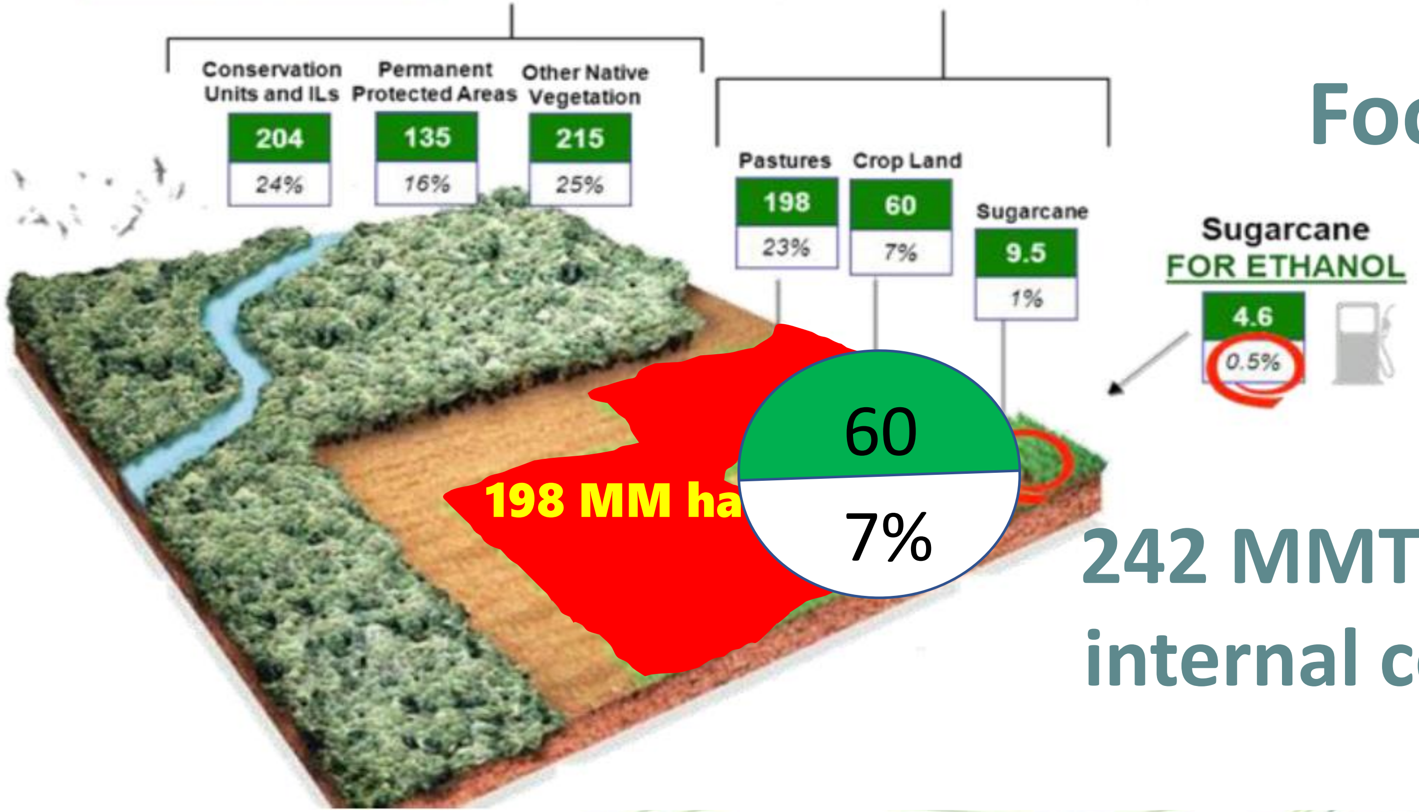
Area Requirement Analysis	
Global Gasoline Consumption	1,3tri liters/year
EtOH Equivalent	1,86 tri liters/year
Required Area E2G + E1G Energy Cane (2020)	*100MM hectares*
Required Area E2G + E1G Energy Cane (2025)	*75MM hectares*

