MAPPING FEEDSTOCK AVAILABILITY FOR THE PRODUCTION OF SUSTAINABLE AVIATION FUELS IN BRAZIL

SUGARCANE RESIDUES

RSB

AGROICONE

TEAM

AGROICONE

Marcelo Moreira
Project Coordination
marcelo@agroicone.com.br

Gabriela Mota
Modeling Expert

Stella Carvalho
GIS Expert

Joaquim Seabra
Scientific advisor

César de Oliveira
GIS Expert

Rafael Capaz
LCA Expert

INDEX

INTRODUCTION

RELEVANCE

AMBITOUS TARGETS

The International Civil Aviation Organization (ICAO) is pursuing the GHG reduction on international flights:

- Improve fleet fuel efficiency by 1.5% per year from 2009 to 2020
- Carbon Neutral Growth from 2020
- Reduction of GHG emissions by 50% in 2050, as compared to 2005

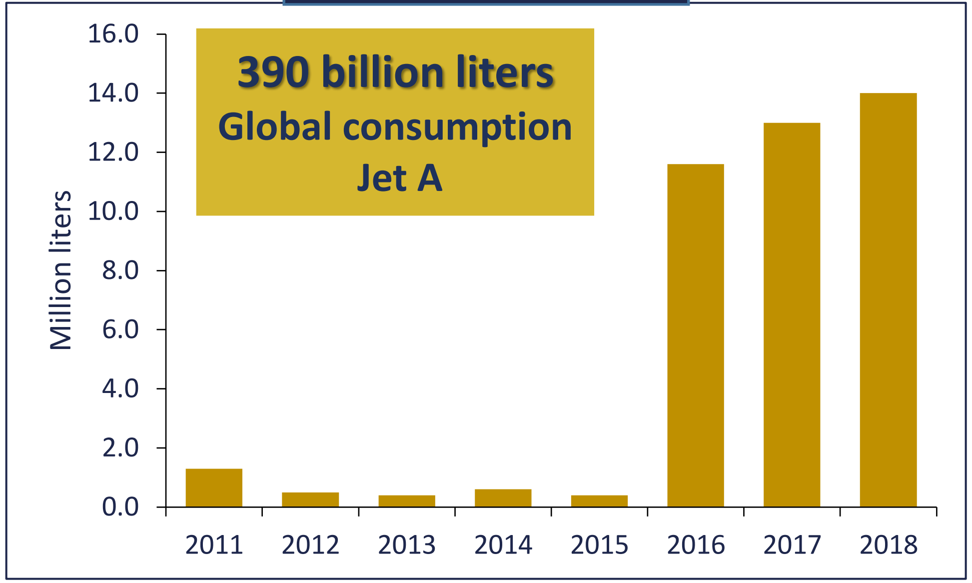
POSSIBLE PATHS

Improvements in the design and engine of aircrafts, or in the operations and infrastructure of aviation could help to achieve these targets. But they are limited.

SAF

Among the options, the substitution of fossil fuels by Sustainable Aviation Fuels (SAF) is considered the only one with the potential to achieve significant GHG reductions in the short-term.

SAF PRODUCTION



Source: ICAO (2020)

SAF must provide a reduction of, at least, <u>10% in GHG emissions</u> when compared to fossil kerosene (on a life cycle basis), and must not have been obtained from <u>high-carbon areas</u> since 2008 (ICAO, 2019)

Thus, residual feedstocks are strategic options for significant GHG reductions, which will likely lead to low costs for SAF production.

GENERAL OBJECTIVES

IDENTIFY AND MAP

Identify and map alternative residual feedstocks for SAF production in Brazil, including CO-rich industrial off-gases, beef tallow, used cooking oil, forestry residues, and sugarcane residues (bagasse and straw).

POTENTIAL

Provide information about feedstock availability and potential production of SAF.

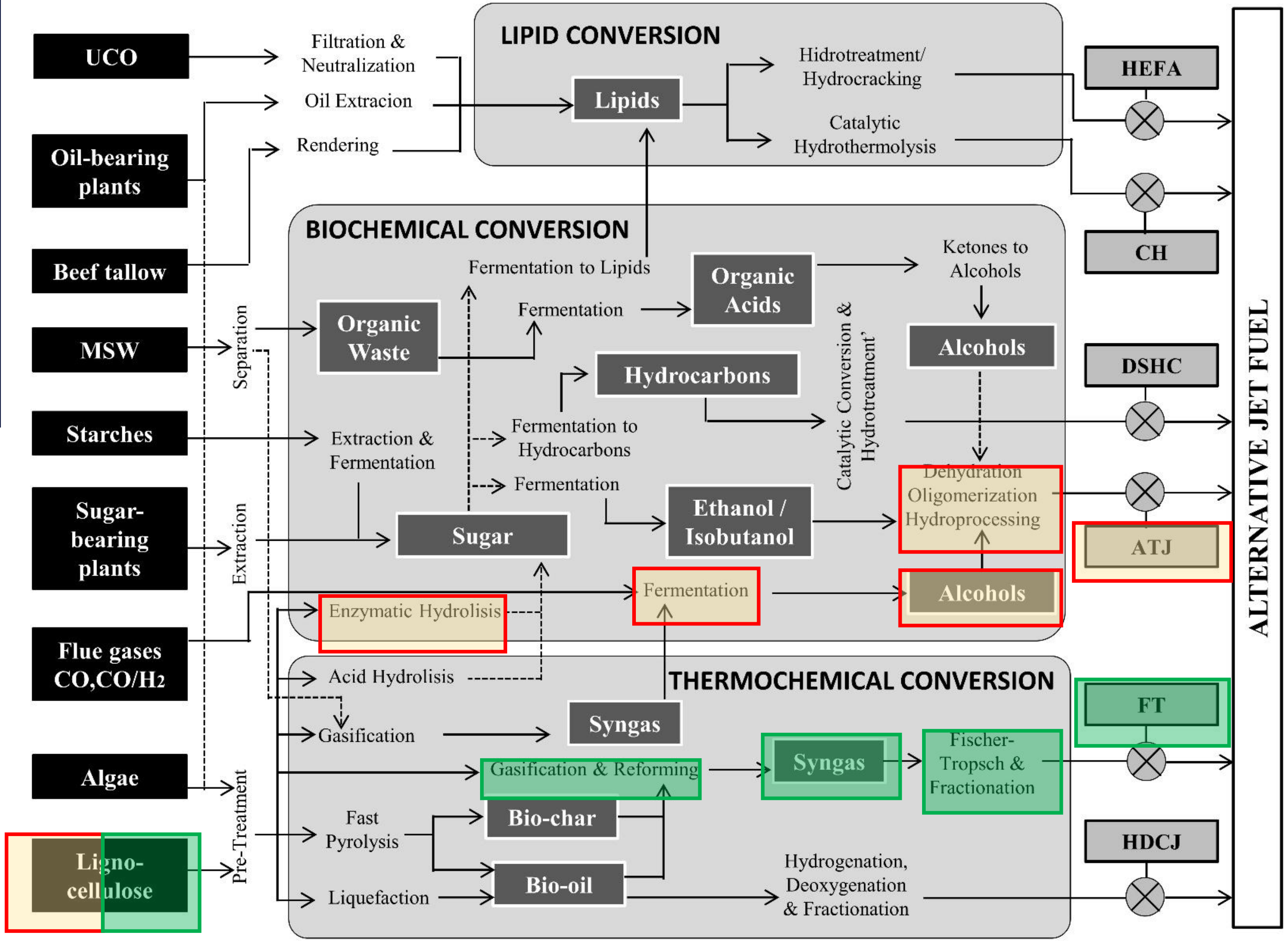
Pathways for SAF production:

Several pathways (feedstock + conversion technology) can be used to produce SAF. Some of them are currently approved or in the pipeline for approval by ASTM. An approved pathway means that the SAF produced is certified as a drop-in fuel and can be use with fossil kerosene within blending limits (v/v).

This case study focusses on lignocellulosic ethanol as a feedstock using ATJ technology, and lignocellulosic material as feedstock using FT technology

Main Pathways for SAF production *

Source: Boeing (2013)



** ASTM recently approved the co-processing of vegetable oils, greases, and Fisher-Tropsch biocrude with fossil middle distillates in oil refineries (maximum blend 5% v/v). Co-processed fuels are not represented in this figure.*

OBJECTIVE OF THIS REPORT

General objective

To map the availability of sugarcane residues for SAF production, with a high level of geographical detail, to enable future studies on investment opportunities and strategies.

Specific objectives:

- Identify the current production and availability of straw and bagasse in Brazil
- List the current applications of straw and bagasse
- Identify locations for feedstock collection and their production capacity
- Identify potential locations for processing industries
- Identify the demand (airports)
- **Develop maps:**
    - Spatializing the availability of straw and bagasse
    - Matching the availability of residues with potential processing locations
    - Matching potential processing locations with the consumption sites
    - Matching all the above with transport infrastructure (pipelines, harbors)

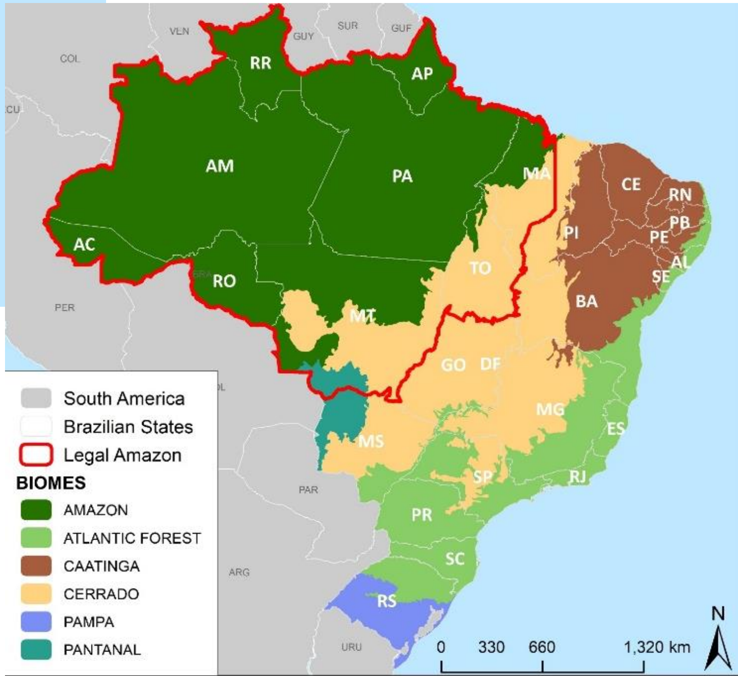
CONTEXT

GEOGRAPHY AND BOUNDARIES OF BRAZIL

The Federal Republic of **Brazil** is a country of continental dimensions, whose territory **covers around 8.5 million km²**.

Politically, **Brazil is divided into 27 federative units**, composed of 26 states and one federal district (where the national capital is located).

These federative units are subdivided into municipalities. The municipalities in the Northern region (in green) have much larger areas than in the Southeast, for example, due to historical and geographical reasons. This fact needs to be considered in order to understand the availability of feedstock, which is spatialized by availability in each municipality.



The second map displays the boundaries of the six Brazilian continental biomes: Amazon, Cerrado (or Brazilian savannah), Caatinga, Atlantic Forest, Pantanal and Pampa.

