

# Breaking the Barriers with Breakthrough Jet Fuel Solutions



Renewable Aviation Fuel Joint Development Program  
Paris Air Show - Salon du Bourget - June 2013

# Amyris's Disruptive Platform for the Renewable Chemicals and Fuels Industry

**ANY BIOMASS  
FEEDSTOCK**



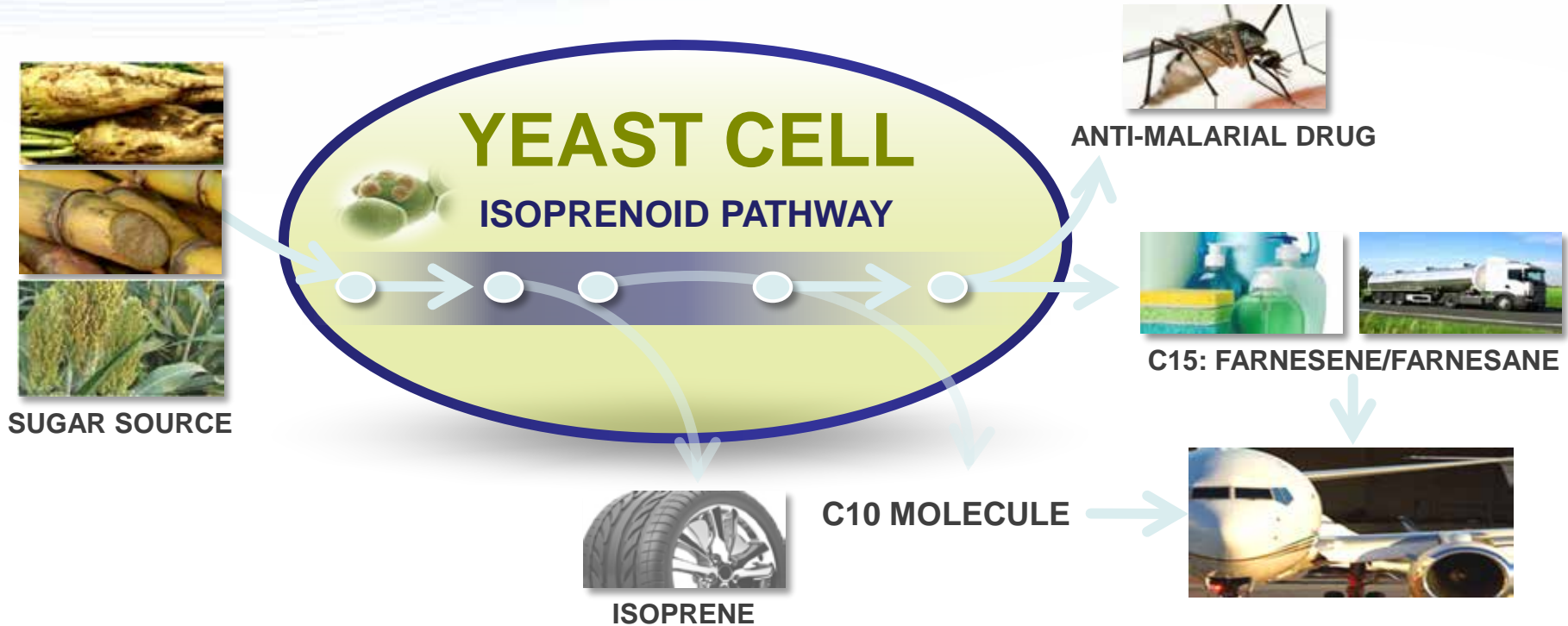
**INDUSTRIAL SYNTHETIC  
BIOLOGY PLATFORM**



**RENEWABLE  
CHEMICALS & FUELS**



# Amyris Renewable Fuel Development Expertise and Capabilities



# Key Issues for Renewable Alternative Jet Fuel

## Advantages

## Challenges

### Quality is paramount

Equivalent quality with fossil jet fuel

Compliance with fossil fuel product criteria (e.g. ASTM D1655 table 1)

Meet regulatory and standards-making organization spec.

OEM validation

### Competitive advantage

Competitive performance vs. fossil jet fuel

Competitive performance vs. other alternative jet fuel

Superior key fuel properties (e.g. freeze point)

### Feedstock is key

Biomass availability

Local (biomass) vs. global (oil) production

Availability and logistics from field to transformation

Meets sustainability criteria (RSB, SAFUG...)

