Life Cycle Assessment of carbon-neutral maritime fuels in Brazil

Comparative Environmental Analysis of Fuels

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Today’s agenda

- **Georeferenced analysis**
- **LCA for selected fuels**
  - Life cycle assessment methods
  - System boundaries and key premisses
  - Carbon footprint of selected biobunkers

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Feedstocks and energy resources

SVO/HVO

- **Soybean** oil
- **Corn** oil
- **Cotton** oil
- **Sunflower** oil
- **Peanut** oil
- **Mammon** oil

FT-diesel

- **Sugarcane** straw and bagasse
- **Soybean** straw
- **Corn** stover
- **Wheat** straw
- **Eucalyptus/Pinus** residues and cuts
- **Forest extraction** residues and cuts

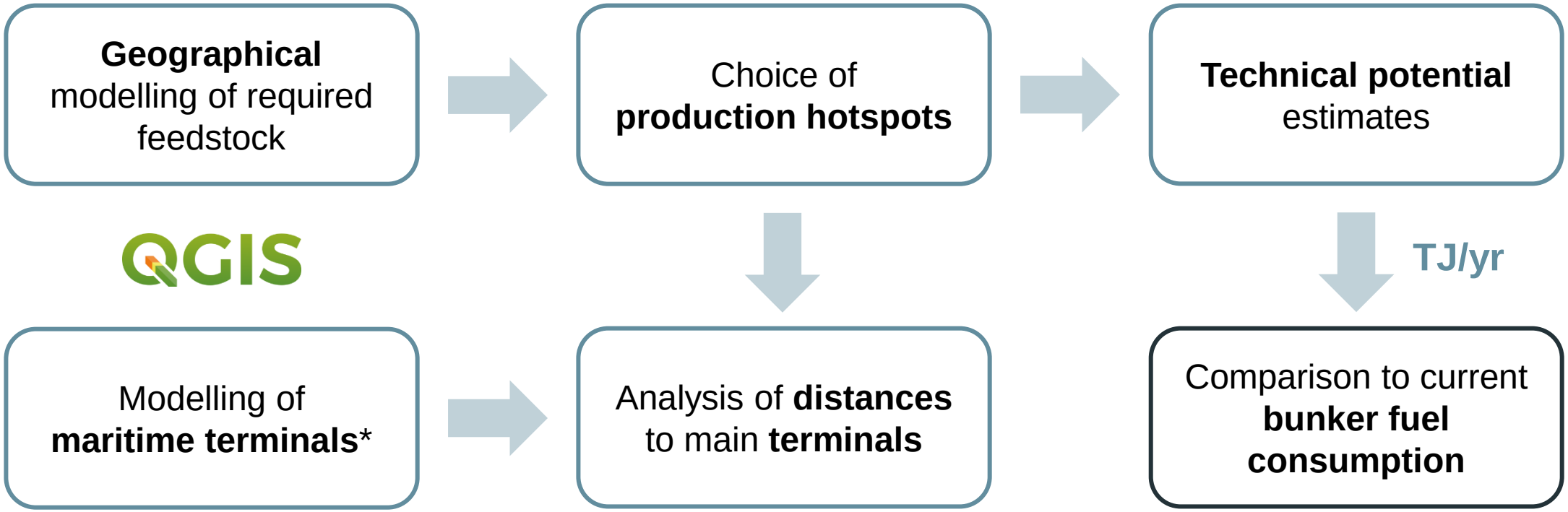
Bio-CH_3OH

- **Rice** straw/husk
- **Soybean** straw
- **Corn** stover
- **Wheat** straw
- **Vinasse**
- Animal **manure**
- **MSW**
- Sewage **sludge**

