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Hydrogen, energy vetor, for sustainable energy security

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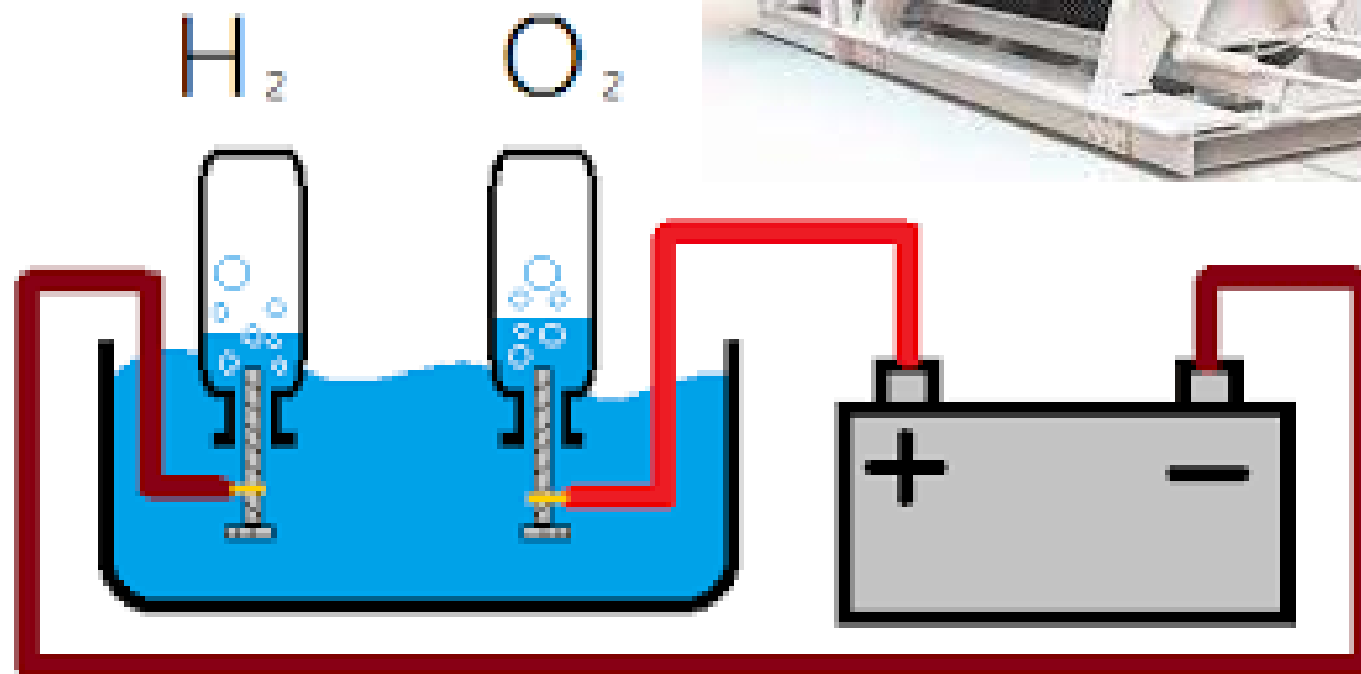
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Conversion of renewable electricity into green hydrogen and oxygen

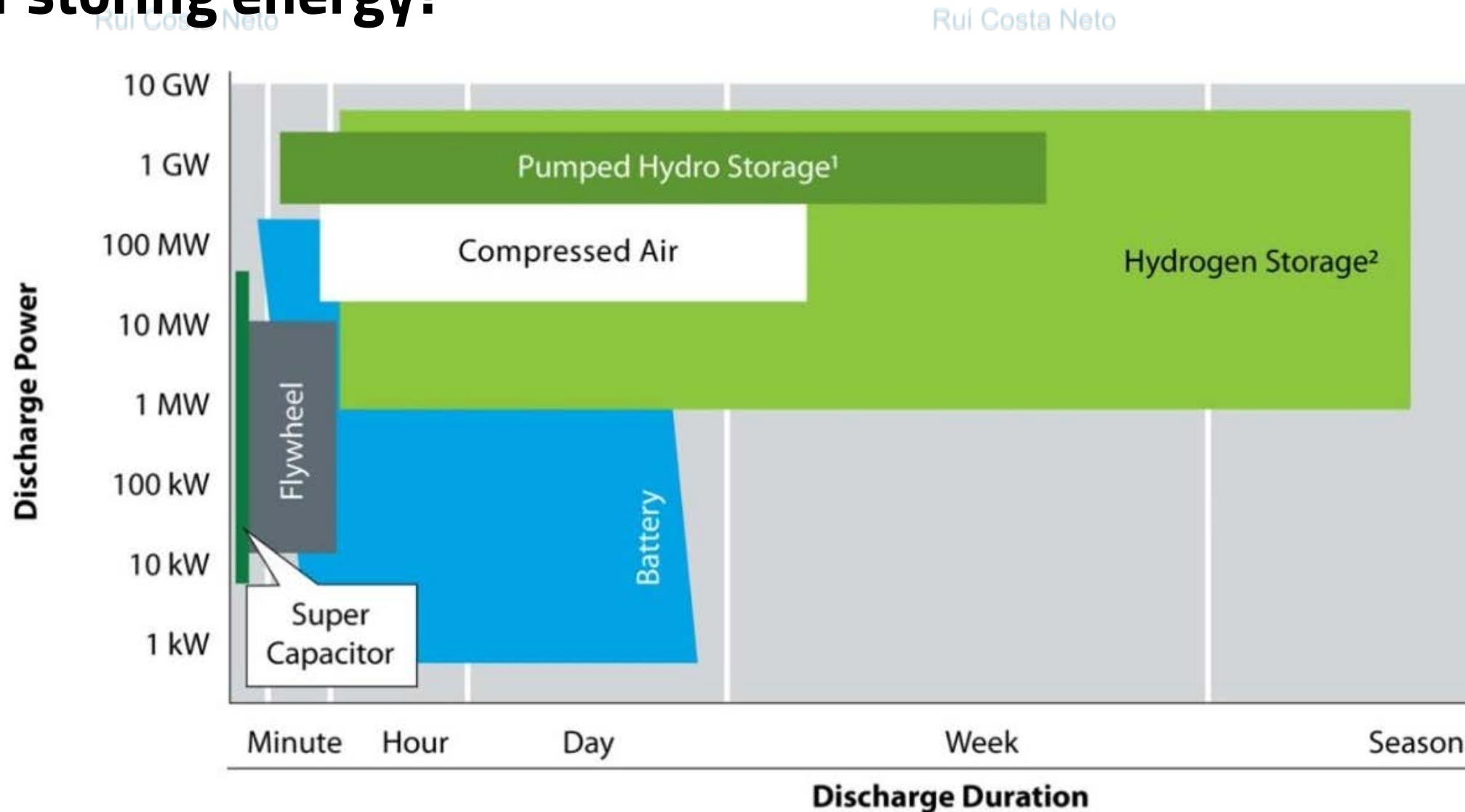
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Why is Hydrogen a differentiated way of storing energy?