SUGARCANE RESIDUES

WHAT ARE SUGARCANE RESIDUES?

The main residues from sugarcane processing are washing water, straw, bagasse, boiler ash, filter cake and vinasse.

This study will address the availability of two types of sugarcane residues: **straw and bagasse**. This choice is justified by the fact that the SAF technology (FT and ATJ) requires a feedstock with high concentration of lignocellulose.

Souce Picture: CNPEM

Source Picture: Portal Ambiente Legal

USE OF SUGARCANE RESIDUES

A large part of the waste generated in the industrial processing of sugarcane can be recycled, reused, transformed and incorporated, in order to produce new materials and meet the growing demand for more efficient, economical and sustainable alternative technologies and practices (SAVASTANO JR. & WARDEN, 2003).

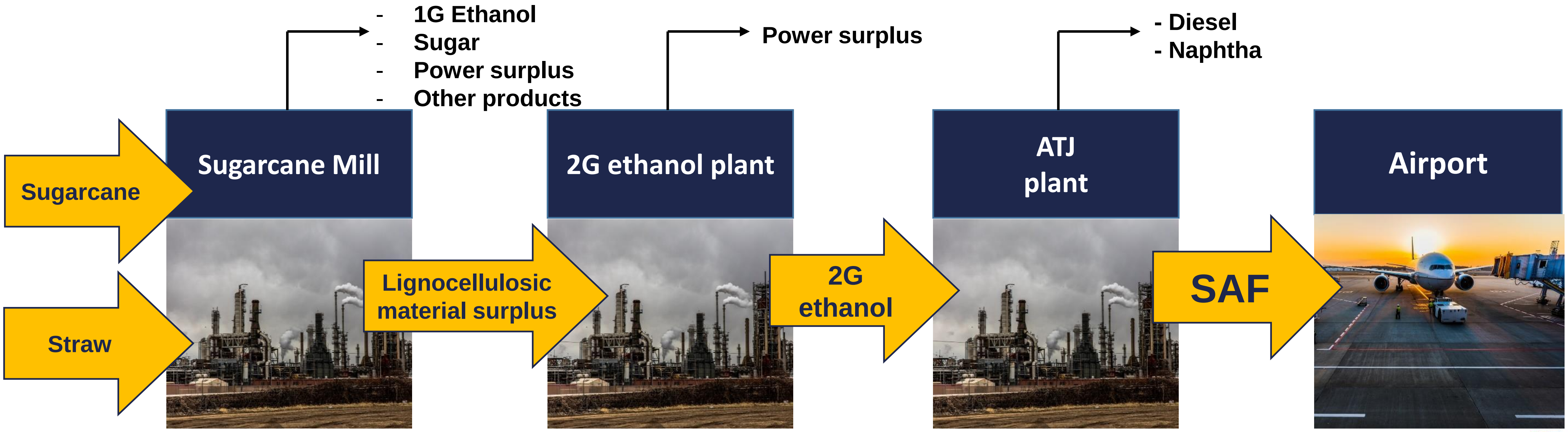
Due to concerns about the sustainability of sugarcane production, practices like harvesting with previous burning have been gradually replaced by mechanized systems. In the Brazilian South-Central region, 96% of the cultivated areas are mechanized, which results in a straw availability of 10-30 t/ha on the field. And although this straw mulching may have advantages for soil protection and yield, it is also a valuable feedstock for bioenergy. Then, considering the characteristics of each region, it is possible to stablish a removal rate that results in a minimal impact for the crop (SUCRE, 2020).

On the other hand, sugarcane bagasse has been commonly used in sugarcane mills in combined heat-power systems, which provide roughly 6% of the power generated in Brazil after guaranteeing the self-supply of the industrial plant (EPE, 2020). Possible competition with current use of sugarcane residues can lead to relevant commercial risks, when allocating this material for SAF production

SUPPLY CHAIN FOR ATJ PATHWAY

In this supply chain we are considering that the sugarcane/ethanol mill, **using the adequate technologies**, would be able to be self-sufficient in terms of energy. It would also be able to produce 1G ethanol, sugar and other products and co-products and still have a surplus of bagasse and straw. In this scenario, the lignocellulosic material from bagasse and straw surplus would be collected at the sugarcane/ethanol mill and would be sent to a 2G ethanol plant. In this plant, which is also considered energetically self-sufficient, the lignocellulosic material would be converted into 2G ethanol.

In turn, the ethanol would be send to a ATJ plant for SAF production. According to the ATJ technology, alcohol molecules are dehydrated, oligomerizeted, and finally hydrogenated to suitable hydrocarbon chains to be used as a drop-in fuel, including SAF. Finally, the SAF would be distributed to consumption sites, considering that the blending of SAF and fossil kerosene (Jet A) would occur at the airport.



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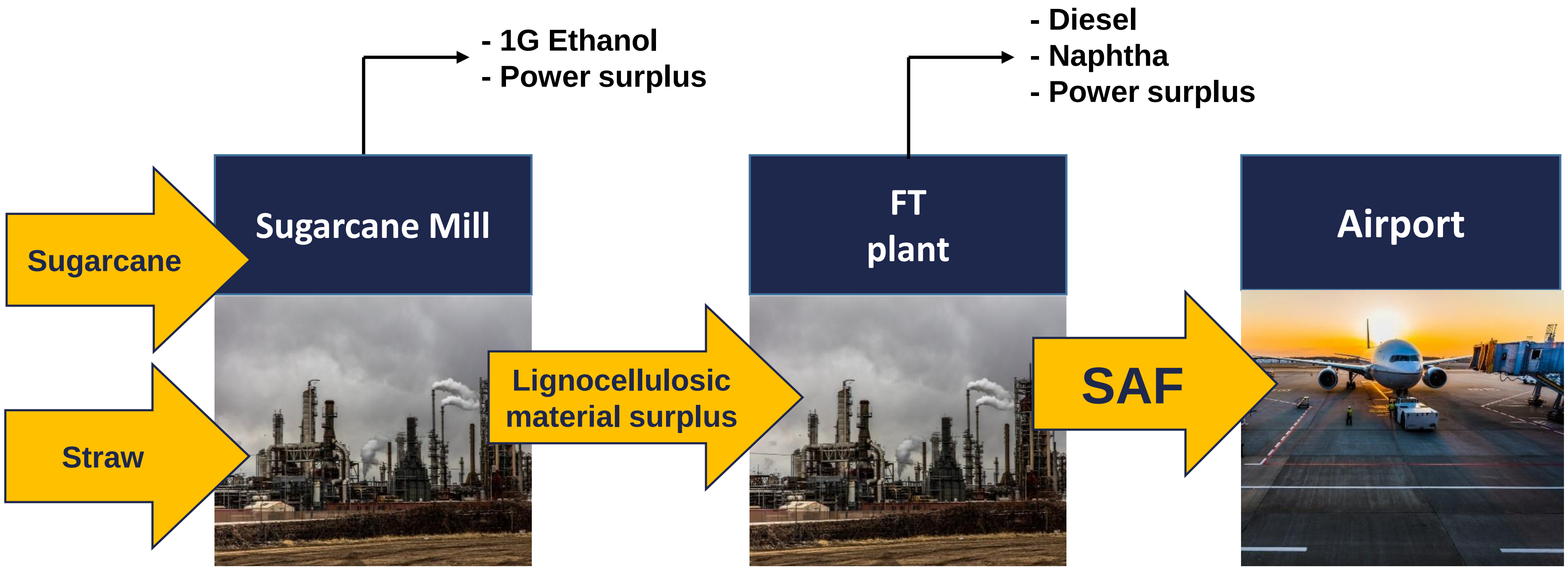
SUPPLY CHAIN FOR FT PATHWAY

Differently from the ATJ pathway, the FT method does not require the conversion of the lignocellulosic material present in the bagasse and in the straw into 2G ethanol. In this process, the bagasse and the straw would be acquired from the sugarcane/ethanol mills considering the same premises described for ATJ. The lignocellulosic material surplus would be sent directly from the sugarcane/ethanol mill to a FT plant.

In the FT plant this material is gasified to syngas. After clean-up process, syngas goes to Fischer-Tropsch reactor, when it is catalytically converted into liquid long-chain hydrocarbons, which are then cracked, isomerized and fractioned into drop-in jet fuel and other products.

Finally, the SAF would be distributed to consumption sites, considering that the blending of SAF and fossil kerosene (Jet A) would occur at the airport.



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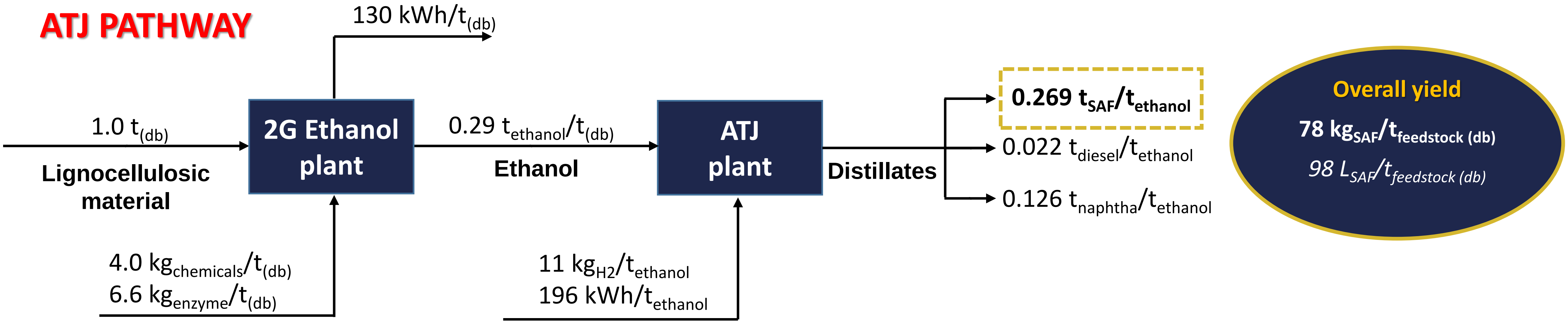
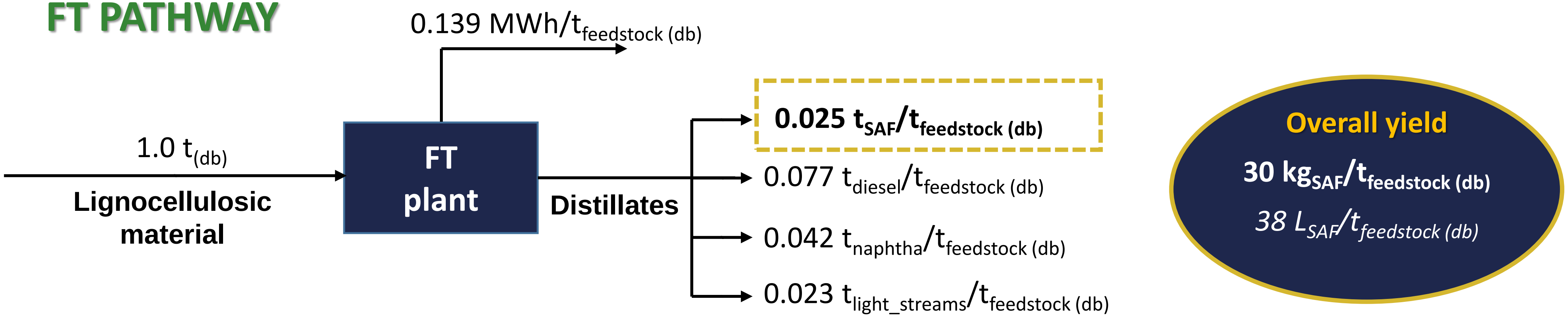
SUPPLY CHAIN: General yields and main inputs

ATJ PATHWAY



FT PATHWAY



Sources: For ATJ pathway, VBS (2019), Bonomi et al. (2016), and Klein et al., (2018). For FT pathway, Jong et al. (2015).