e-diesel

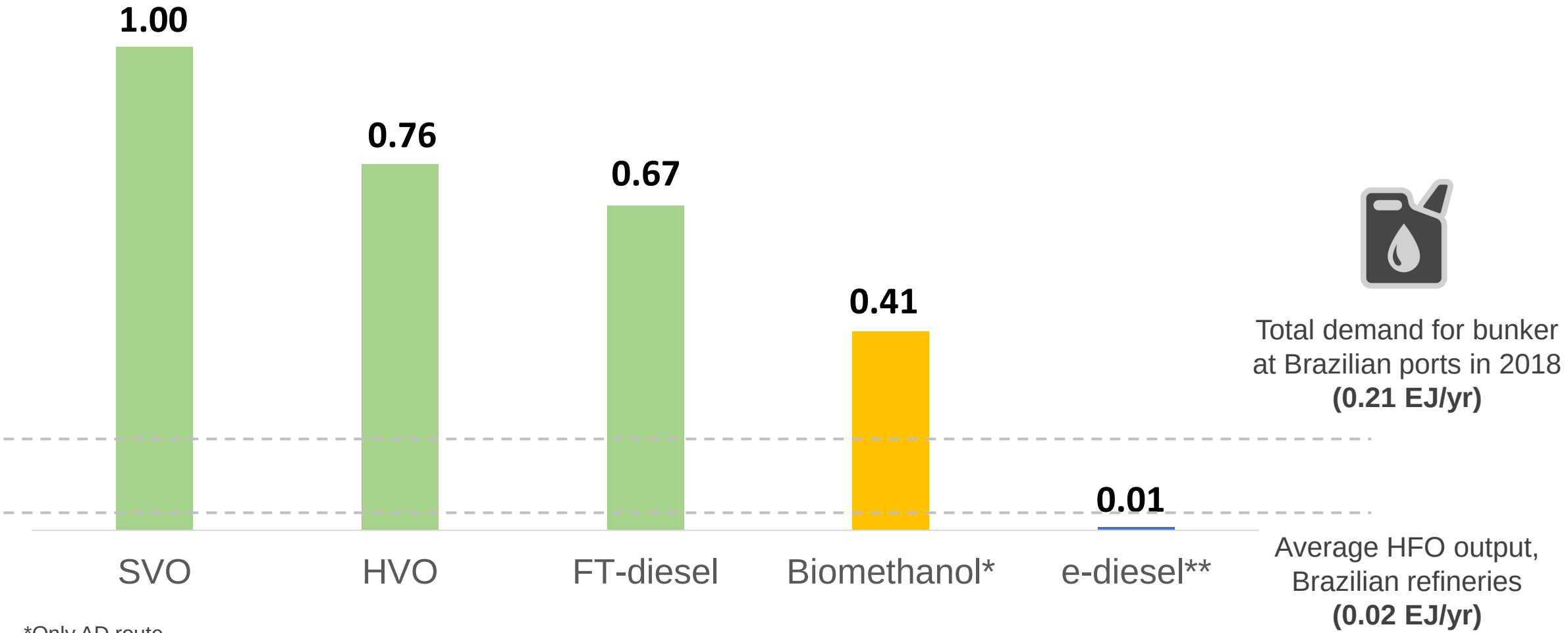
- **Solar** irradiation
- **Water** (H_2O)
- **Sodium** hydroxide
- **Calcium** carbonate
- Natural **gas** (CH_4)
- **Oxygen** (O_2)

6-steps of our GIS modelling analysis



**Santos (SP), Ilha d'Água (RJ), Paranaguá (PR), São Luís/Ponta da Madeira (MA)*

Fuel production potential (EJ/yr) is enough to supply Brazil's bunker demand



*Only AD route
**Only DAC-FV route

SVO and HVO Hotspots underline logistical challenges

PRODUCTION POTENTIAL (TJ/year)

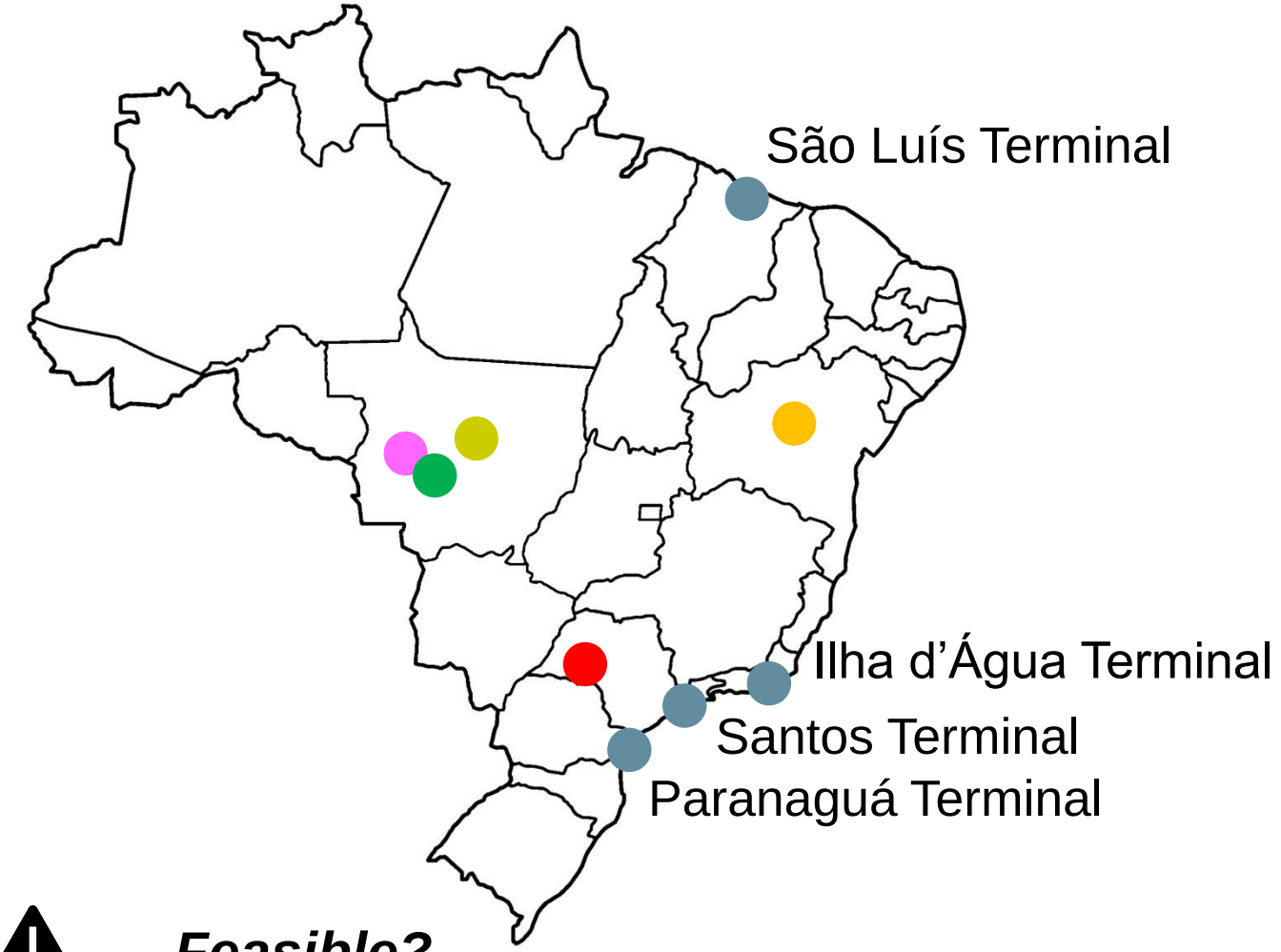
	Terminal	d (km)
● *Soybean*	Santos	1,467
● *Corn*	Santos	1,466
● *Cotton*	Paranaguá	1,592
● *Peanut*	Paranaguá	401
● *Sunflower*	Paranaguá	1,521
● *Mammon*	São Luís	930