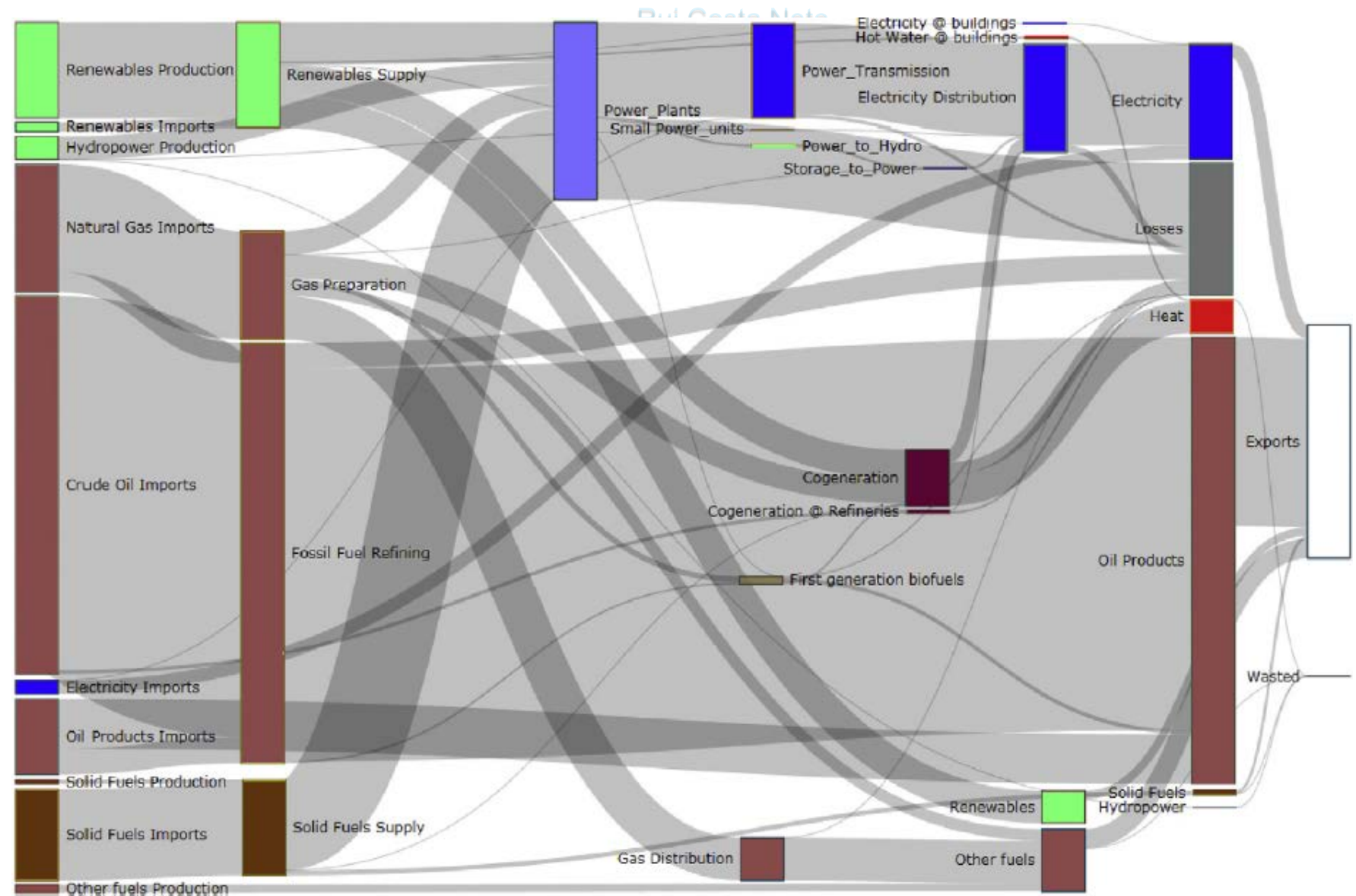
¹ Pumped hydro capacity is limited due to geographic constraints. Estimated maximum potential is <1% of U.S. electrical energy demand

² As hydrogen, ammonia, or synthetic natural gas

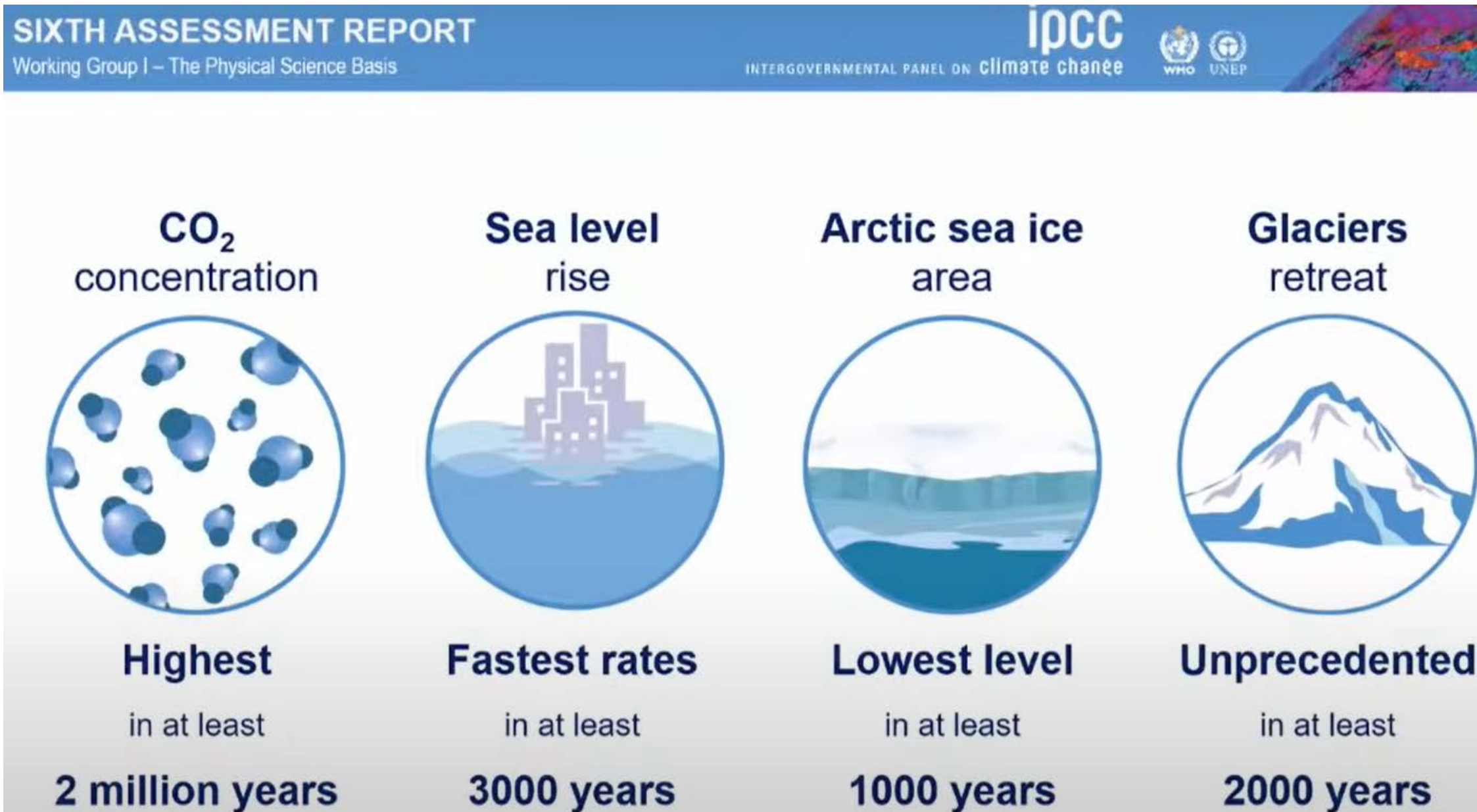
Portugal's Energy Dependence

Sankey diagram of the energy flows at mainland Portugal for 2015

P. Partidario, R. Aguiar, P. Martins, C.M. Rangel, I. Cabrita, The Hydrogen roadmap in the Portuguese energy system e Developing the P2G case, International Journal of Hydrogen Energy Volume 45, Issue 47, 2020, 25646-25657.