75 MM ha = Global Gasoline Consumption Equivalent

Brazilian Landscape

Million Hectares

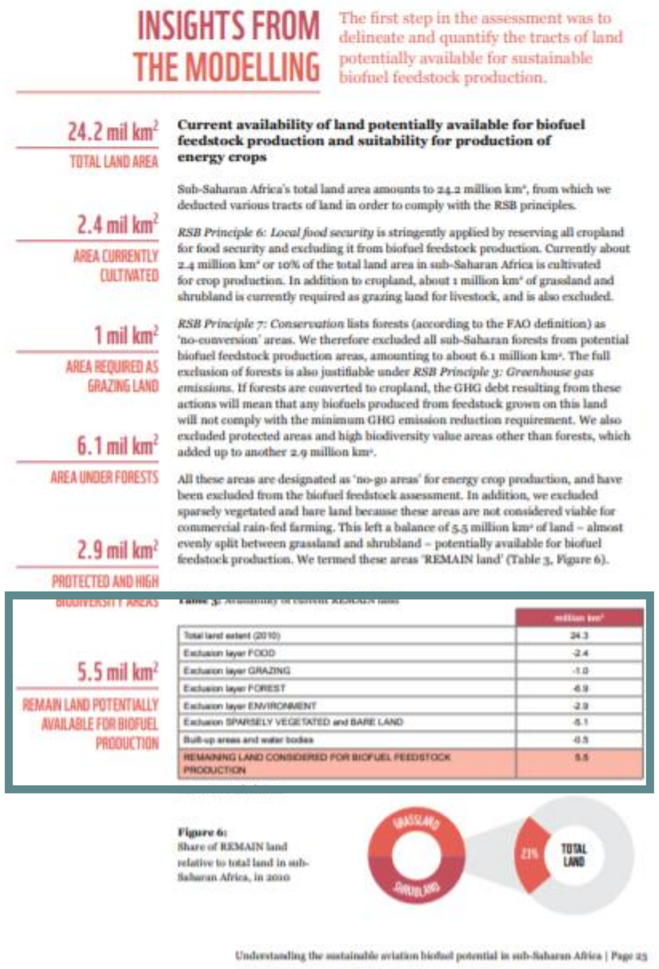
Total Area	Native Vegetation	Land in Actual Use	Other Uses
851	554	258	38
100%	*65%*	*30%*	*5%*



Food X Fuel

242 MMT (7,5 years of internal consumption)

Africa



INSIGHTS FROM THE MODELLING

The first step in the assessment was to delineate and quantify the tracts of land potentially available for sustainable biofuel feedstock production.

24.2 mil km²
TOTAL LAND AREA

2.4 mil km²
AREA CURRENTLY CULTIVATED

1 mil km²
AREA REQUIRED AS GRAZING LAND

6.1 mil km²
AREA UNDER FORESTS

2.9 mil km²
PROTECTED AND HIGH BIODIVERSITY AREAS

5.5 mil km²
REMAIN LAND POTENTIALLY AVAILABLE FOR BIOFUEL PRODUCTION

Current availability of land potentially available for biofuel feedstock production and suitability for production of energy crops

Sub-Saharan Africa's total land area amounts to 24.2 million km², from which we deducted various tracts of land in order to comply with the RSB principles.

RSB Principle 6: Local food security is stringently applied by reserving all cropland for food security and excluding it from biofuel feedstock production. Currently about 2.4 million km² or 10% of the total land area in sub-Saharan Africa is cultivated for crop production. In addition to cropland, about 1 million km² of grassland and shrubland is currently required as grazing land for livestock, and is also excluded.

RSB Principle 7: Conservation lists forests (according to the FAO definition) as 'no-conversion' areas. We therefore excluded all sub-Saharan forests from potential biofuel feedstock production areas, amounting to about 6.1 million km². The full exclusion of forests is also justifiable under *RSB Principle 3: Greenhouse gas emissions*. If forests are converted to cropland, the GHG debt resulting from these actions will mean that any biofuels produced from feedstock grown on this land will not comply with the minimum GHG emission reduction requirement. We also excluded protected areas and high biodiversity value areas other than forests, which added up to another 2.9 million km².

All these areas are designated as 'no-go areas' for energy crop production, and have been excluded from the biofuel feedstock assessment. In addition, we excluded sparsely vegetated and bare land because these areas are not considered viable for commercial rain-fed farming. This left a balance of 5.5 million km² of land – almost evenly split between grassland and shrubland – potentially available for biofuel feedstock production. We termed these areas 'REMAIN land' (Table 3, Figure 6).

Table 3: Availability of current REMAIN land

	million km²
Total land extent (2010)	24.3
Exclusion layer FOOD	-2.4
Exclusion layer GRAZING	-1.0
Exclusion layer FOREST	-6.9
Exclusion layer ENVIRONMENT	-2.9
Exclusion SPARSELY VEGETATED and BARE LAND	-6.1
Built-up areas and water bodies	-0.5
REMAINING LAND CONSIDERED FOR BIOFUEL FEEDSTOCK PRODUCTION	5.5

Figure 6: Share of REMAIN land relative to total land in sub-Saharan Africa, in 2010