Total SVO ***12,900*** *TJ/yr*

Total HVO ***9,800*** *TJ/yr*

Fuel oil* ***24,900*** *TJ/yr*

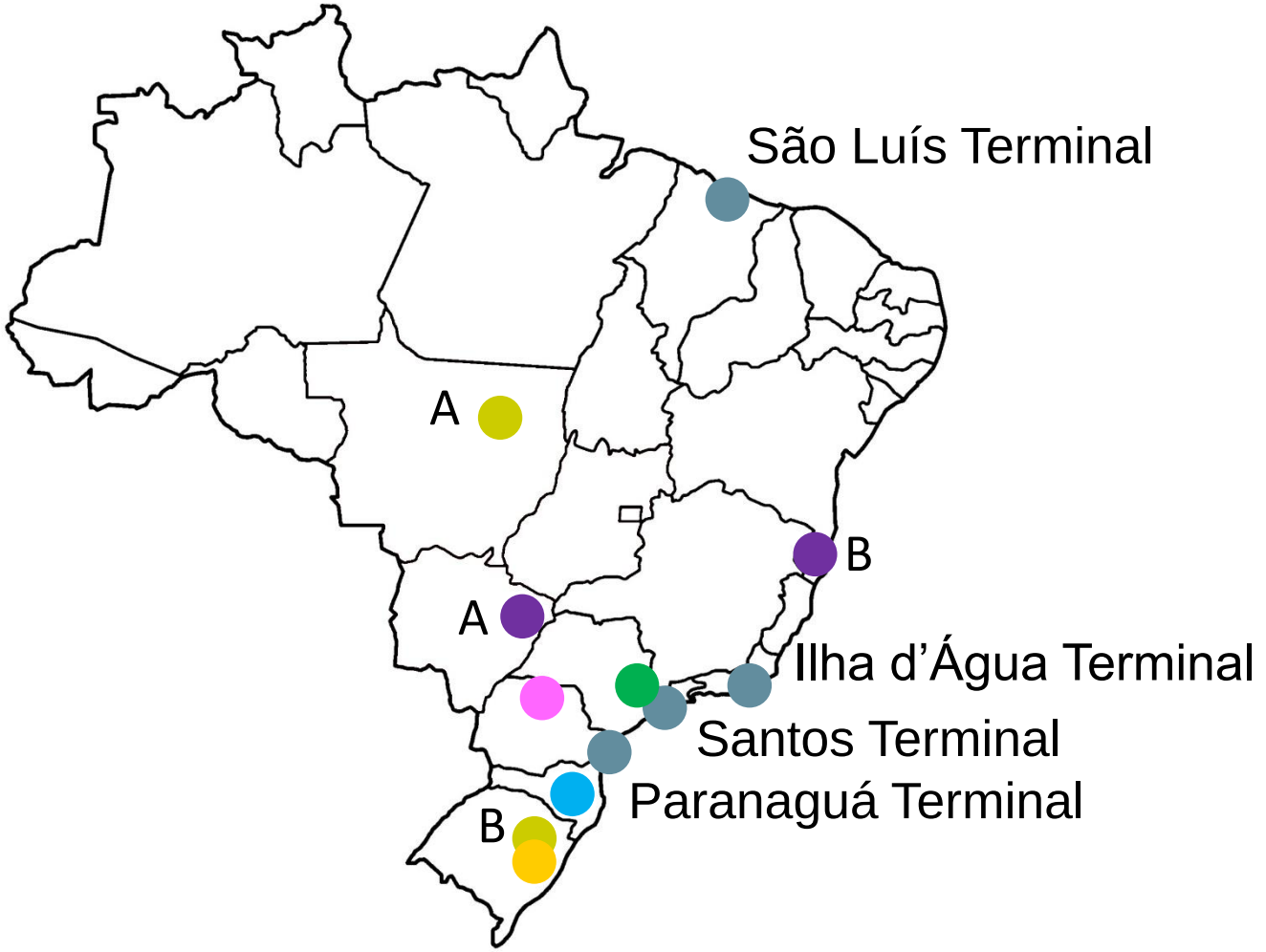
*Average fuel oil production in a Brazilian oil refinery