Irrefutable proof of global warming



Irrefutable proof of global warming

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Extreme heat

More frequent

More intense



Heavy rainfall

More frequent

More intense



Drought

Increase in some
regions



Fire weather

More frequent



Ocean

Warming
Acidifying
Losing oxygen

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Number of solar hours in Portugal per year

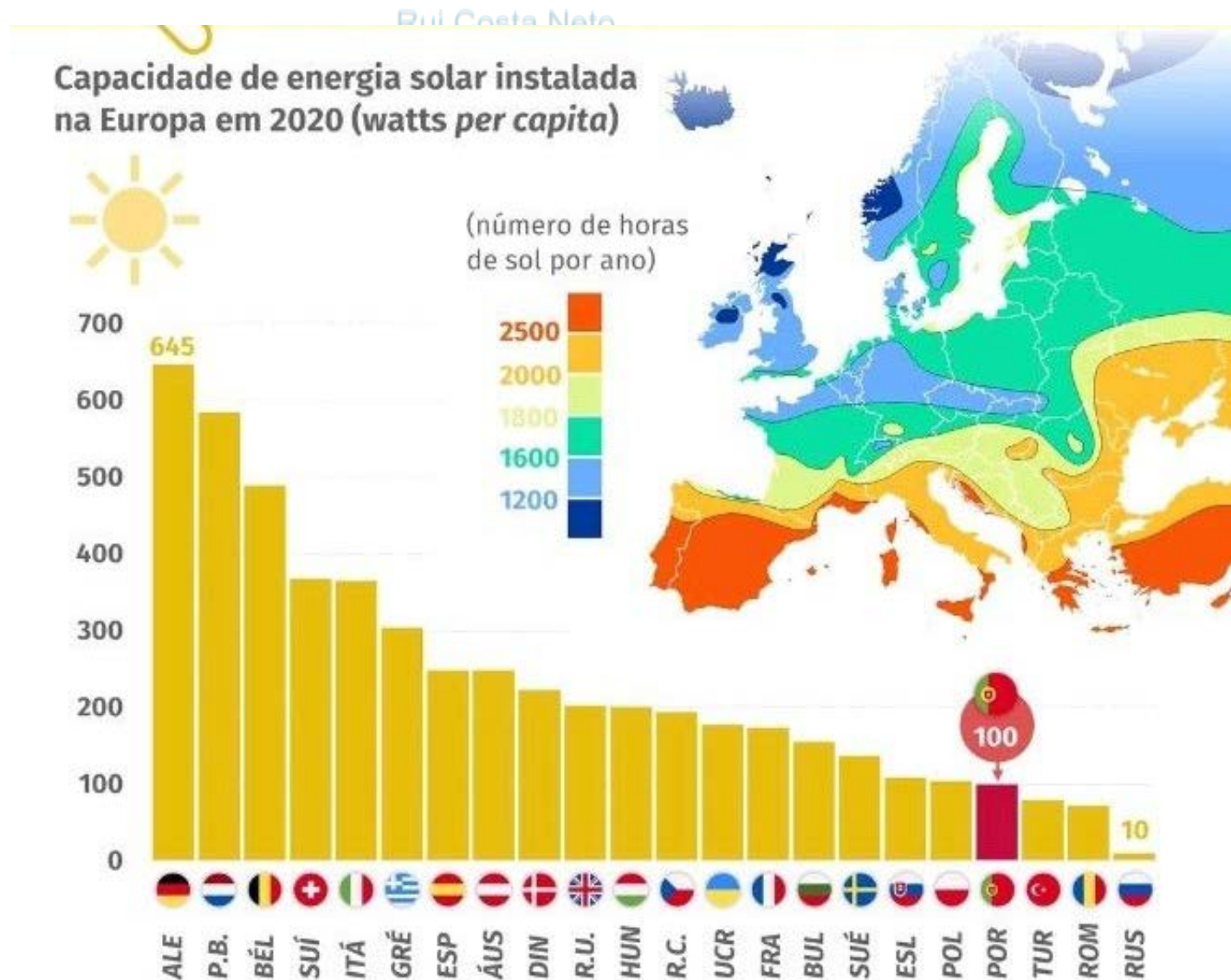
In Portugal we have **2X more annual solar hours**, but compared to **Germany** we have **6.4X less installed capacity per person**.

Fonte: Meteostat

[maisfactos.pt](https://www.maisfactos.pt)

Fonte: Statistical Review of World Energy (2021), BP e Solargis
Produzido a 29 de maio de 2022

+ factos



CO2 price evolution (€/ton) UE

23-25
EU Carbon
Permits

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Preço do CO₂
subiu, **13x**,
entre **7 €/ton**
para **88 €/ton**
entre **2017** e
2022

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EU Carbon Permits (UTC+1)

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7 €/ton

13x

88 €/ton



source: tradingeconomics.com

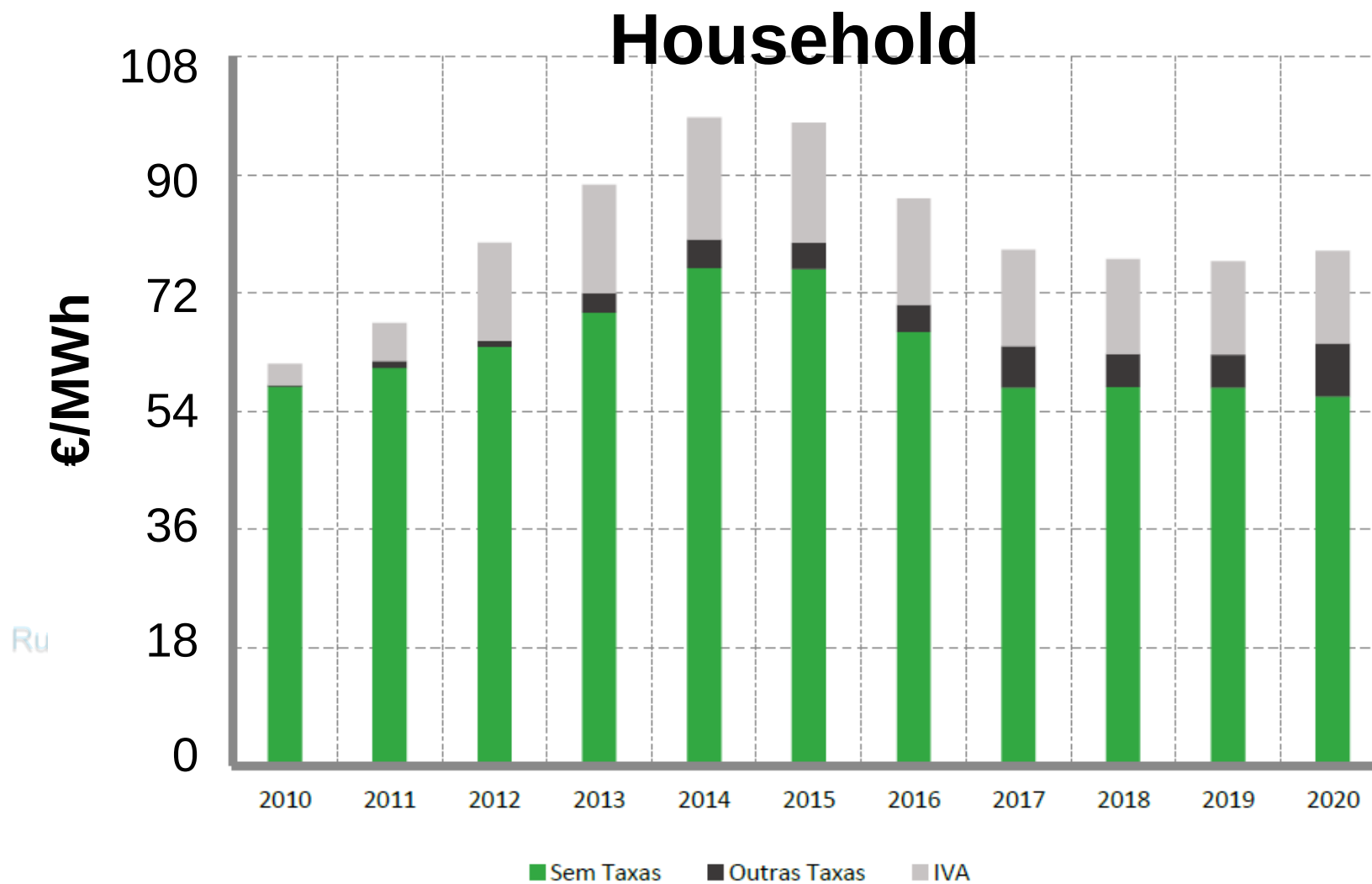
<https://tradingeconomics.com/commodity/carbon>