FEEDSTOCK AVAILABILITY

SUGARCANE RESIDUES: HYPOTHESIS AND CONSIDERATIONS

The estimates of the potential availability of **sugarcane residues** were made considering:

The sugarcane enters the sugarcane/ethanol mill, where it will be crushed in order to separate the juice from the bagasse. The juice will be used to produce 1G ethanol, sugar and other products and co-products. The bagasse (rich in lignocellulosic material) is typically burned to heat the boilers and to generate electricity and its availability is directly related to the plant's efficiency. In this project, it is assumed that when using the adequate technology, which is already available on the market, 65% of the bagasse produced by each mill would be enough to meet the plant's energy demand (Cervi, 2015). The remaining 35% would be the surplus amount of residue available for SAF production.

The straw is also a source of lignocellulosic material. When mechanical harvesting is in place, a low quantity of straw, referred to as vegetable impurities, enters the mill with the sugarcane, and a large part remains in the field. There is not a reference number in terms of the adequate amount of straw that should remain in the field. Many studies have been conducted in order to estimate the appropriate amount of straw that should remain in the field according to criteria such as soil type, climate, period of harvest, GHG emissions (CARDOSO, et al 2013; LISBOA, et al 2017). In this case, we are considering that 7,5 t_{straw}/ha (HASSUANI et al, 2015) would be a suitable amount to be left in field in order to meet environmental and agricultural purposes. Therefore, the straw considered as a residue available for SAF production would not impact the sugarcane yield. In terms of logistics, it is considered that the straw would be recovered in the sugarcane/ethanol mill as well.

For the ATJ pathway, the lignocellulosic material has to be converted into 2G ethanol. The Alcohol-to-jet pathway dehydrates the alcohol from the 2G ethanol, which is produced from bagasse and straw, in order to produce SAF based on catalytic steps (Geleynse, et al. 2018).

Differently from the ATJ pathway, the FT method does not require de conversion of the lignocellulosic material present in the bagasse and in the straw to be converted into 2G ethanol. The FT pathway converts the lignocellulosic materials into hydrocarbons by catalysis through a gas-to-liquid technology.

SUGARCANE STRAW

The potential availability of **sugarcane straw** was estimated based on the following data and assumptions:

- Best practices in terms of planting and harvesting were assumed;
- Sugarcane is harvested mechanically without previous burning;[1]
- All **sugarcane yields per municipality** in Brazil, regardless of the final use, such as ethanol, sugar, or other (Source: IBGE/PAM, 2018);
- All **sugarcane planted area per municipality** in Brazil, regardless of the cultivar, harvest type or current use of the sugarcane (Source: IBGE/PAM, 2018);
- Straw production: 140 $kg_{db}/t_{sugarcane}$ (Source: HASSUANI et al, 2005);
- Straw kept on field for agronomic purposes: 7.5 $t_{straw\ (db)}/ha_{sugarcane}$ (Source: HASSUANI et al, 2015).

SCOPE

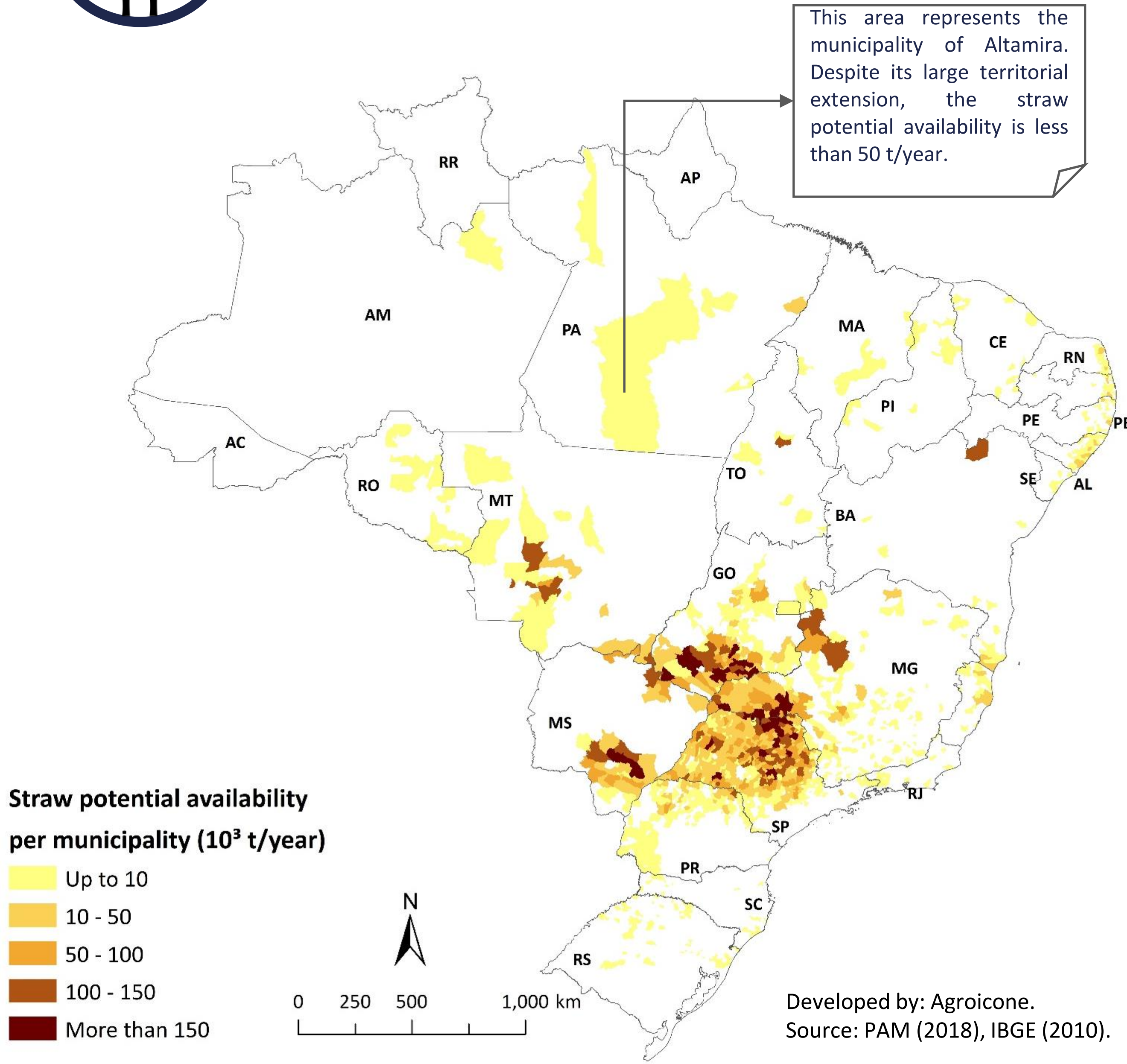
The potential availability of straw was calculated based on data from IBGE/PAM on municipal sugarcane yield and planted area, considering the yields of generation and availability as assumed above[3]. The data were spatialized by municipality, according to the sugarcane planted areas reported by IBGE.

Total straw (t) = Sugarcane yield (t) * 0.14 ($t_{straw(db)}$)

Straw availability (t) = Total straw (t) – [7.5 $t_{straw(db)}$ * Sugarcane planted area (ha)]

[1] It is also possible to harvest sugarcane manually without burning, but it might impact working conditions and the harvesting efficiency is very low.
[2] The figures above were also compared to recommendations from a recently published project focused on sugarcane straw (SUCRE) and deemed reasonable. Whenever the total amount of straw per municipality was negative (bellow the amount that should remain in the field), we considered that all the straw would stay in the field and nothing would be collected from this municipality.

POTENTIAL AVAILABILITY OF STRAW



Developed by: Agroicone.
Source: PAM (2018), IBGE (2010).

Potential availability of straw in Brazil is around

30 10^6 $t_{(db)}$

States	Straw Availability 10^6 t (db)
SP	18.99
GO	3.22
MG	3.12
MS	1.90
PR	1.10
MT	0.73
BA	0.18
AL	0.18
TO	0.14
PE	0.07
RN	0.06
PB	0.05
ES	0.03
PA	0.03
MA	0.02
PI	0.01
SE	0.01
AM	0.01
RS	0.01
CE	0.00
RJ	0.00
SC	0.00
RO	0.00
DF	0.00
Total	**29.86**

As expected, the straw potential availability in Brazil is mostly located at the Central-South, which is responsible by more than 90% of the national sugarcane production. **SP State** would be responsible by **63%** of the whole potential.

SUGARCANE BAGASSE

The potential availability of **sugarcane bagasse** was estimated considering:

- The best practices and technologies in terms of sugarcane and ethanol processing, such as reduction of steam demand and improvements in cogenerations system;
- **Amount of sugarcane effectively processed** in sugarcane/ethanol mills in Brazil in 2018 per State (Source: UNICA[1], 2018);
- Milling capacities of Brazilian sugarcane/ethanol plants (NovaCana[2] database, 2020)
- Data from 70 ethanol mills certified until July of 2020, out of a total of 195 certified by the RenovaBio[3] program , in order to calibrate the results related to **milling capacities**;
- Bagasse production from sugarcane processing: 280 $kg_{bagasse\ (wb)}/t_{sugarcane}$ (on wet basis, 50% of moisture);
- Bagasse surplus : 35% of the bagasse from sugarcane processing would be available for other uses, while the remaining amount (65%) would supply the energy demand of the sugarcane mill (Source: Cervi, 2020).

SCOPE

The potential availability of bagasse was calculated based on milling data per State from UNICA (Brazilian Sugarcane Industry Association), considering the yields and availability mentioned above. These data were spatialized based on the milling capacity from the Nova Cana[2] database of sugarcane mills in Brazil. The milling data from 70 plants certified before July 16th of 2020 by RenovaBio were also used, in order to calibrate the distribution of bagasse based on idle rates, allowing a more accurate distribution per municipality.

$$\text{Total bagasse } (t_{db}) = \text{Sugarcane processed (t)} * 0.28\ (t_{bagasse\ (wb)}) * 0.5$$

$$\text{Bagasse availability } (t_{(db)}) = \text{Total bagasse } (t_{db}) * 0.35$$

[1] UNICA is the entity that represents the main production units of sugar, ethanol (fuel alcohol) and bioelectricity in the South-Central region of Brazil, mainly in the State of São Paulo.
[2] NovaCana it's the world's largest website about the sugarcane industry.
[3] RenovaBio is a Brazilian program that establishes national decarbonization targets for the fuel sector by increasing the participation of biofuels in the transportation sector.