⚠ ***Feasible?***

FT-diesel hotspots in south and southeast regions are close to terminals

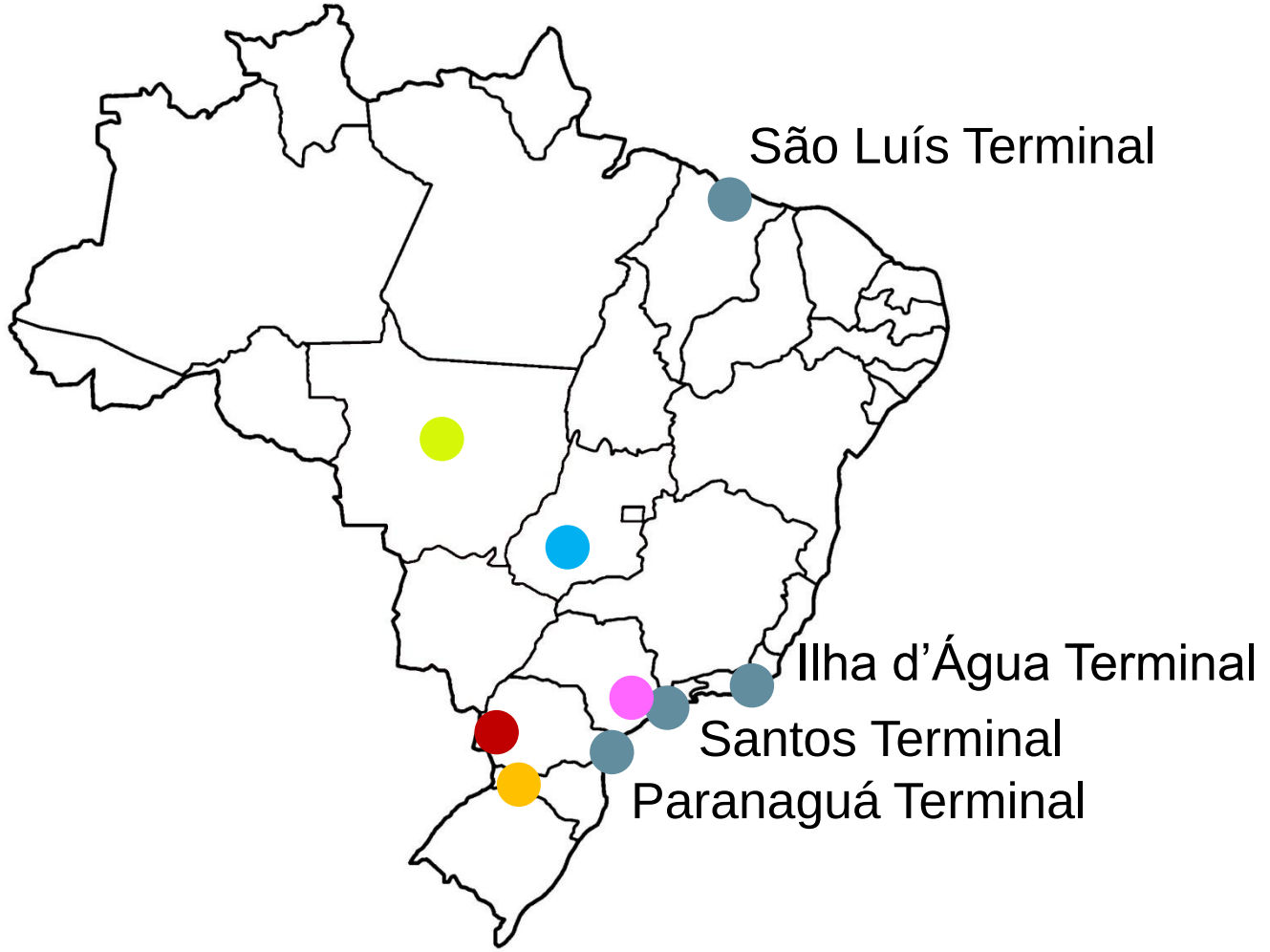
	Terminal	d (km)
Sugarcane	Santos	151
Soybean A	São Luís	1,352
Soybean B	Paranaguá	474
Corn	São Luís	1,346
Wheat	Paranaguá	413
Eucalyptus A	Paranaguá	636
Eucalyptus B	Ilha d'Água	611
Pinus	Paranaguá	265
Forest Extraction	Paranaguá	505



Bio-methanol hotspots in south and southeast regions are close to terminals

	Terminal	d (km)
● *Hotspot PR*	Paranaguá	530
● *Hotspot GO*	Santos	860
● *Hotspot MT*	Santos	1,590
● *Hotspot SC*	Paranaguá	440
● *Hotspot SP*	Santos	51

Only MSW and sewage sludge



Electrodiesel Hotspots

PRODUCTION POTENTIAL (TJ/year)