Natural gas price evolution (€/MWh) (90% Methane)

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Context <https://www.improvement-sudoe.es/>

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Fonte: DGEG

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Industrial



Fonte: DGEG

Natural Gas Prices

Price and volume Index per gas day

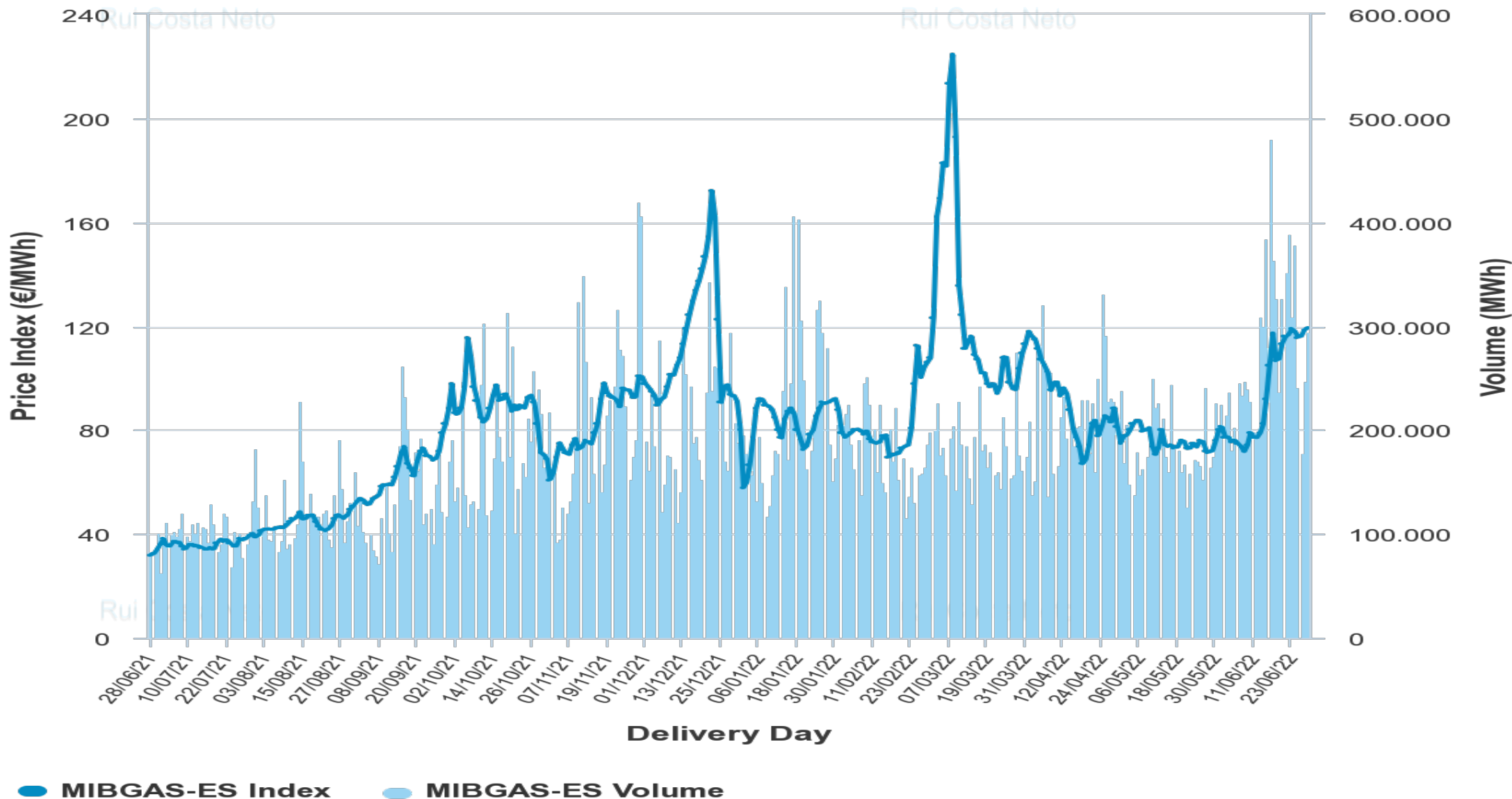
Economia Circular Regenerativa
e as "Nature-Based Solutions"

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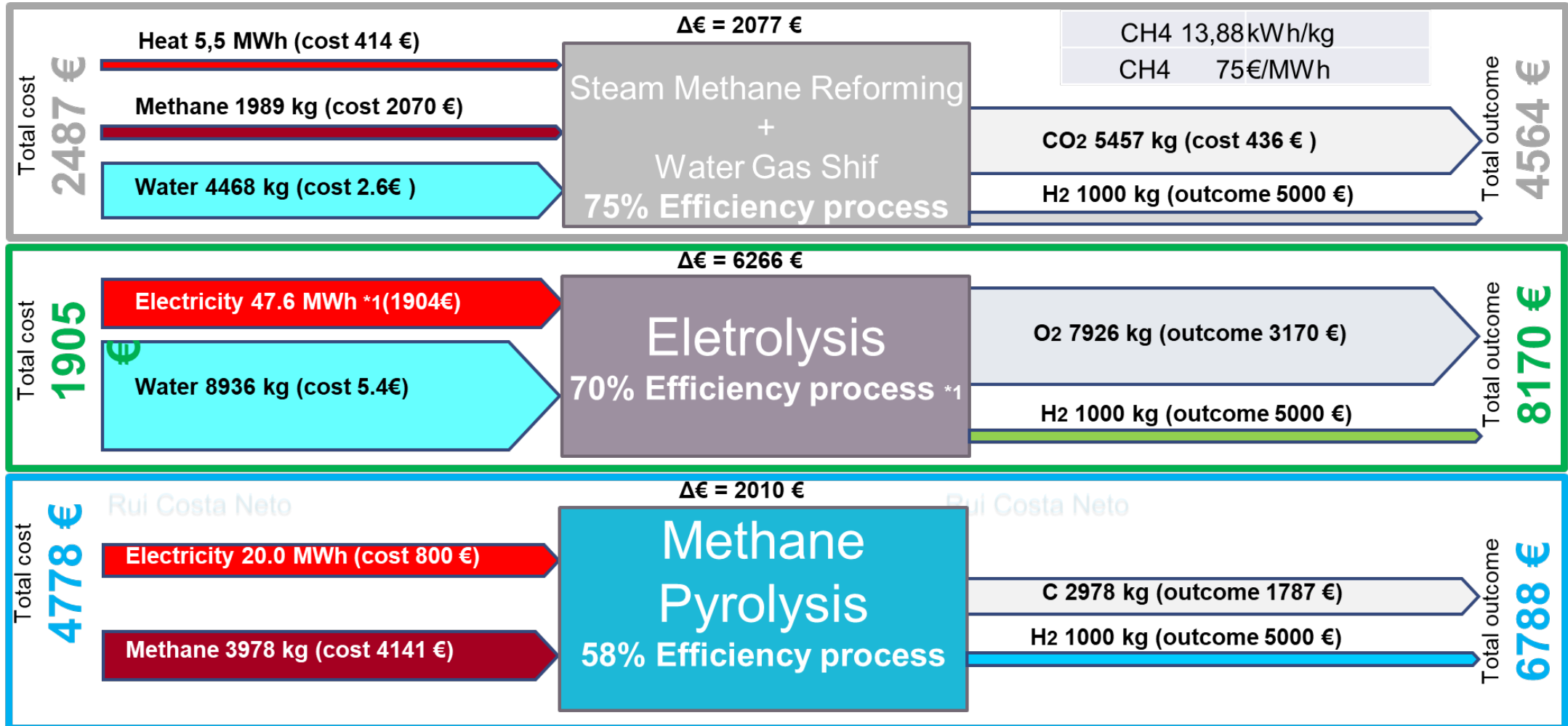
<https://www.mibgas.es/en/market-results/gas-daily-price-index-and-volumes?daterange=28/06/2021%20-%2028/06/2022>