POTENTIAL AVAILABILITY OF BAGASSE

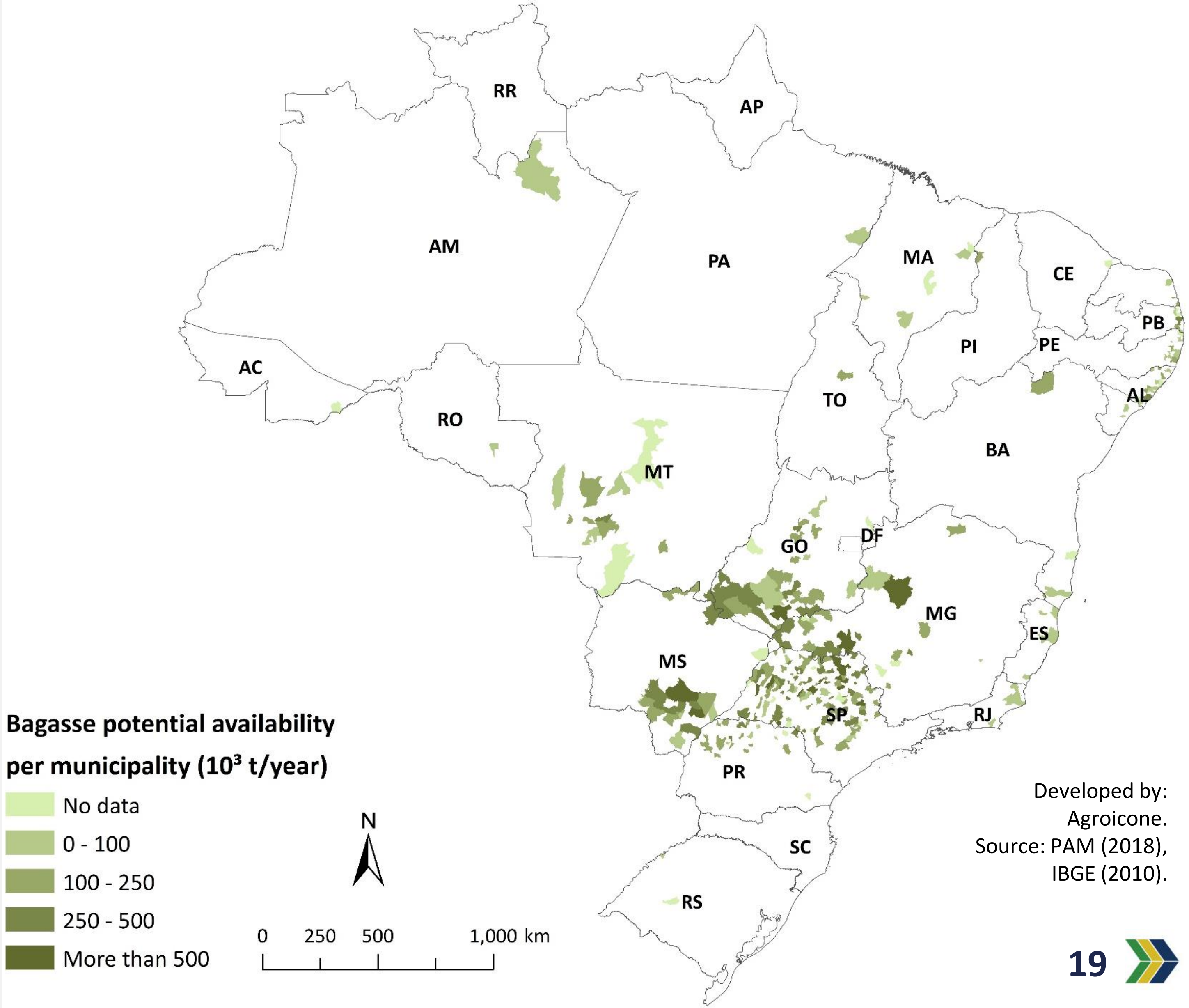
States	Bagasse 10^6 t (db)
SP	17.50
GO	3.46
MG	3.18
MS	2.30
PR	1.82
MT	0.79
AL	0.67
PE	0.53
PB	0.29
BA	0.17
RN	0.12
ES	0.12
MA	0.11
TO	0.10
SE	0.08
PI	0.06
RJ	0.05
PA	0.05
AM	0.01
RO	0.00
RS	0.00
AC	0.00
CE	0.00
Total	**31.43**

Bagasse potential availability in Brazil is of around

$31 \; 10^6 \; t_{(db)}$

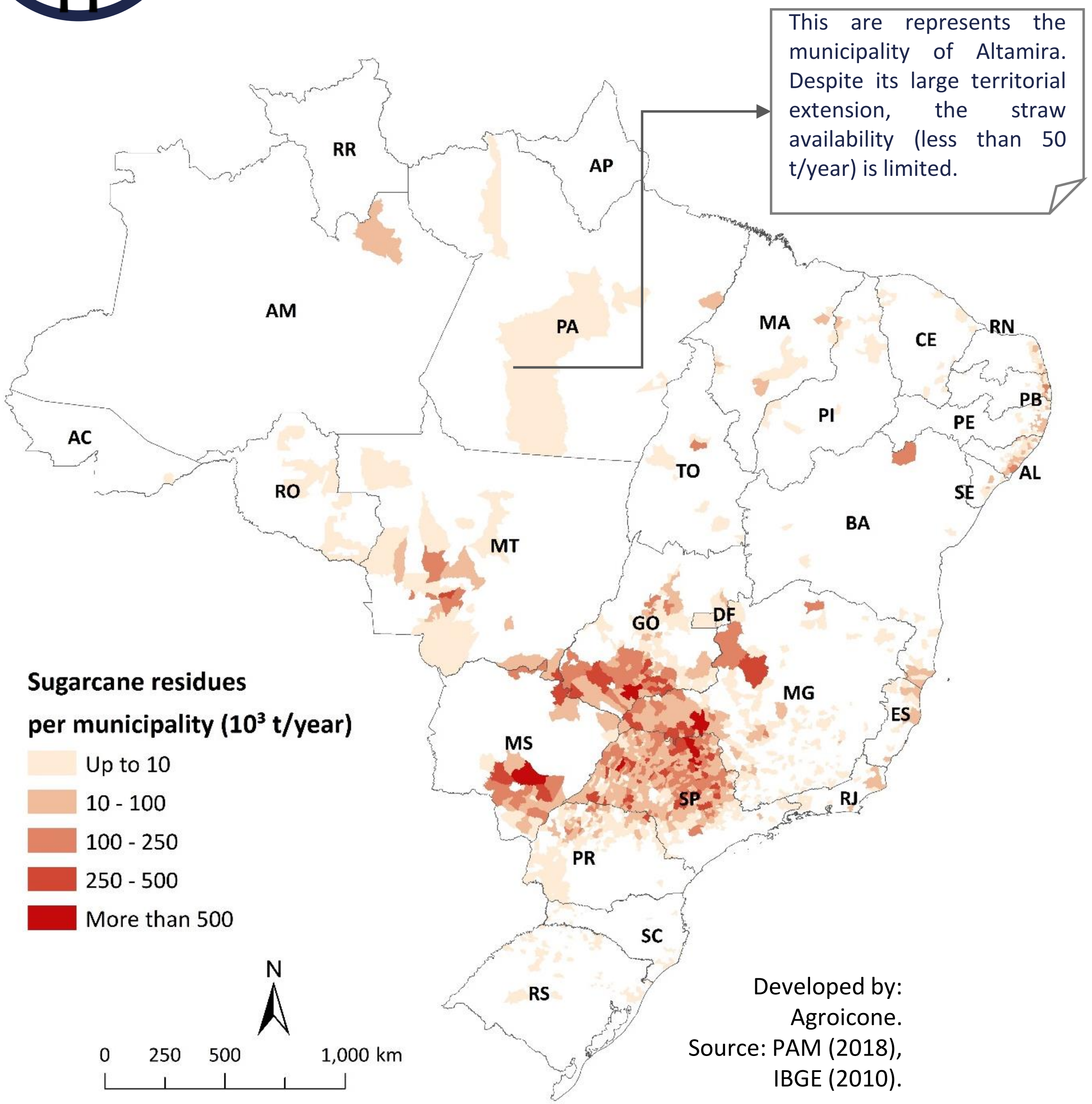
The high concentration of sugarcane mills in the Central-South region is related to a high potential availability of bagasse. The SP State corresponds to more than 50% of the total values.

However, as previously mentioned, the availability of bagasse surplus depends on the industry efficiency gains. Considering the high technological level in this region, it is reasonable to expect that the potential bagasse surplus would come from the mills located in this area.



Developed by: Agroicone.
Source: PAM (2018), IBGE (2010).

POTENTIAL AVAILABILITY OF SUGARCANE RESIDUES (STRAW + BAGASSE)



Developed by: Agroicone.
Source: PAM (2018), IBGE (2010).

Availability of sugarcane residues in Brazil is of around

61 10^6 t$_{(db)}$

The South-Central region is responsible for most of the Brazilian sugarcane production and processing. It also has a high technological level regarding agricultural practices and industrial processes.

Therefore, it is not a surprise that the five States (**SP, GO, MG, MS, and PR**) located in these regions correspond to **more than 90%** of the total potential availability of sugarcane residues in Brazil.

State	Sugarcane Residues 10^6 t (db)
SP	36.49
GO	6.68
MG	6.30
MS	4.20
PR	2.92
MT	1.52
AL	0.85
PE	0.60
BA	0.36
PB	0.34
TO	0.24
RN	0.18
ES	0.15
MA	0.13
SE	0.09
PA	0.08
PI	0.07
RJ	0.05
AM	0.02
RS	0.01
RO	0.01
CE	0.00
SC	0.00
DF	0.00
AC	0.00
Total	61.29

MATCHING FEEDSTOCK AVAILABILITY WITH PROCESSING SITES AND DEMAND

GENERAL ASSUMPTIONS

Regarding the SAF production from sugarcane residues, the spatially explicit data of feedstock availability was combined with possible processing sites and consumers according to the following assumptions:

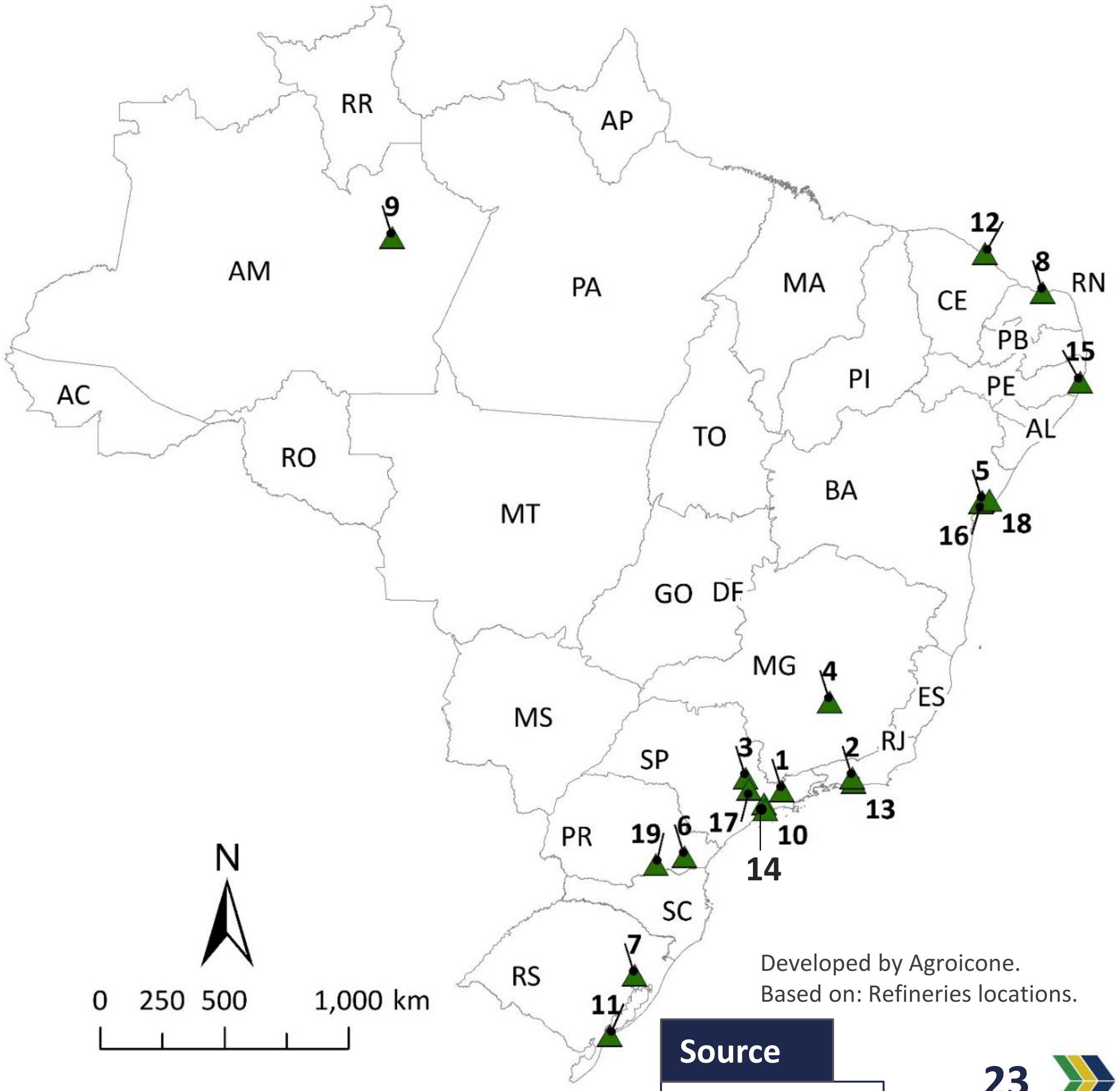
- The sugarcane residues would be collected from the sugarcane mills;
- The 2G ethanol plants, which are an intermediary stage in the ATJ pathway, could be placed close to a sugarcane mill (or even integrated to it) due to the possible advantages of logistic costs or process integration.
- The FT plants should be close to the sugarcane mills with high feedstock availability, reducing the relative capital expenses for building the industrial plants and the transportation costs.
- ATJ plant, where ethanol is converted into SAF, should be close to an oil refinery due to hydrogen demand and process integration possibilities.
- Alternatively, ATJ plants may be located near natural gas pipelines for possible hydrogen production through Steam Methane Reform.
- Before to supply an aircraft, SAF must be blended with Jet A.
- Considering that GHG reduction targets are related to international flights, only the international airports' supply was considered here.

OIL REFINERIES

According to ANP (2019), the map present the of the Brazilian oil refineries.

The refineries that had no production of Jet A were not considered for the following evaluations.

ID	Brazilian Refineries	Jet A Production 2018 (Million m³)
1	Revap (SP)	1.93
2	Reduc (RJ)	1.43
3	Replan (SP)	1.13
4	Regap (MG)	0.71
5	Rlam (BA)	0.36
6	Repar (PR)	0.27
7	Refap (RS)	0.21
8	RPCC (RN)	0.20
9	Reman (AM)	0.13
10	RPBC (SP)	0.02
11	Riograndense (RS)	0
12	Lubnor (CE)	0
13	Manguinhos (RJ)	0
14	Recap (SP)	0
15	Rnest (PE)	0
16	Fasf (BA)	0
17	Univen (SP)	0
18	Dax Oil (BA)	0
19	Six (PR)	0

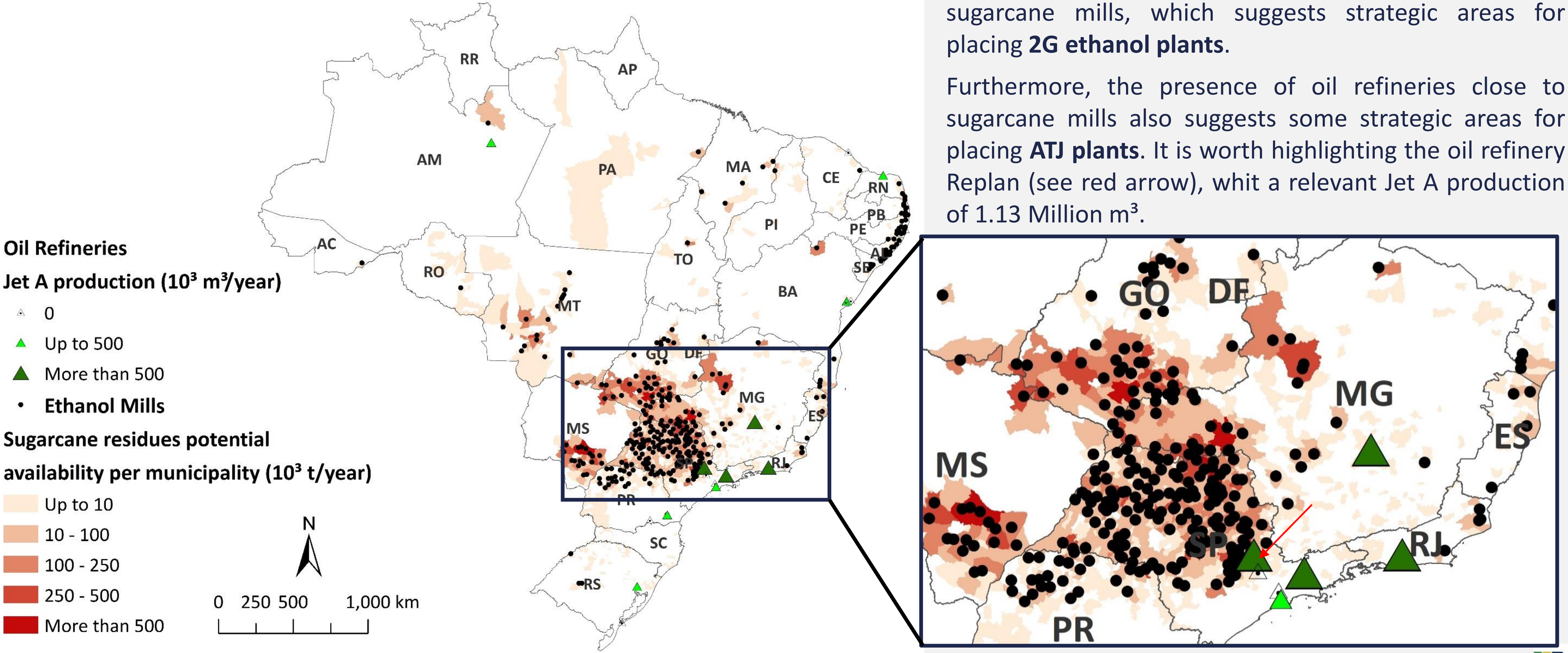


Source
ANP (2019)

MATCHING FEEDSTOCK AND PROCESSING SITES – ATJ PATHWAY

In South-Central region, mainly in **SP State**, there is a relevant feedstock availability combined with several sugarcane mills, which suggests strategic areas for placing **2G ethanol plants**.

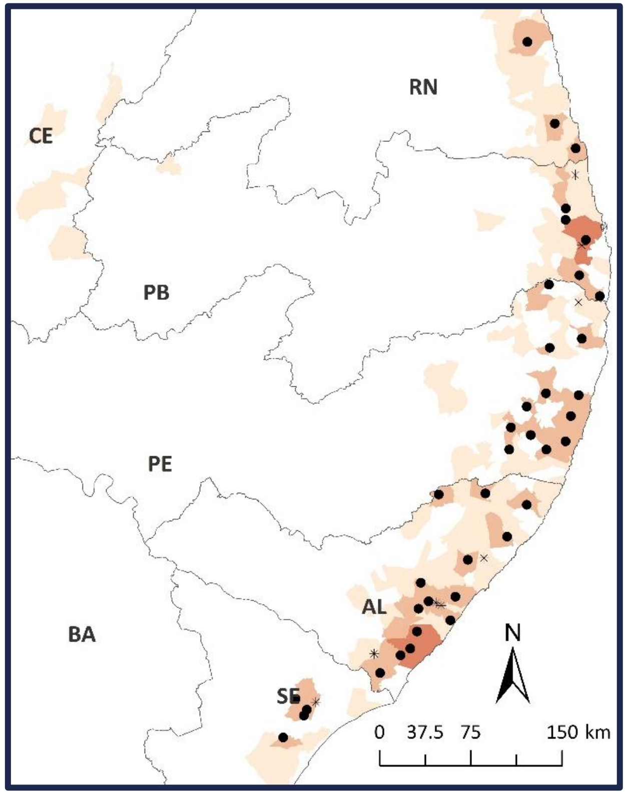
Furthermore, the presence of oil refineries close to sugarcane mills also suggests some strategic areas for placing **ATJ plants**. It is worth highlighting the oil refinery Replan (see red arrow), whit a relevant Jet A production of 1.13 Million m³.

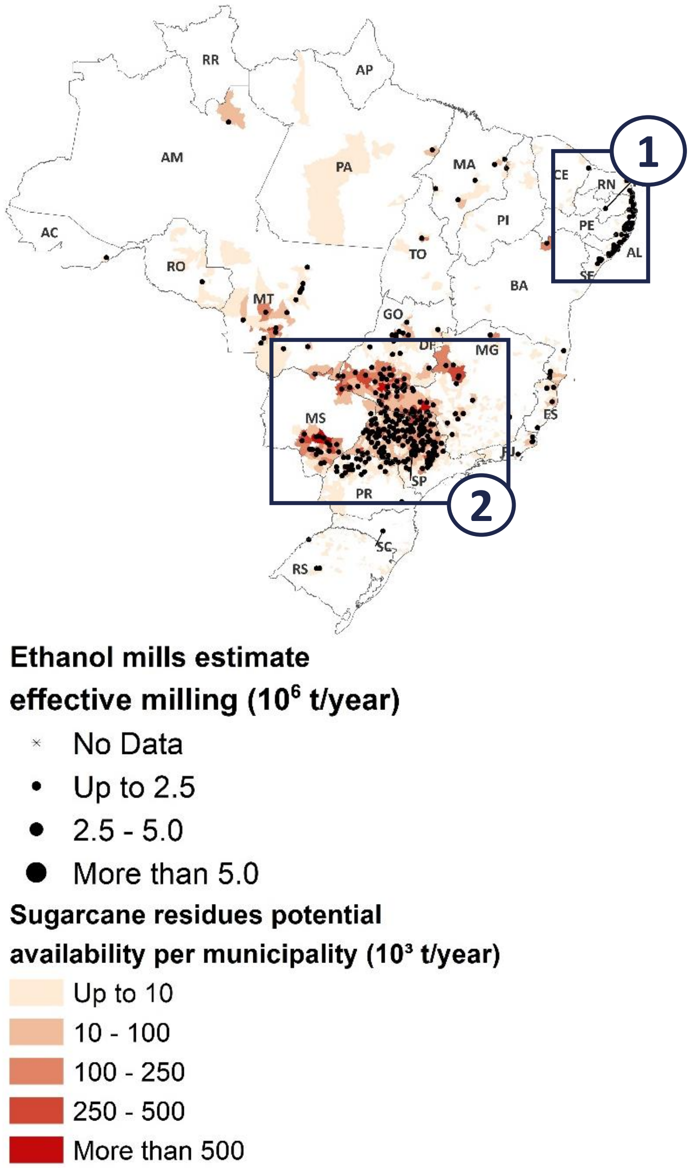


MATCHING FEEDSTOCK AND PROCESSING SITES – FT PATHWAY

As mentioned previously, FT plants should be installed close to feedstock collection sites, decreasing the logistics costs. Furthermore, the feasibility of FT technology is highly influenced by capital expenses, implying that the production scale is a important issue to be considered. Then, South-Central region present strategic areas for placing FT plants.