- *Hotspot SP* 2,400
- *Hotspot BA* 2,270
- *Hotspot AL* 1,920

Total e-diesel **6,600** *TJ/yr*

Fuel oil* ***24,900*** *TJ/yr*

Hotspots → Proximity to chlorine/caustic soda plants

15 tonnes of NaOH per TJ

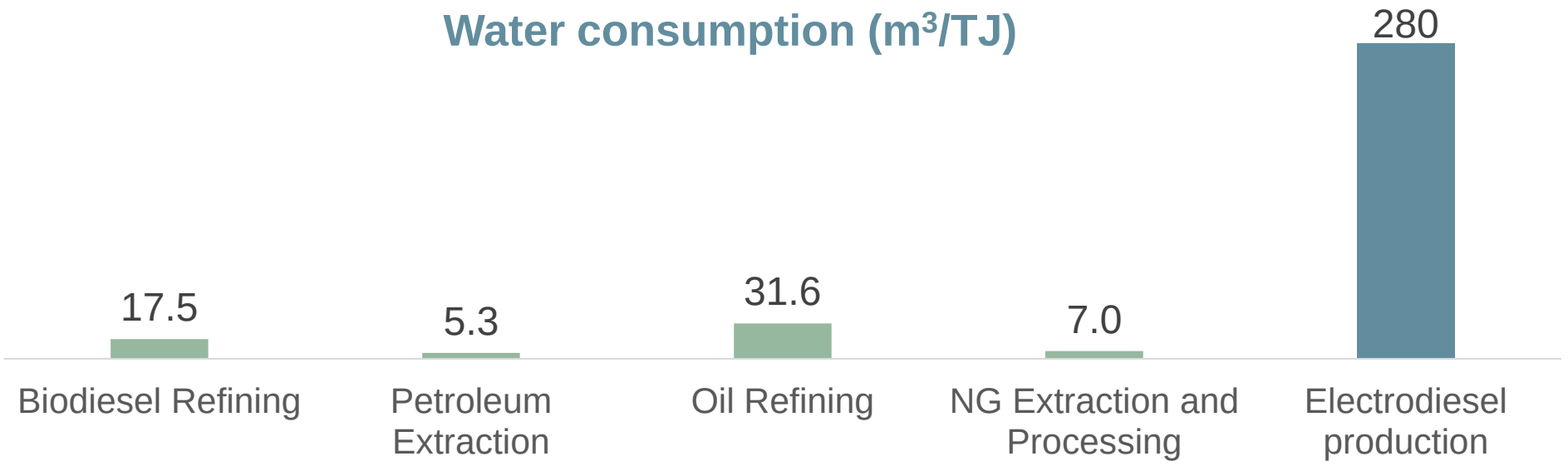
*Average fuel oil production in a Brazilian oil refinery

Electrodiesel Hotspots are close to terminals

	Terminal	d (km)
● *Hotspot SP*	Paranaguá	475
	Santos	20
	Ilha d'Água	495
● *Hotspot BA*	São Luís	1,560
● *Hotspot AL*	São Luís	1,615

But electrodiesel production demands too much water…

Water demand | **≈ 1,800 m^3/day** | **≈ 280 m^3/TJ**



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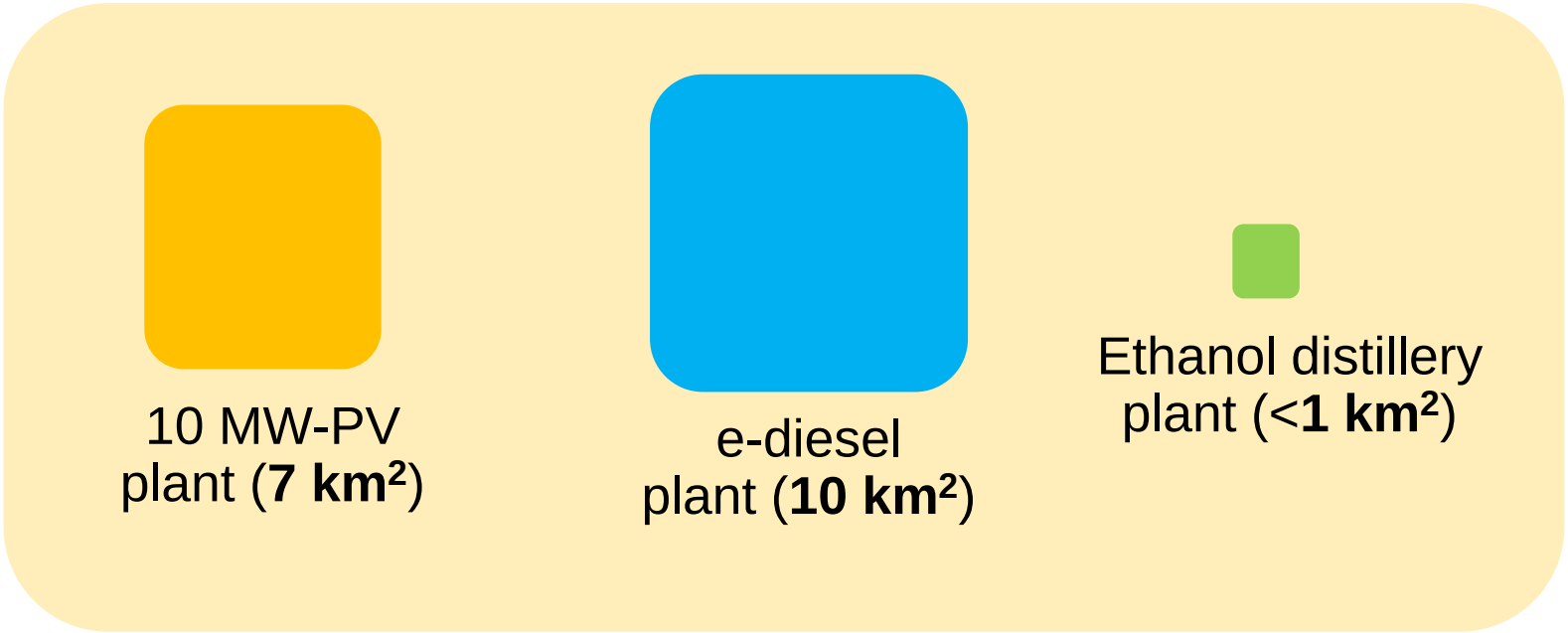
… and land.