Rui Costa Neto, <https://www.linkedin.com/in/rui-costa-neto-60106920>

OPEX Green Hydrogen Production 2022

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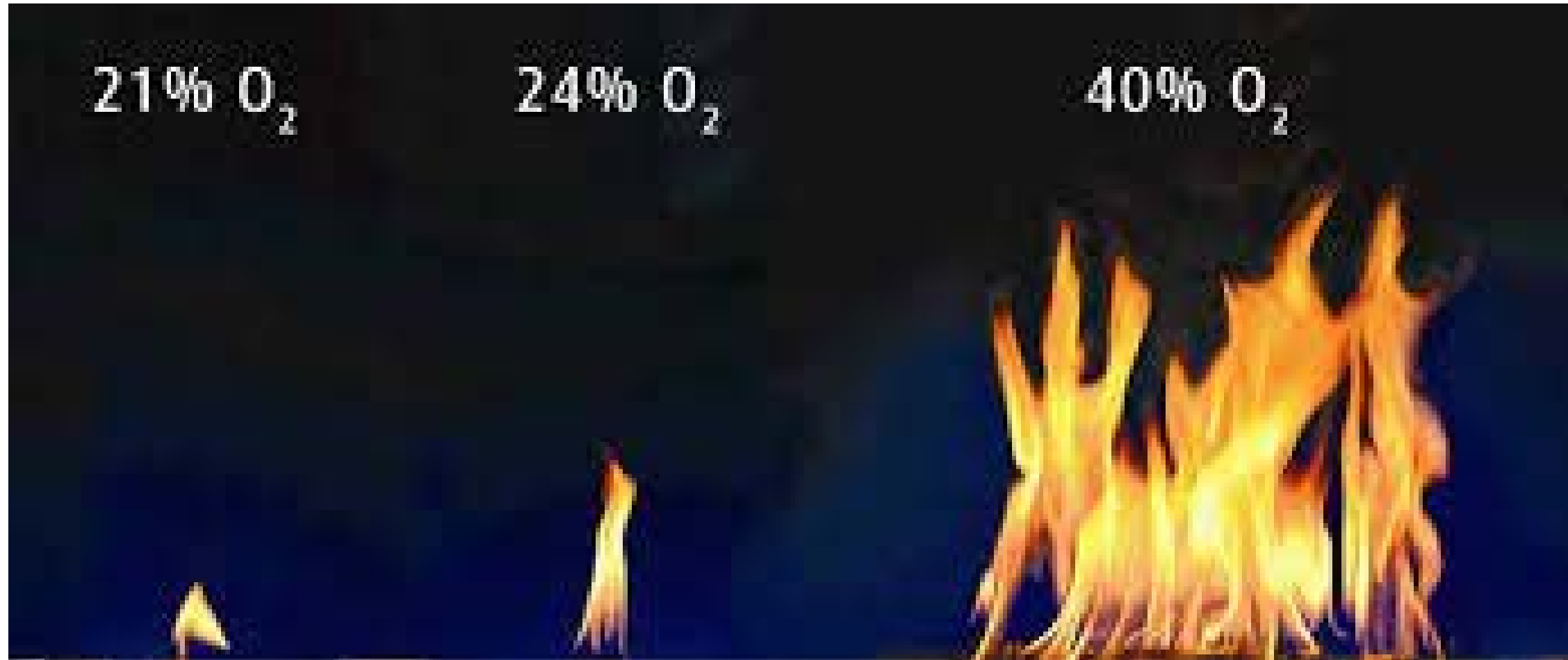
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Oxygen Enrichment in Combustion

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Sectors where Hydrogen and Oxygen is most likely to prosper

Oxi combustion in Glass and Ceramics

Economia Circular Regenerativa
e as "Nature-Based Solutions"