Africa

BIODIVERSITY AREAS

5.5 mil km^2

REMAIN LAND POTENTIALLY AVAILABLE FOR BIOFUEL PRODUCTION

Table 3: Availability of current REMAIN land

	million km^2
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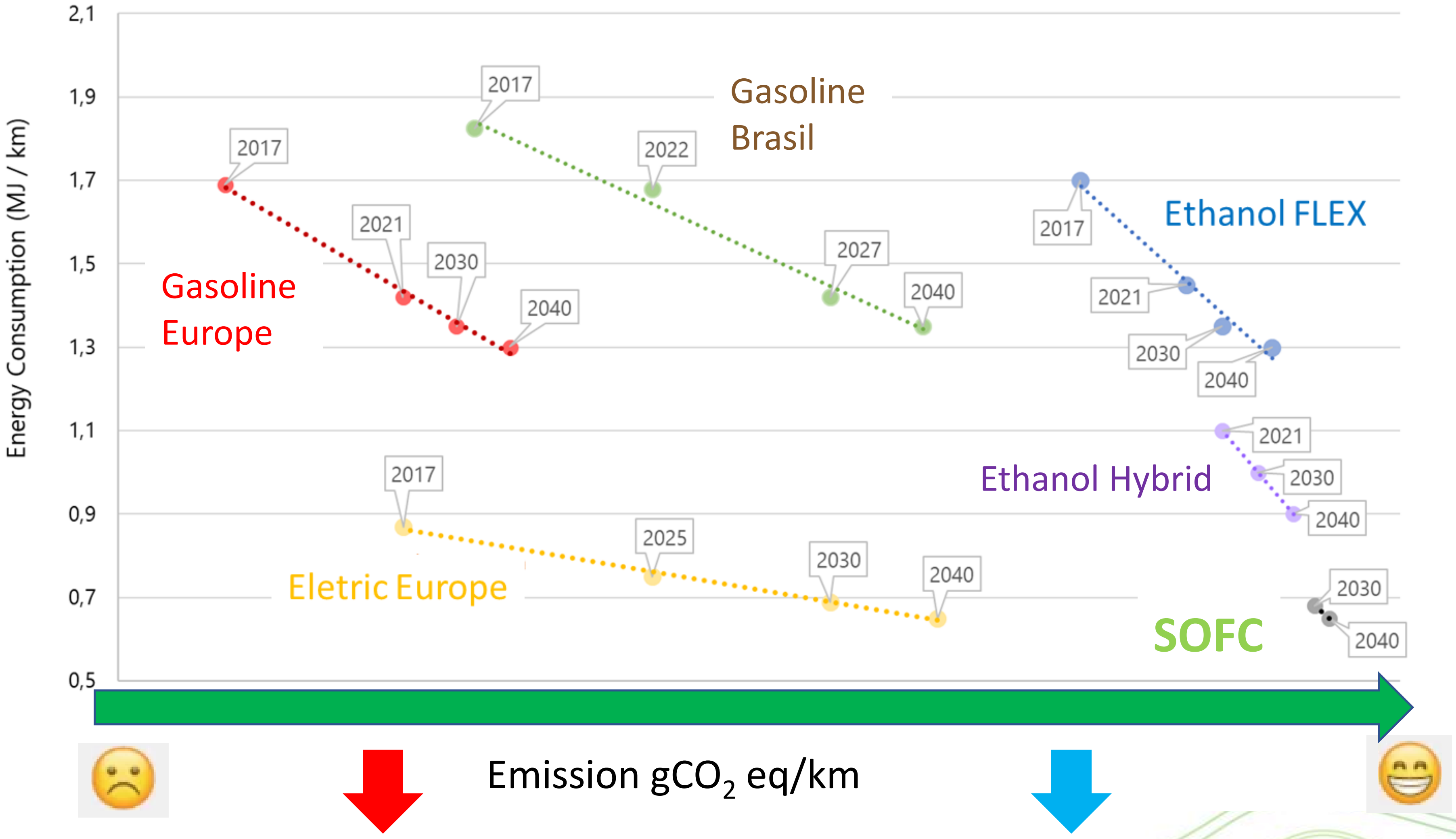
Exclusion layer FOREST	-6.9
Exclusion layer ENVIRONMENT	-2.9
Exclusion SPARSELY VEGETATED and BARE LAND	-5.1
Built-up areas and water bodies	-0.5
REMAINING LAND CONSIDERED FOR BIOFUEL FEEDSTOCK PRODUCTION	5.5

Source: Own calculations

550 MM Ha

Life Cycle Analysis



Biomass Production

Biomass Transformation

Mobility by Biofuels

SUSTAINABLE MOBILITY: ETHANOL TALKS THAILAND

portal bioenergia

Universidade de São Paulo

UNICAMP

unesp

International PhD Program

biofuture

SUSTAINABLE MOBILITY: ETHANOL TALKS

THAILAND

REALIZATION:

Thai Sugar Millers

BRAZIL
Sugarcane Bioenergy Solution

unica
SUSTAINABLE ENERGY AND FOOD FROM BRAZIL TO THE WORLD

PROMOTION:

APLA BRASIL

ApexBrasil

MINISTRY OF FOREIGN AFFAIRS

PÁTRIA AMADA BRASIL
BRAZILIAN GOVERNMENT

TECHNICAL SUPPORT

DATAGRO