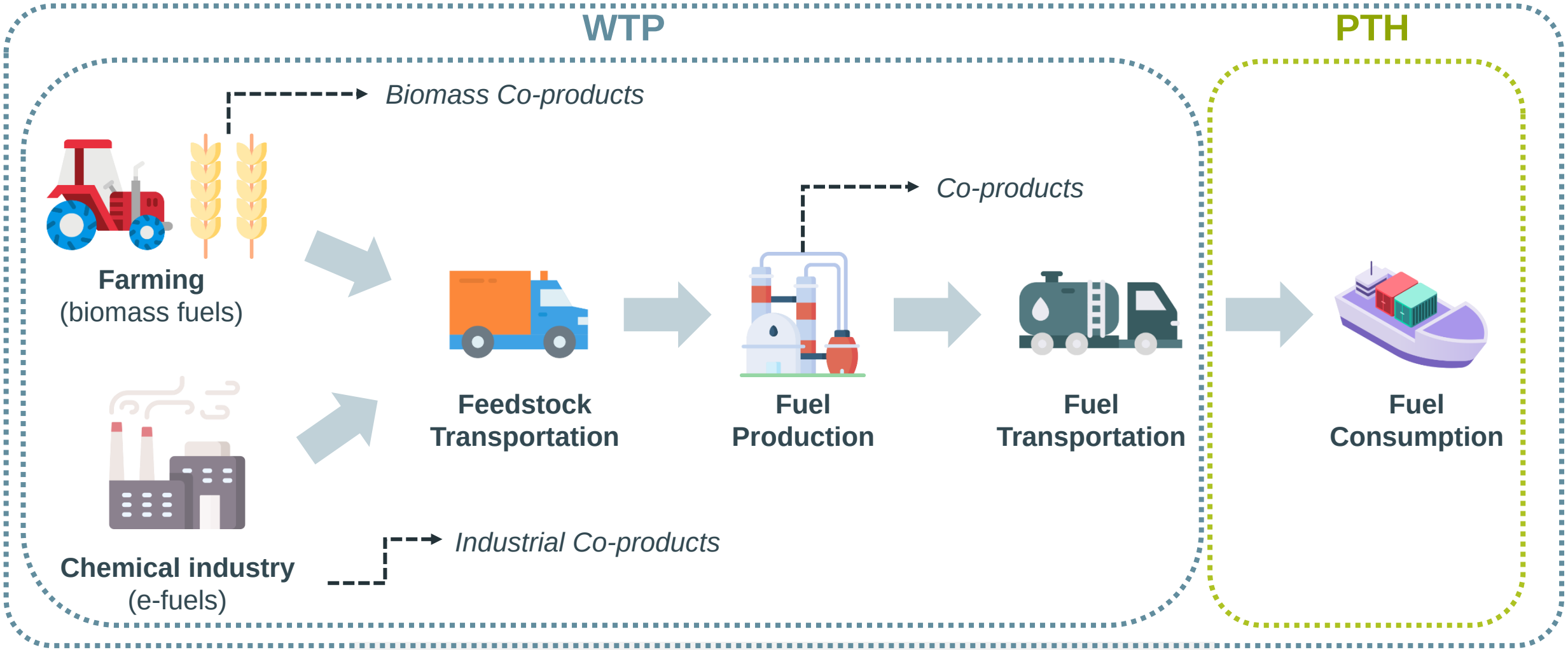
Required area	≈ 10 km²	≈ 4300 m²/(TJ/year)



100 MW-PV power plant (**70 km²**)

To sum it up: Brazil’s technical potential to produce renewable-based fuels is significant, but we put a caveat on several logistic challenges.