1 NORTHEAST REGION

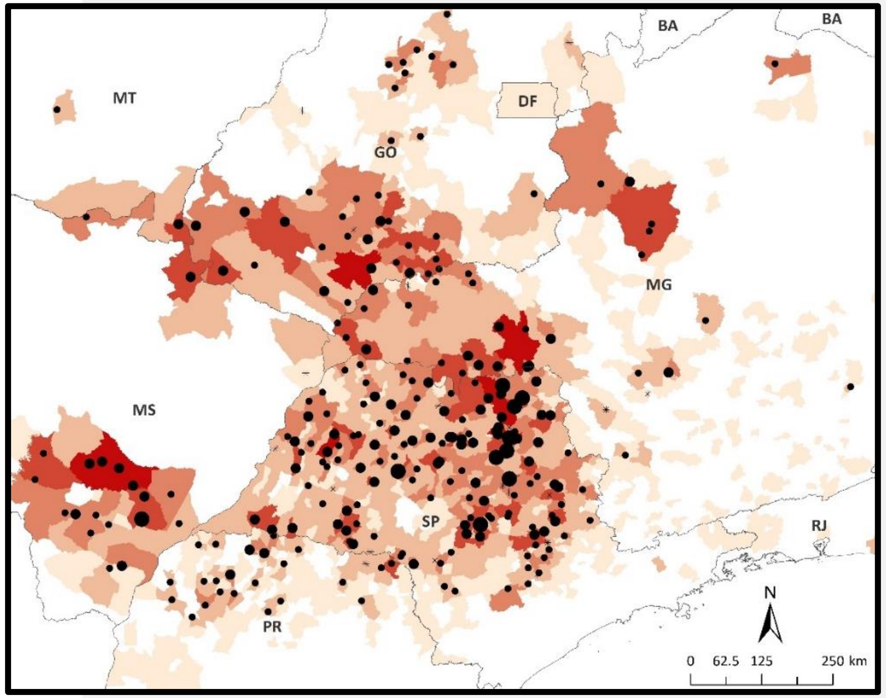




Developed by: Agroicone.

Source: PAM (2018), IBGE (2010), Mapbiomas (2018).

SOUTH-CENTRAL REGION 2

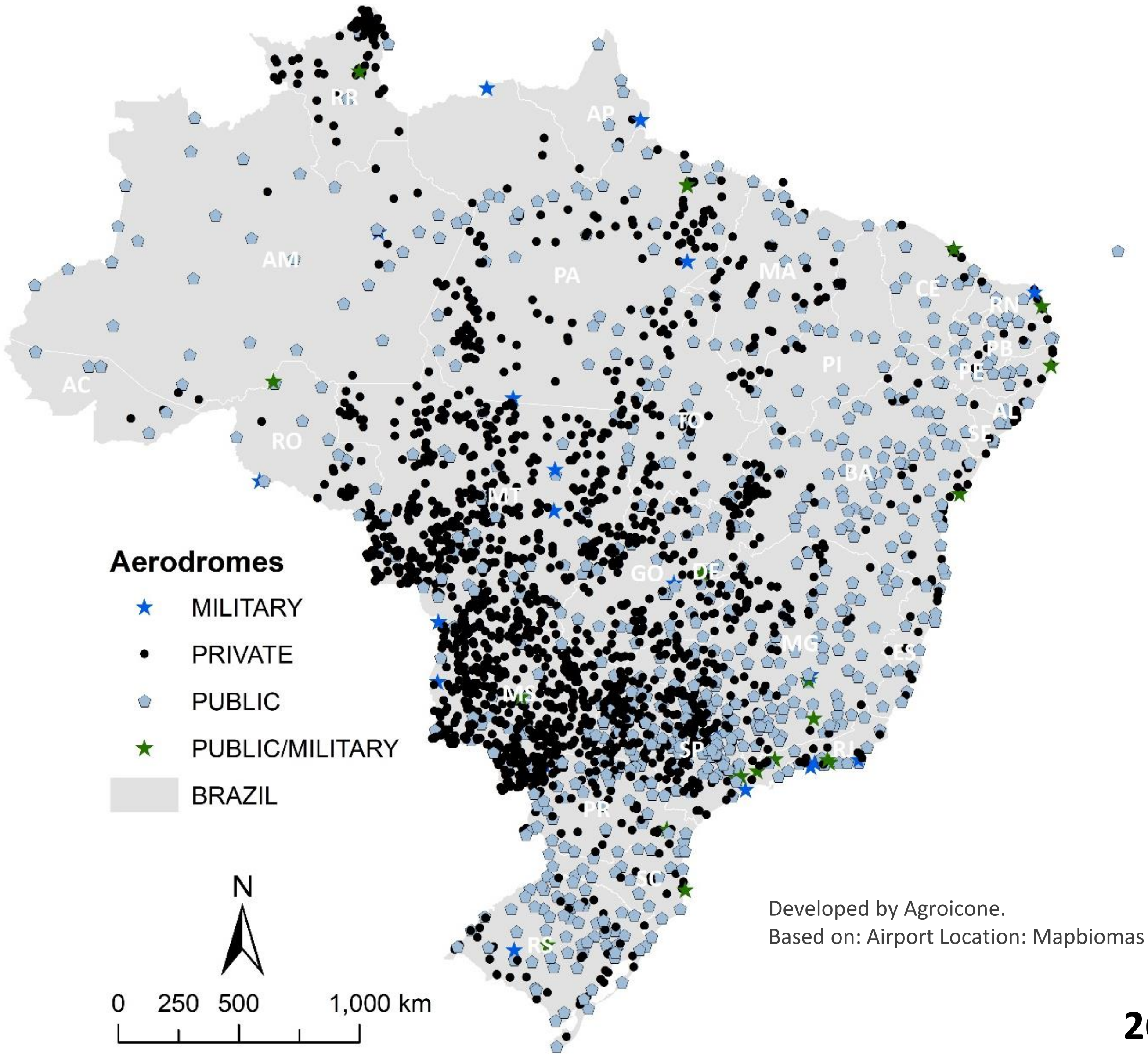


AIRPORTS LOCATION

Brazil has more than 2600 registered aerodromes, from those at least 650 are public, 1900 are private and 40 are military.

In 2018 ANAC (National Agency for Civil Aviation) registered the Jet A consumption of 143 airports, from which 34 are international airports.

The ANAC database was used to categorize the International Airports.



Developed by Agroicone.
Based on: Airport Location: Mapbiomas (2018)

JET A CONSUMPTION AND AIRPORTS

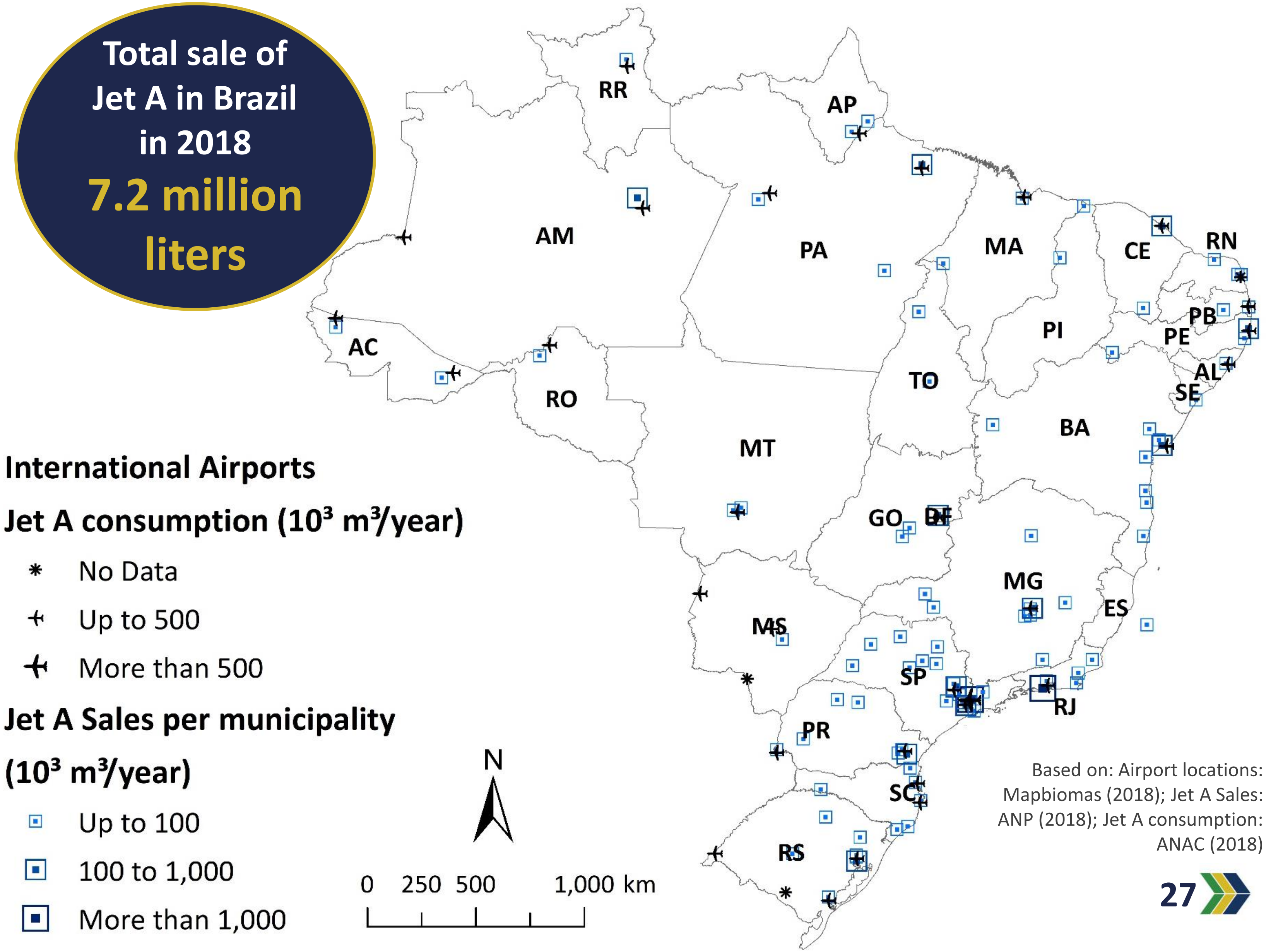
According to The Global Economy (2020), Brazil consumed an average of 123.46 thousand barrels per day of Jet fuel in 2018, whereas the world average, based on 43 countries, is 98.57 thousand barrels per day. Out of the 43 countries analyzed by this research group, Brazil is the 10th highest consumer of Jet fuel.