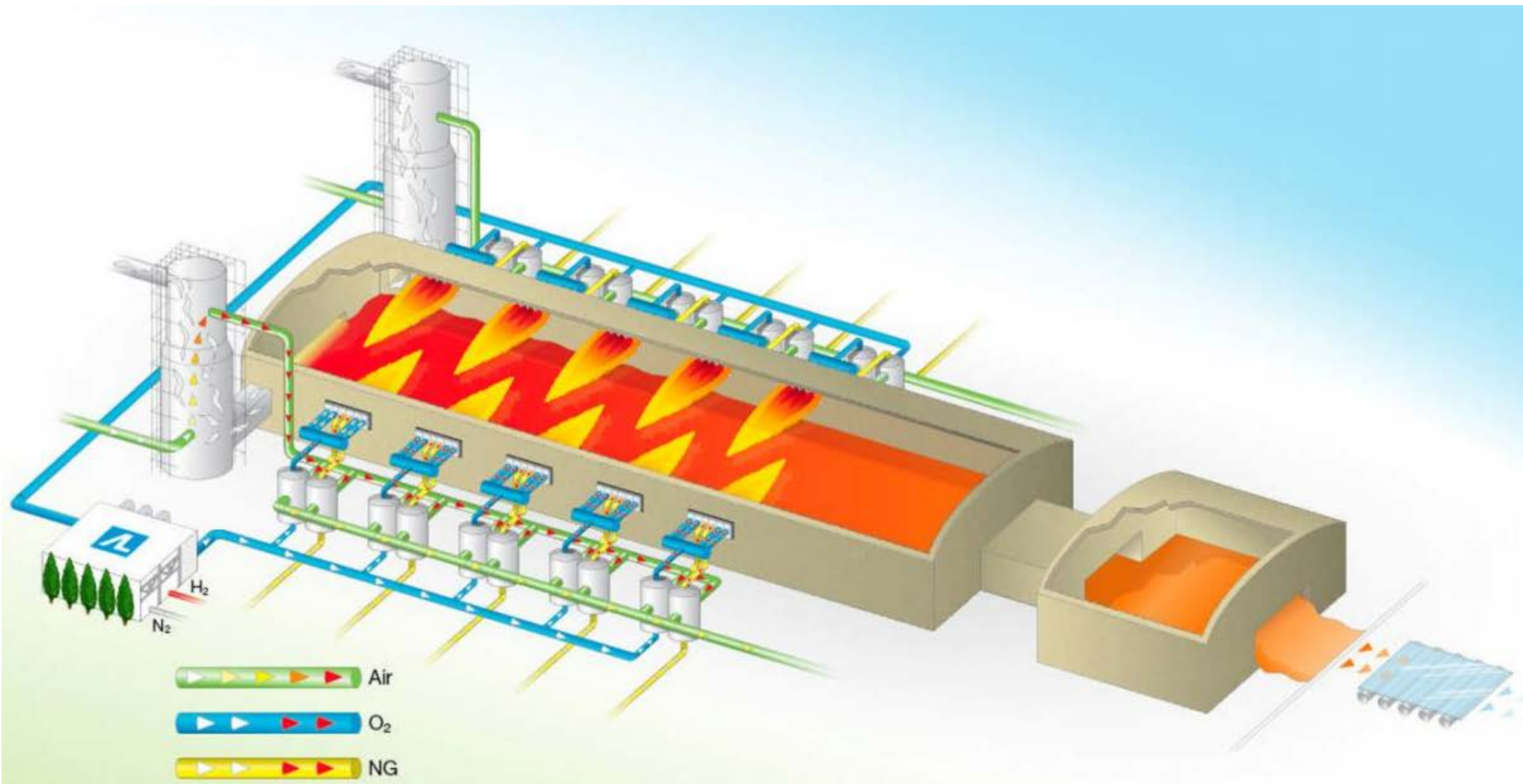
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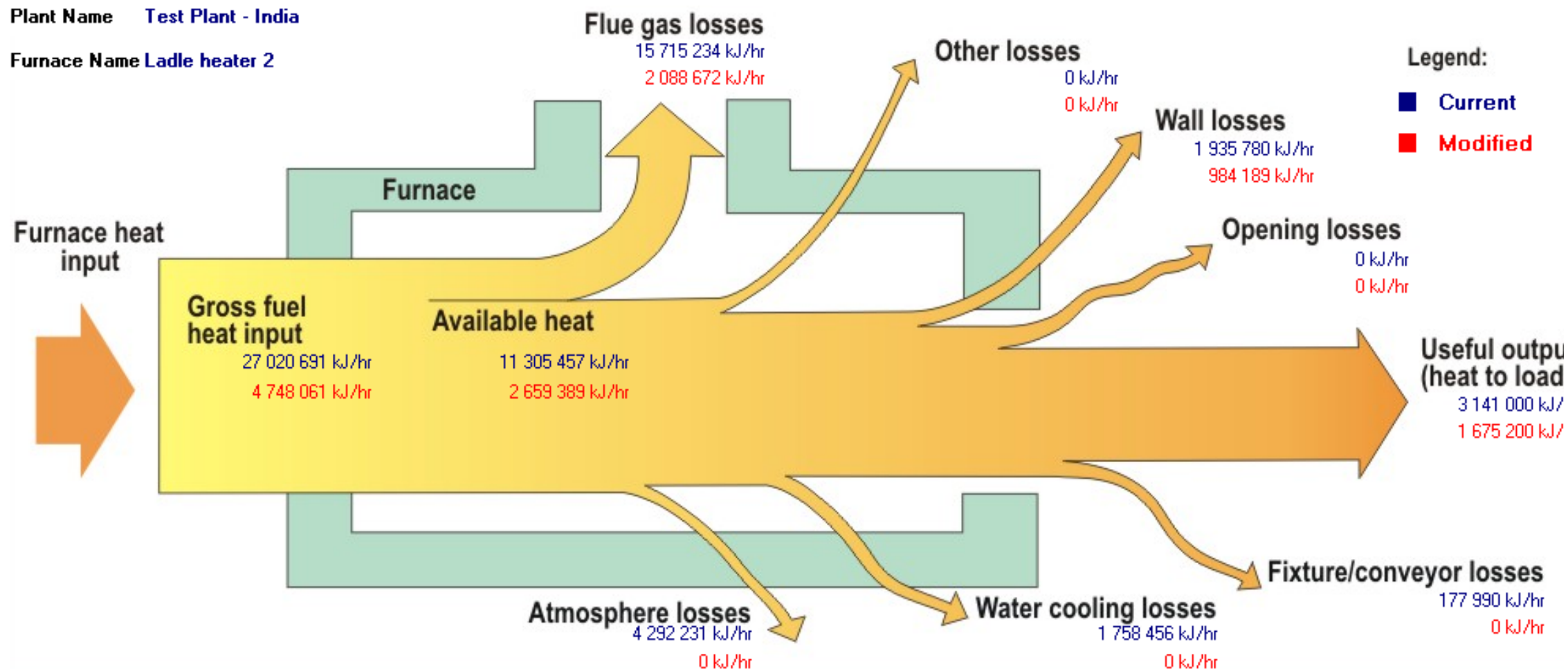


Oxygen combustion generates combustion efficiency

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Plant Name Test Plant - India

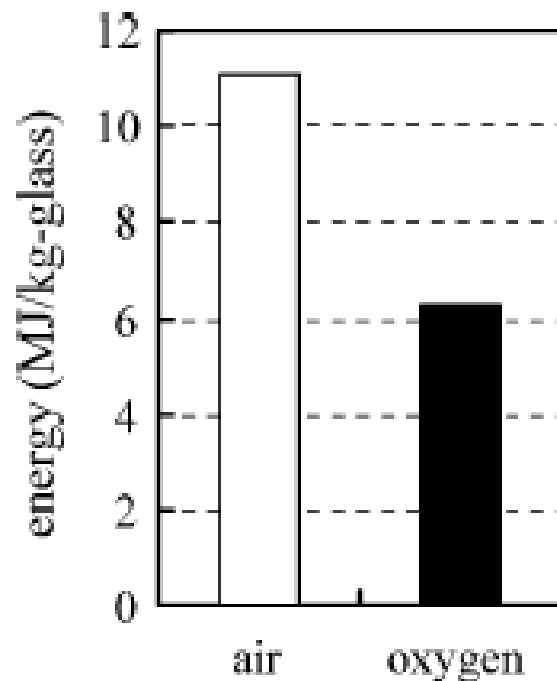
Furnace Name Ladle heater 2



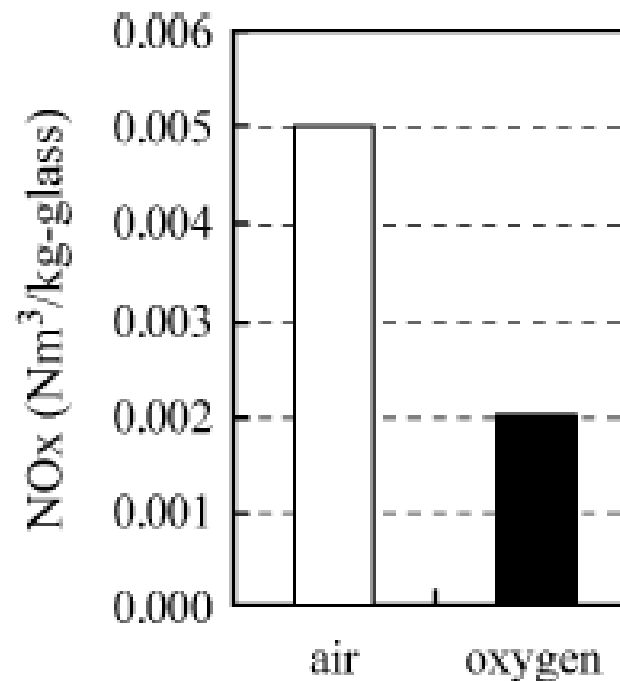
Combustion of natural gas with AIR vs Pure oxygen