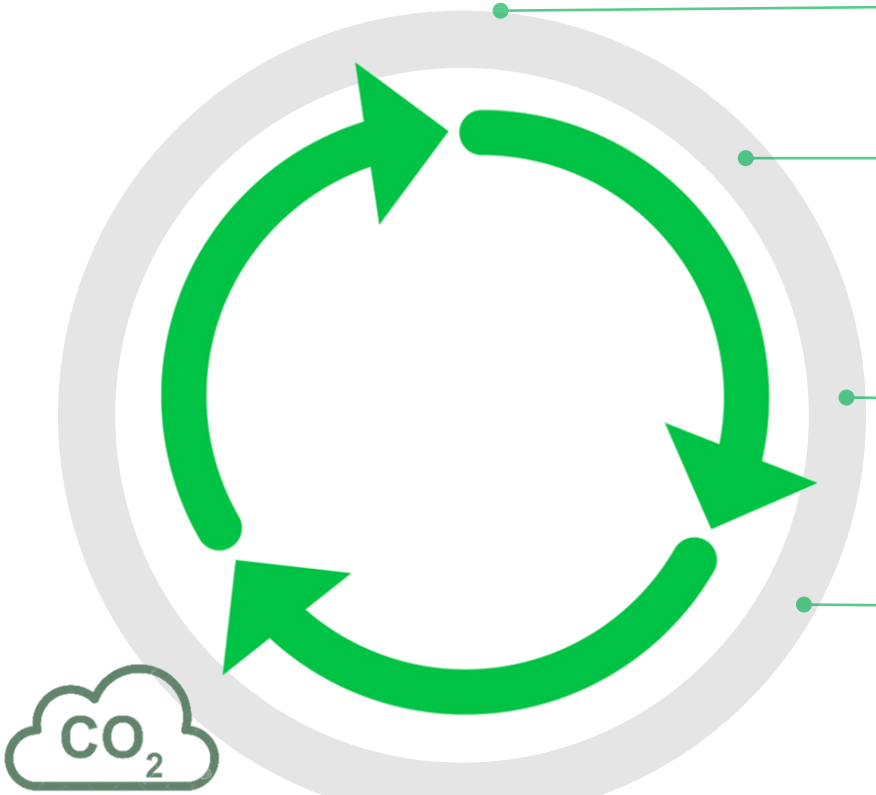
Life Cycle Assessment (LCA)



WTP (*Well-to-Pump*) + PTH (*Pump-to-Hull*) = WTH (*Well-to-Hull*)

WTH

LCA assumptions



Functional energy unit: MJ

GHG emissions – GWP_{100}

CO_2 (**1**), N_2O **(265)**, CH_4 **(28)**

Transport distances:
Georeferenced analysis

Tailored inputs

Electricity generation mix, oil properties, agricultural inputs, farming yields,

2 approaches:

aLCA: ***Attributional*** *– Energy Allocation Method*
cLCA: ***Consequential*** *– Avoided emissions from residue wastes (FT-diesel and Bio-CH_3OH)*

Specific LCA assumptions

SVO → **Soybean oil** (80% of the potential)

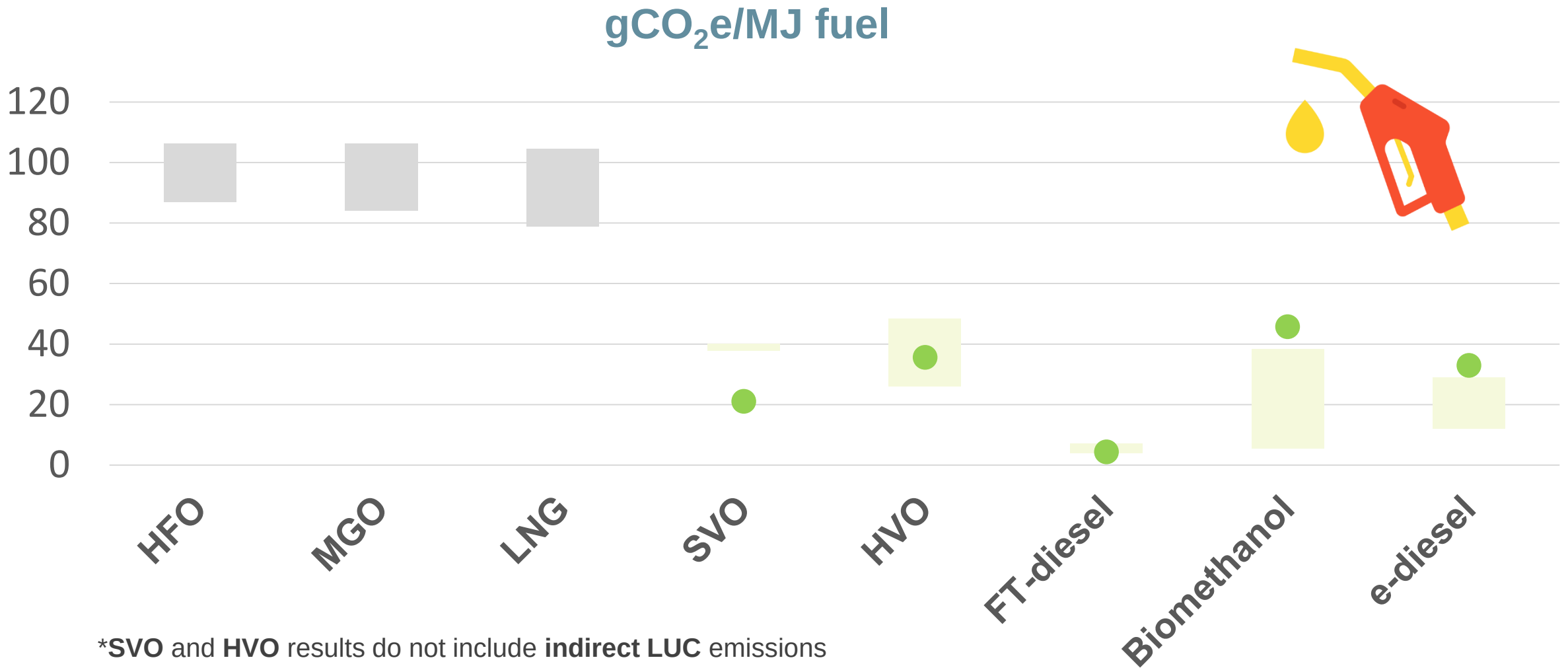
HVO → From **soybean oil,** using **renewable H_2**