The consumption of Jet A was spatialized according to the fuel sales reported by ANP (2018).

In general, international airports are related to high regional consumption rates.

The **highest consumption** occurs in the **Southeast region**, which also holds the largest numbers of national and international flights. Around **58% of Jet A** sales are destined to SP State and RJ State.

Total sale of Jet A in Brazil in 2018
7.2 million liters



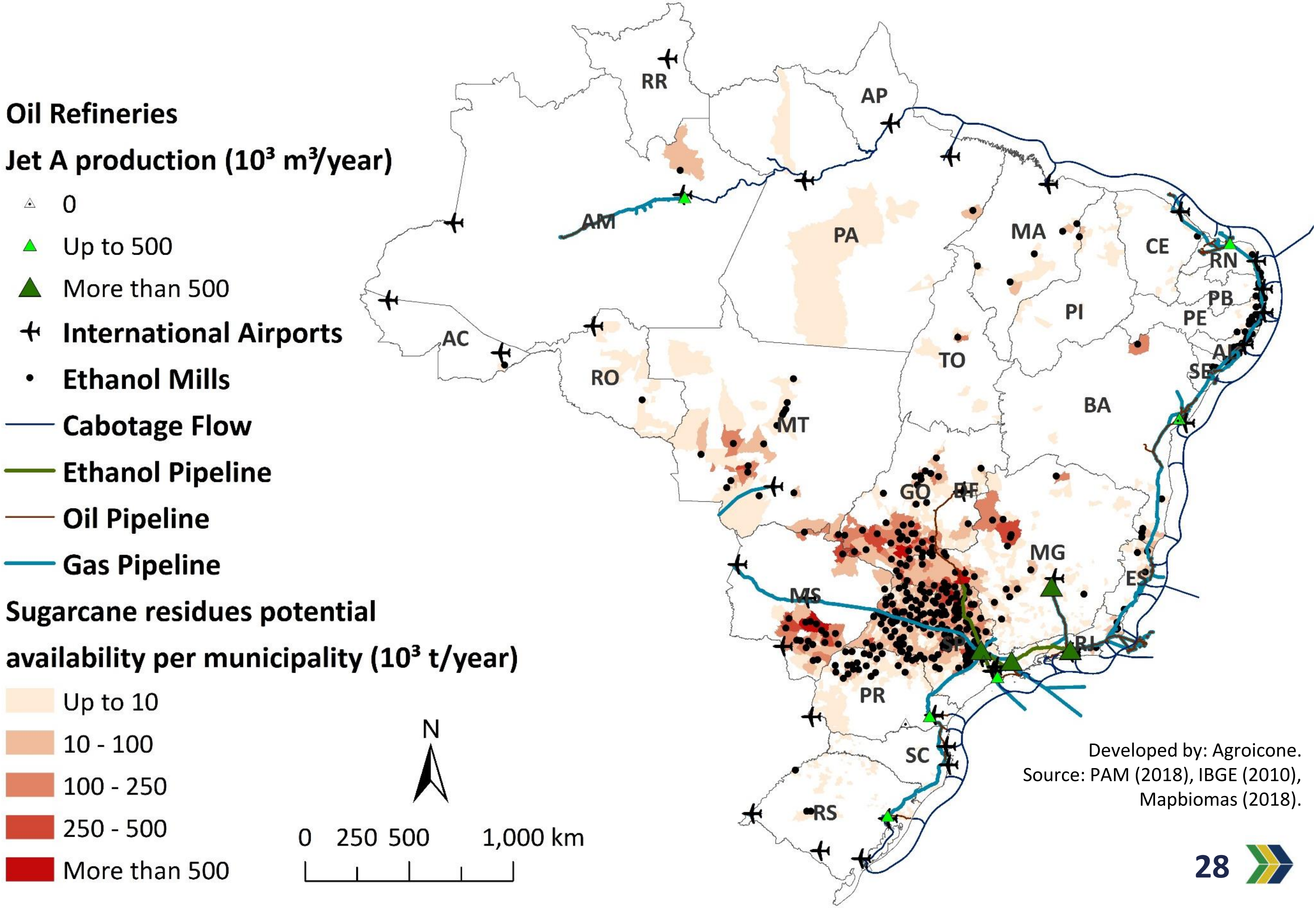
Based on: Airport locations: Mapbiomas (2018); Jet A Sales: ANP (2018); Jet A consumption: ANAC (2018)

MATCHING FEEDSTOCK, PROCESSING SITES, AND AIRPORTS

This map shows the location of the sugarcane residues combined with the processing sites, the transportation infrastructure and the consumption sites.

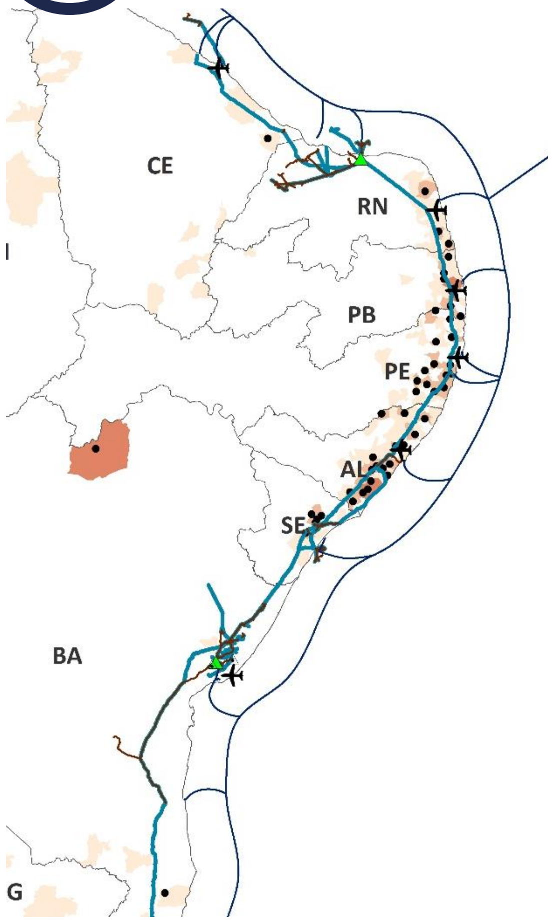
The **SP State** is considered strategic for placing **ATJ pathway**, due to the high availability of feedstocks – which is a result from the great concentration sugarcane mills – the presence of oil refineries and high Jet A demand. It is worth mentioning that ethanol pipeline could provide the distribution of 2G ethanol for ATJ plants close to oil refineries. Or the gas pipeline could support hydrogen for ATJ plants through Steam Methane Reform.

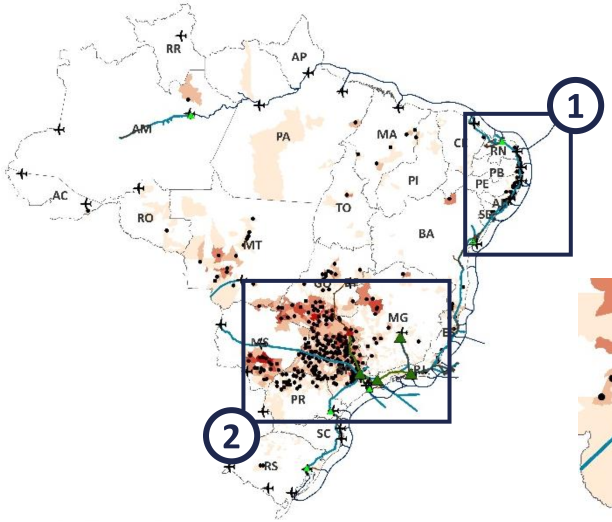
Combining the high availability of the feedstocks and Jet A demand, **FT pathway** could be placed in South-Central region, especially **SP, GO, or MS States**.



MATCHING FEEDSTOCK, PROCESSING SITES, AND AIRPORTS

1 NORTHEAST REGION





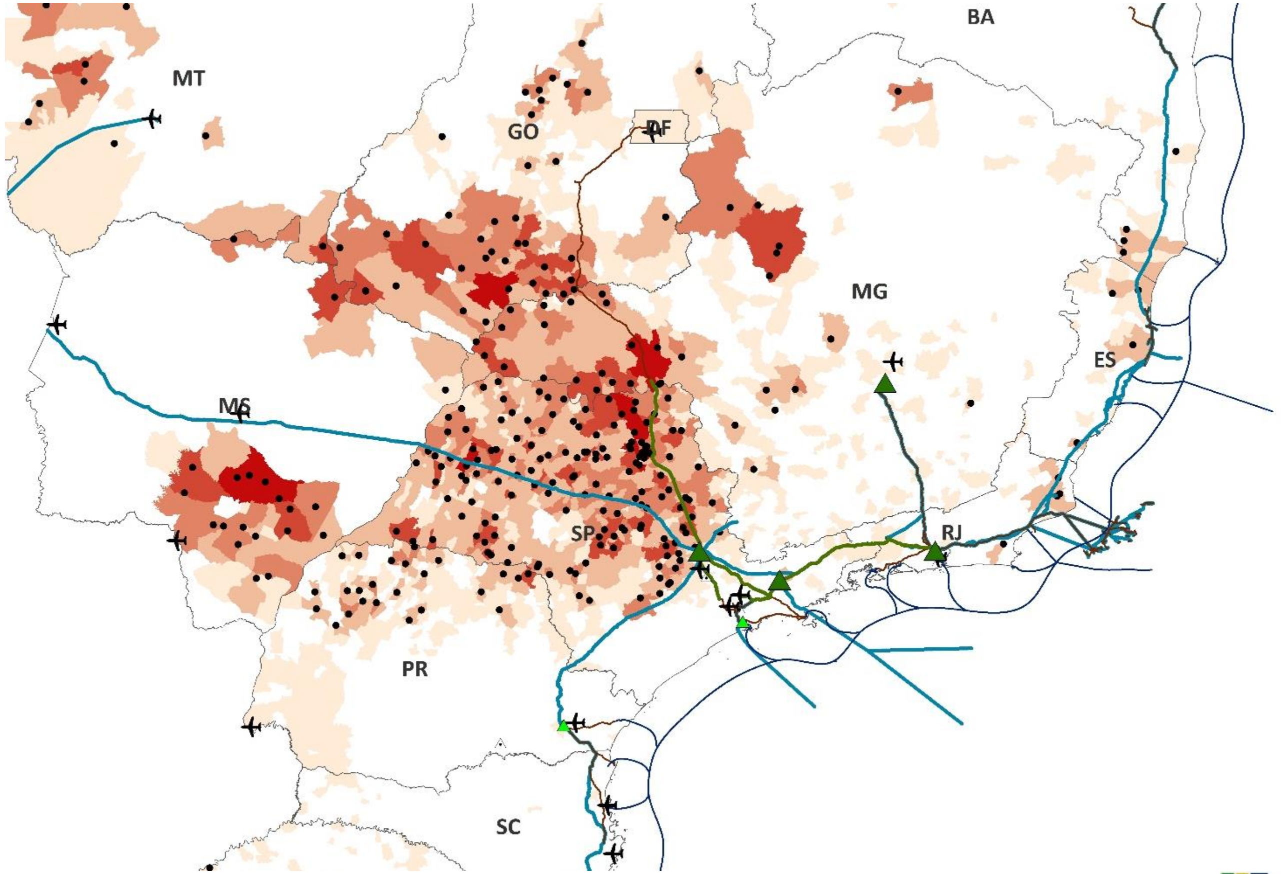
Jet A production (10^3 m^3/year)