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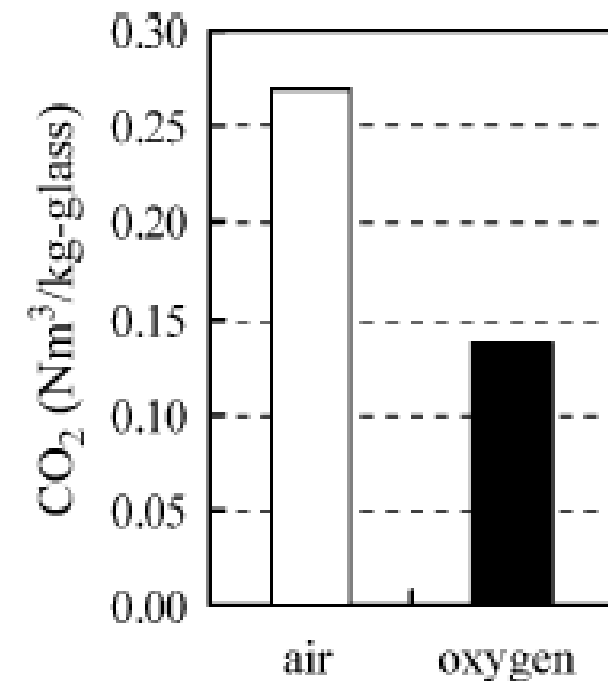
Glass Furnace



(a) Energy consumption



(b) NO_x emission



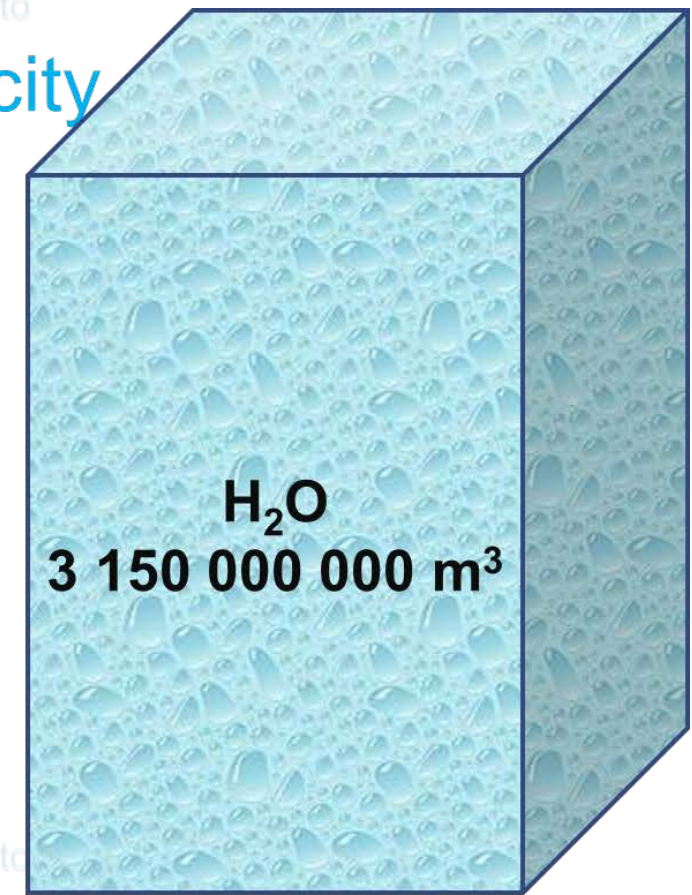
(c) CO₂ emission

Fig. 3. Comparison between air-blown combustion and oxygen-blown combustion in glass melting.

How much **water** do we need to produce H₂ to put in all Portuguese vehicles?



H₂O Useful Alqueva Capacity
150 000 000 m³



5,6 kg H₂ travels 600 km
12 000 km/year
5 500 000 Mirais II



Consumption 616 000 ton H₂
Consumption 5 549 550 m³ H₂O

0,2% H₂O to H₂ to
all vehicles

How much Green Energy do we need to produce H₂ to put into all Portuguese vehicles?

Economia Circular Regenerativa
e as "Nature-Based Solutions"

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55,5 km² = Território 0,06%



5,6 kg H₂ travels 600 km

12 000 km/year

5 500 000 Mirais II

Consumption 616 000 ton H₂

47 kWh/kg H₂

Eletricidade 28 952 000 MWh

8760 hours

3 305 MW Nominal Average Power

197 MW aumentar solar para 3 305 MW Potência média nominal (~17X)

92 212 km²



de todos os veículos

How much Green Energy do we need to produce H₂ to put into all Portuguese vehicles?

est

Produção Nominal Renováveis (MW) 2021	Produção Nominal (MW) 2020
3 370 (59,6%)	3 285 (59,0%)
Produção Nominal Solar (MW) 2021	Produção Nominal Solar (MW) 2020
197 (3,5%)	145 (2,6%)
Consumo Total (MW) 2021	Consumo Total (MW) 2021
5 650 (100%)	5 572 (100%)

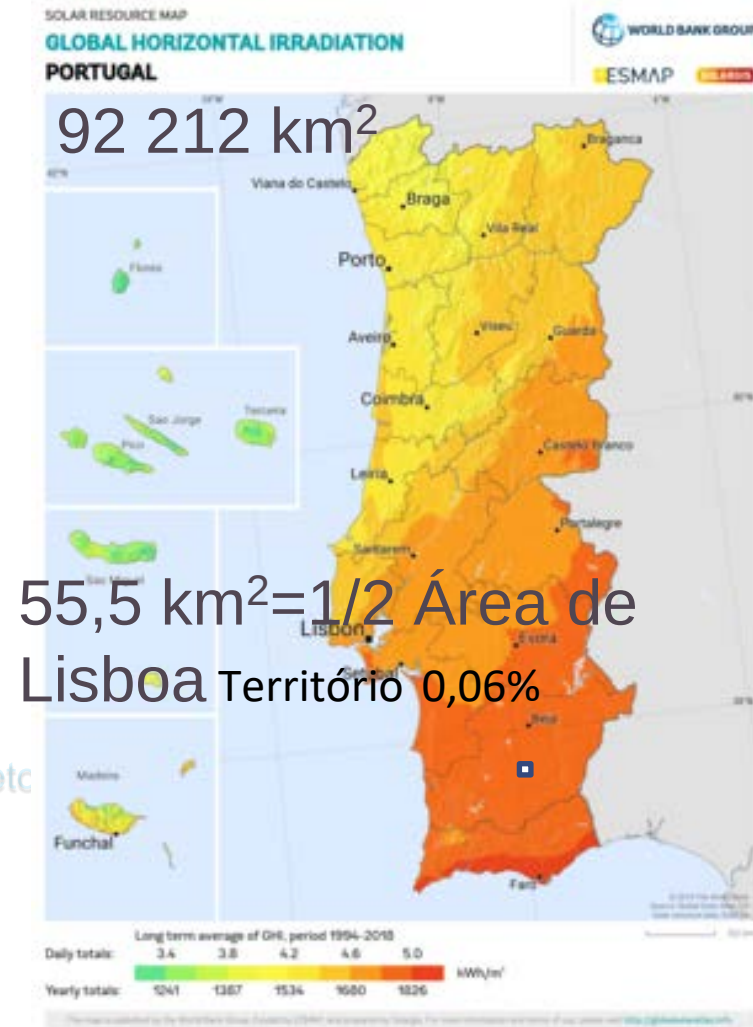
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5,6 kg H₂ fazem 600 km
12 000 km/ano
5 500 000 Mirais II