FT-d → From a mix of **agricultural residues** and **forest residues**

MetOH → From a mix of **agricultural residues**, **vinasse**, **MSW** and **sewage sludge**

e-diesel → From **renewable-based H_2** and **CO_2** from **DAC**

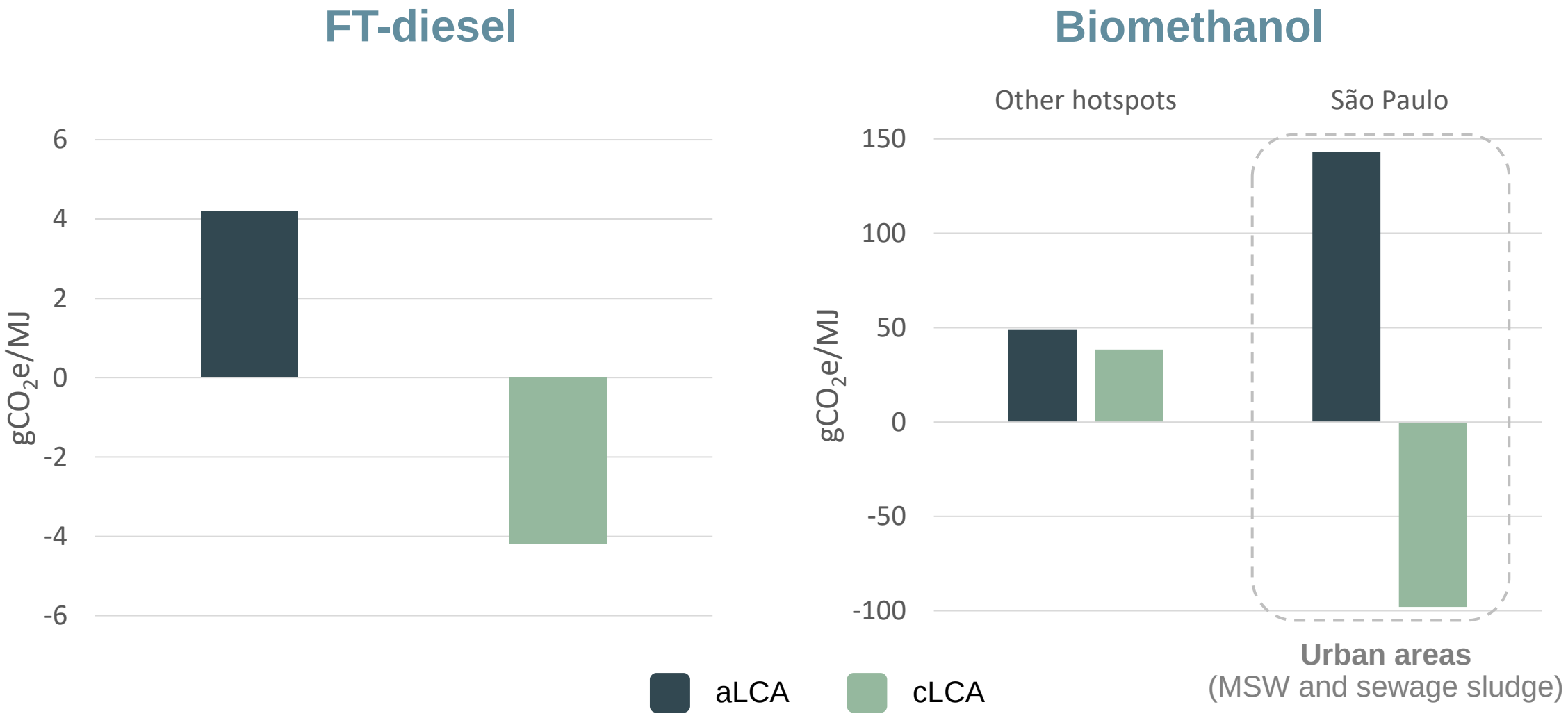
Renewable-based fuels are less carbon intensive than conventional fuels



*__SVO__ and __HVO__ results do not include __indirect LUC__ emissions

Icons: freepik/flaticon

If we consider avoided emissions from wastes, emission savings are even greater



Take away messages

- Brazil has some **advantages** to kick off the production of low-emission alternative fuels for maritime transportation

- Expressive **GHG reduction** in comparison with HFO (between **45** and **85%**)
  - FT-diesel has the best performance regarding sustainability
  - Sustainability concerns associated to SVO/HVO
- **Logistic challenges** associated to the concentration of **hotspots in countryside areas**
- Only 4 terminals evaluated – analysing **other ports** may reduce hotspots distances
- **E-fuels**: high demand for **NaOH**, **area** and **water**

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Thank you for your attention.

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