- 0
- Up to 500
- More than 500
- International Airports
- Ethanol Mills
- Cabotage Flow
- Ethanol Pipeline
- Oil Pipeline
- Gas Pipeline

Sugarcane residues potential availability per municipality (10^3 t/year)

- Up to 10
- 10 - 100
- 100 - 250
- 250 - 500
- More than 500

SOUTH-CENTRAL REGION 2



POTENTIAL SAF FROM SUGARCANE RESIDUES

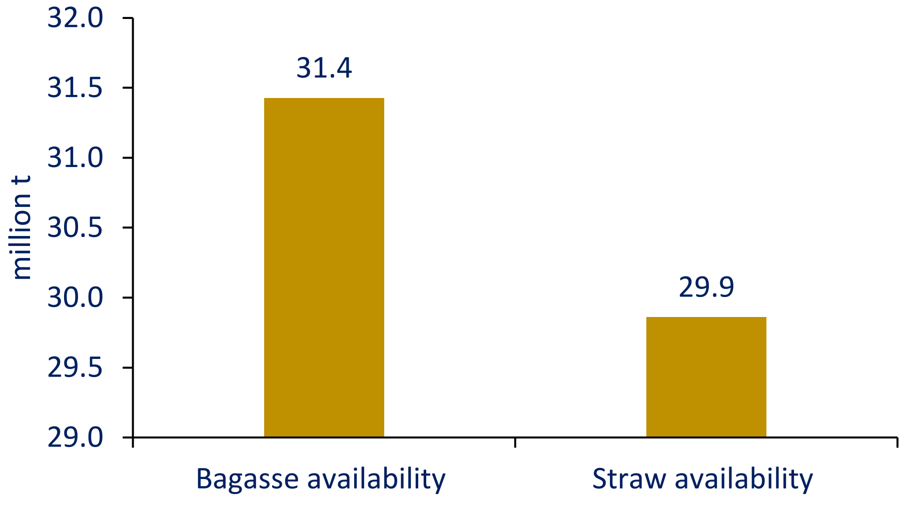
Sugarcane bagasse and straw are currently being used for cogeneration of energy in the sugarcane mills. These results show the availability of sugarcane residues after discounting the share required for the industrial plant to be energetically self-sufficient.

The surplus bagasse and straw could supply **90%** of the total demand for Jet A in Brazil, assuming SAF production through the **ATJ pathway**. Through FT technology, sugarcane residues could supply roughly **30%** of the total demand for Jet A.

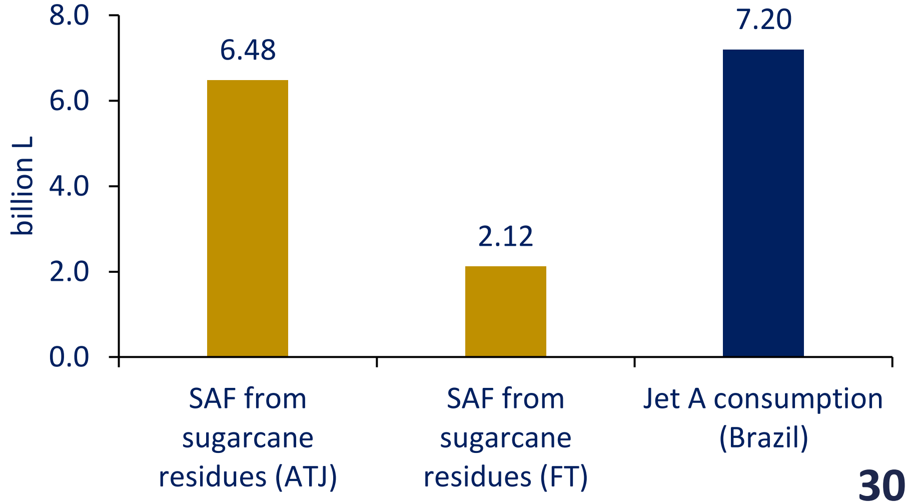
The main differences between both technologies are related to the industrial yields herein assumed. It is worth mentioning that ATJ pathways are based on an advanced ethanol production process, while, in the literature, some authors have modeled the FT process with higher SAF production in comparison with diesel.

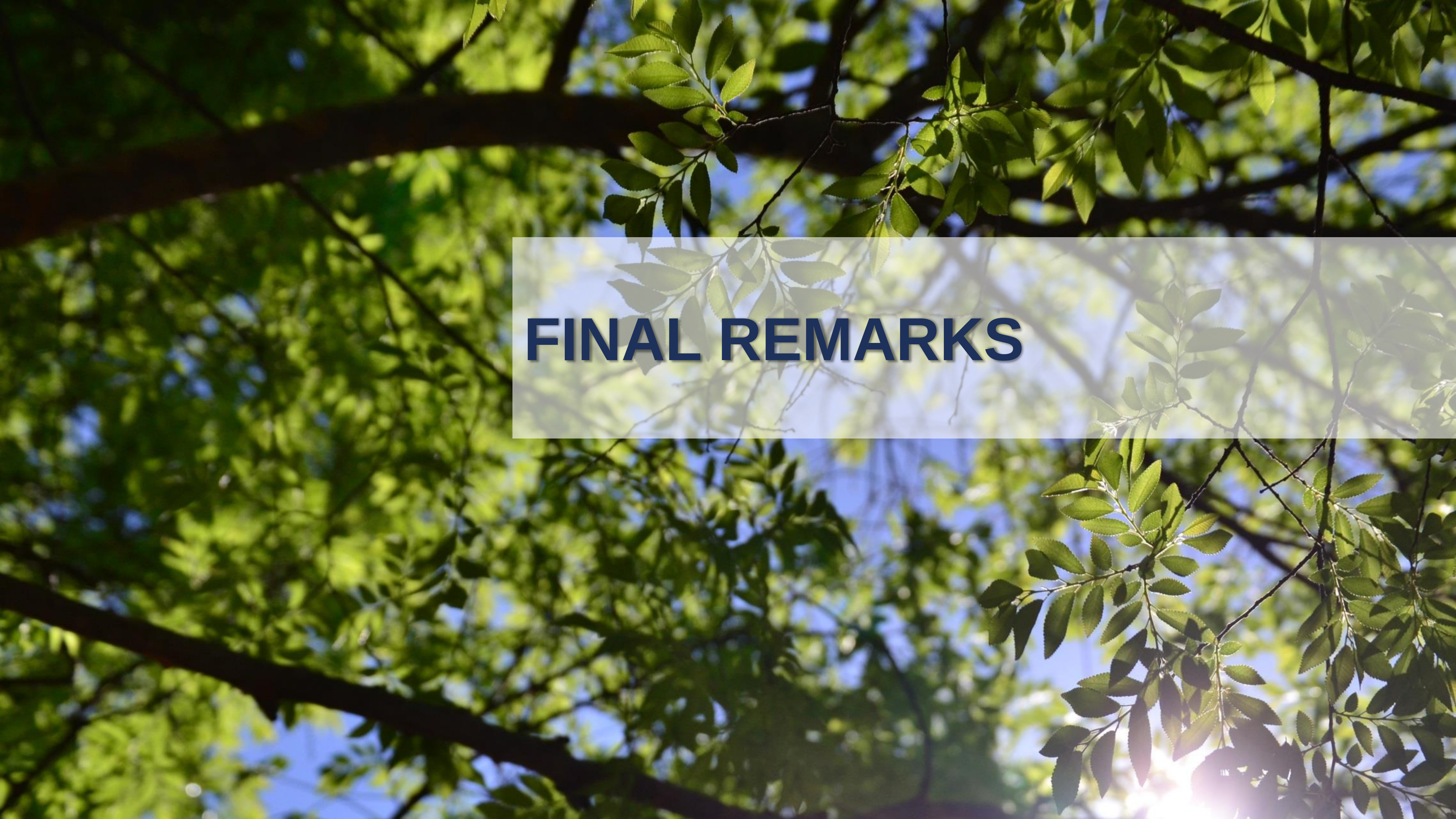
Despite the pros and cons regarding the application and implementation of each technology and pathway, it is important to emphasize that both applied to sugarcane residues have presented outstanding results that could be **very representative in the Brazilian market.**

Feedstock availability and use



Potential SAF production





FINAL REMARKS

KEY-MESSAGES

- This project has made significant effort in building a **spatially explicit database** comprising the availability of sugarcane residues for SAF production. These data will be **available in an online platform** with functionalities to download information for research and within the interest of investors.
- The sugarcane residues were assumed to be composed of bagasse and straw, which would be provided by optimized sugarcane mills that use a share of sugarcane residues for their self-supply of energy. Sugarcane straw would be recovered from the field, considering that a minimum rate must remain in the soil for environmental purposes.
- The mapping considers the adoption of the best practices in terms of harvest and industrial technology to estimate the availability of sugarcane residues. It may not reflect the exact amount of residues currently available, since most bagasse and straw have been internally used in sugarcane mills for energy generation.
- Sugarcane residues are mostly available in the South-Central region (88%). The **SP State** represents roughly **60**% of all sugarcane residues available in Brazil, followed by MS (10%) and GO (10%).
- The potentially available sugarcane residues would enable the production of almost **6.5 billion liters of SAF** considering the **ATJ pathwa**y. The same amount of sugarcane residues would produce **2.12 billion liters of SAF** through the **FT technology**.
- FT plants do not depend on hydrogen and it is convenient that they remain near the feedstock availability. Eventually, they could be constructed close to sugarcane mills. Combining the high availability of the feedstocks and Jet A demand, **FT pathway** could be placed in South-Central region, especially **SP, GO, or MS States**.
- ATJ plants require a previous conversion of the feedstock into ethanol (2G technology, as this report addresses only residue-based biofuels). Thus, in order to achieve low logistics costs and better utilization of the infrastructure, 2G plants could be conveniently placed close to sugarcane mills. Due to the level of hydrogen consumption of the ATJ plants, it would be best to place them near oil refineries. Therefore, **SP State** is considered strategic for placing **ATJ pathway**, also considering that ethanol pipeline could provide the distribution of 2G ethanol for ATJ plants, the gas pipeline could support hydrogen for ATJ plants through Steam Methane Reform.

NEXT STEPS

- The project has not performed analysis on issues that deserve to be further investigated, such as:
  - Cost evaluation
  - Life Cycle evaluation
  - Optimization of logistics
  - Integration with other feedstock and with other fuels.

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