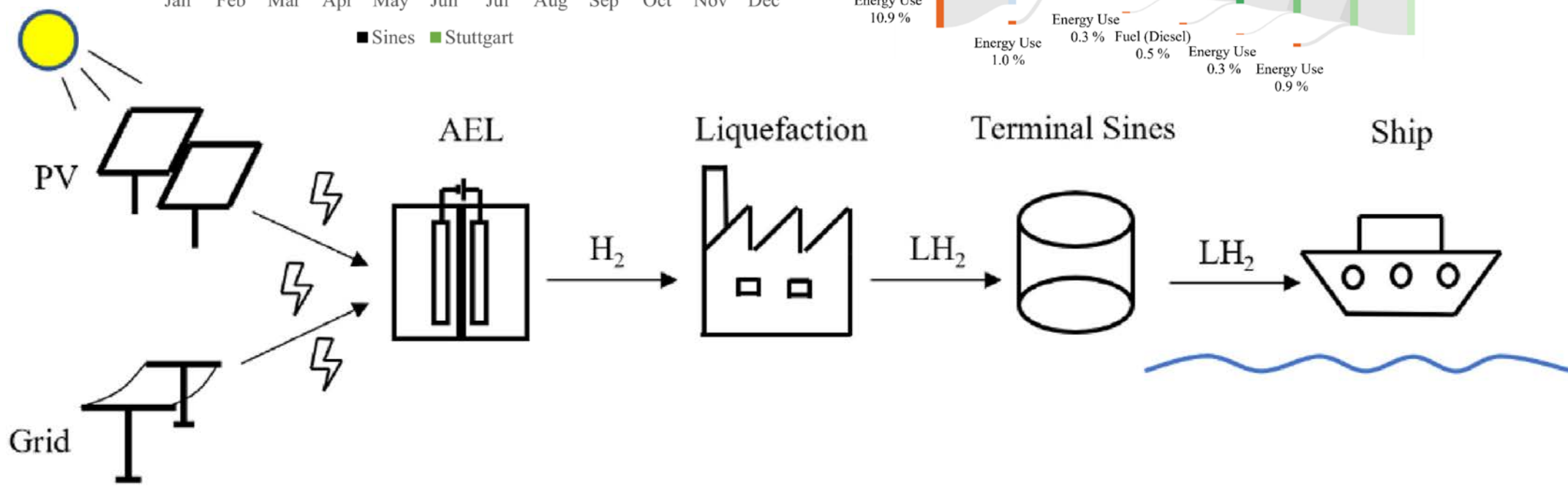
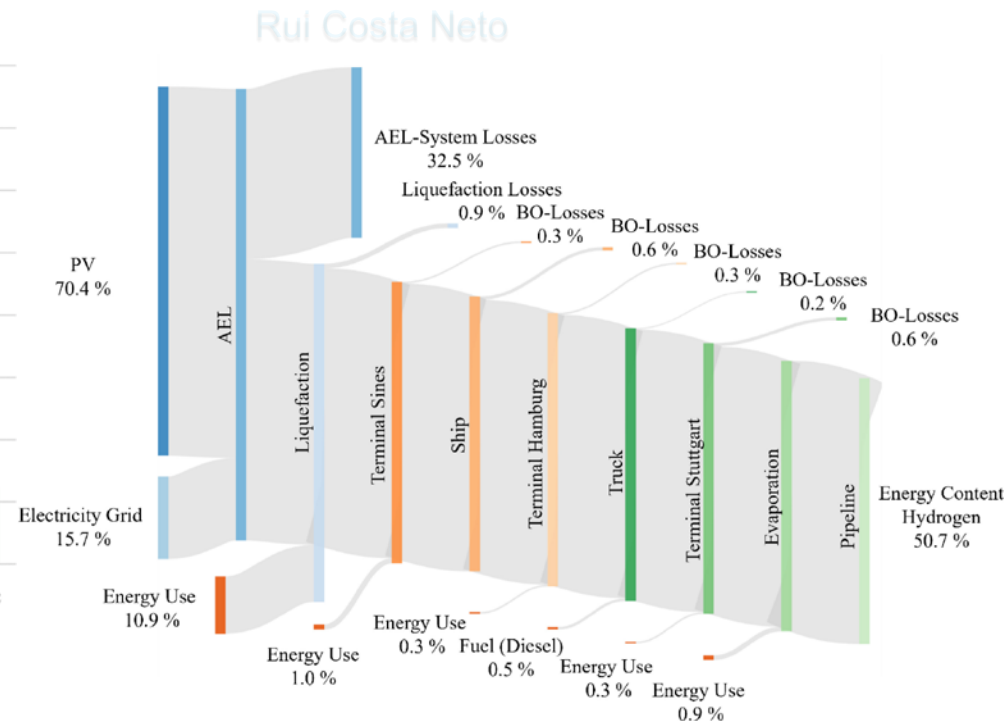
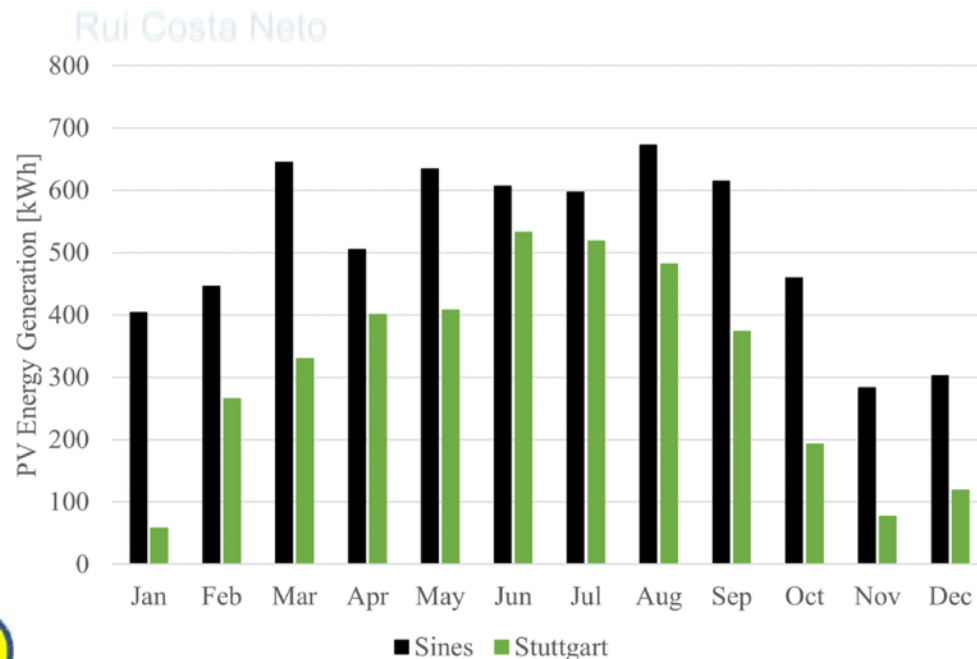
Consomem 616 000 ton H₂
47 kWh/kg H₂
Eletricidade 28 952 000 MWh
8760 horas
3 305 MW Potência média nominal

197 MW aumentar solar para 3 305 MW Potência média nominal (~17X)



0,2% H₂O para H₂
de todos os veículos

Techno-economic evaluation of two hydrogen supply options to southern Germany: On-site production and import from Portugal



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As hydrogen is indispensable and the need for hydrogen will be forever.

Just for that, let's make it green!!!!

Rui Costa Neto

Rui Costa Neto,

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