### Jet fuel Logistics

Drop-in mandatory

Local (biomass) vs. global (oil) distribution

# Strategy: Market a Renewable Alternative Jet Fuel Through the Direct Sugar to Hydrocarbon Pathway

The DSHC pathway has been initiated in June 2011 at the ASTM

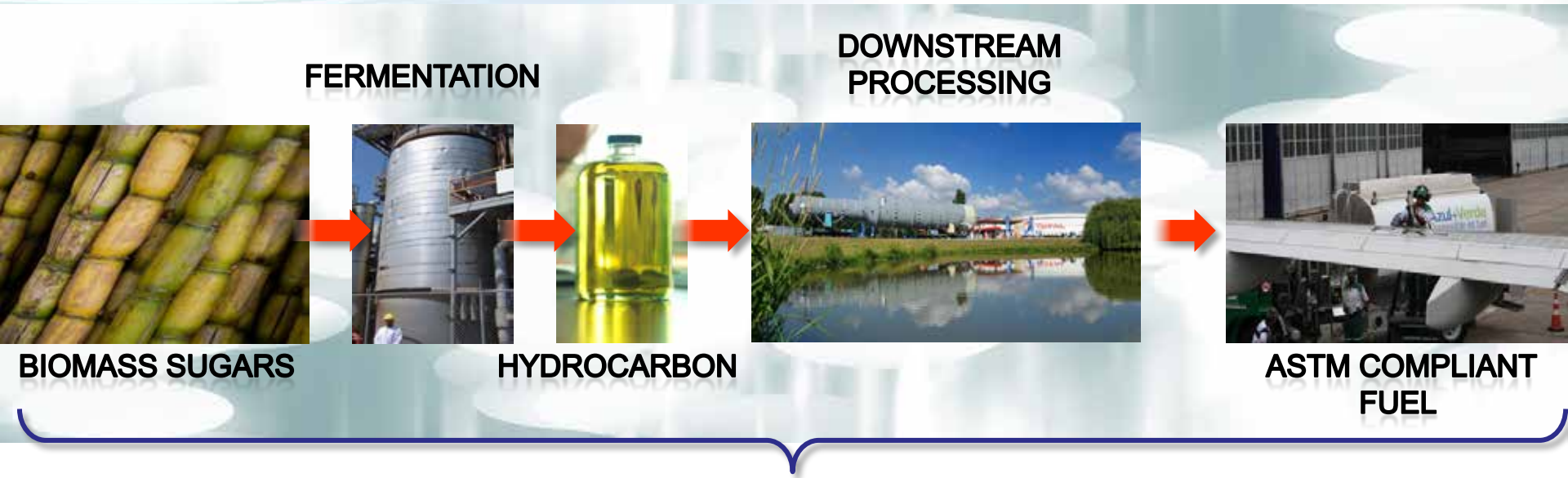
A **specification** to allow:

- An early introduction of existing renewable molecules (farnesane) at a low incorporation rate
- The integration of more bio-molecules under R&D to increase the incorporation rate

DSHC delivers a **drop-in renewable jet fuel** so that commercial blends:

- § Mimic as much as possible fossil jet fuel distillation curve and properties
- § Satisfy the ASTM D7566 specification

# Amyris-Total Jet Fuel Production Process



“Drop-in” Jet Fuel Properties Comply With Appropriate ASTM Jet Fuel Standards : industrial production in Brazil in 2013 (Brotas plant)

# At scale process based on common industrial steps

## Fermentation



- § **Microbe-catalyzed conversion** of sugar: key is the development of a **farnesene producing yeast**
- § Production to date: around **2 million liters of farnesene**
- § **Farnesene plant with a capacity of up to 50 million liters per year** at target efficiency in Brotas, Brazil is ramping-up

## Downstream processing

- § **Combination of hydroprocessing and separation operations**
- § Production to date: **~1 million liters of farnesane for diesel application**
- § Using diesel process slightly modified, production to date: **>90,000 liters of farnesane-containing jet**



# Sugar is Available Today



Abundant and low cost raw material



Not direct/basic food (FAO)



Sustainable

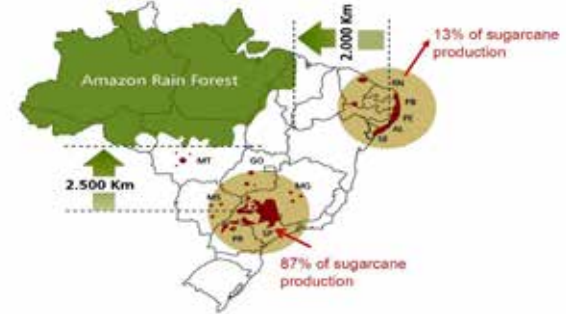


Available as cellulose in the future (advanced biofuels)



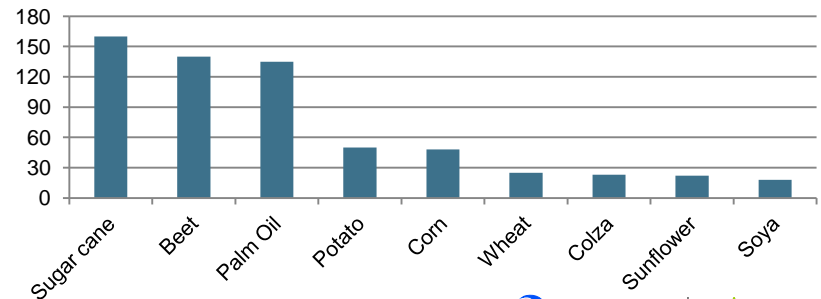
To complement first generation sugar

## Sugarcane Location in Brazil



Source : ANP from NIP-Unicamp, IBGE, CTC and UNICA

## Energy Yields of Major Crops (GJ/ha)



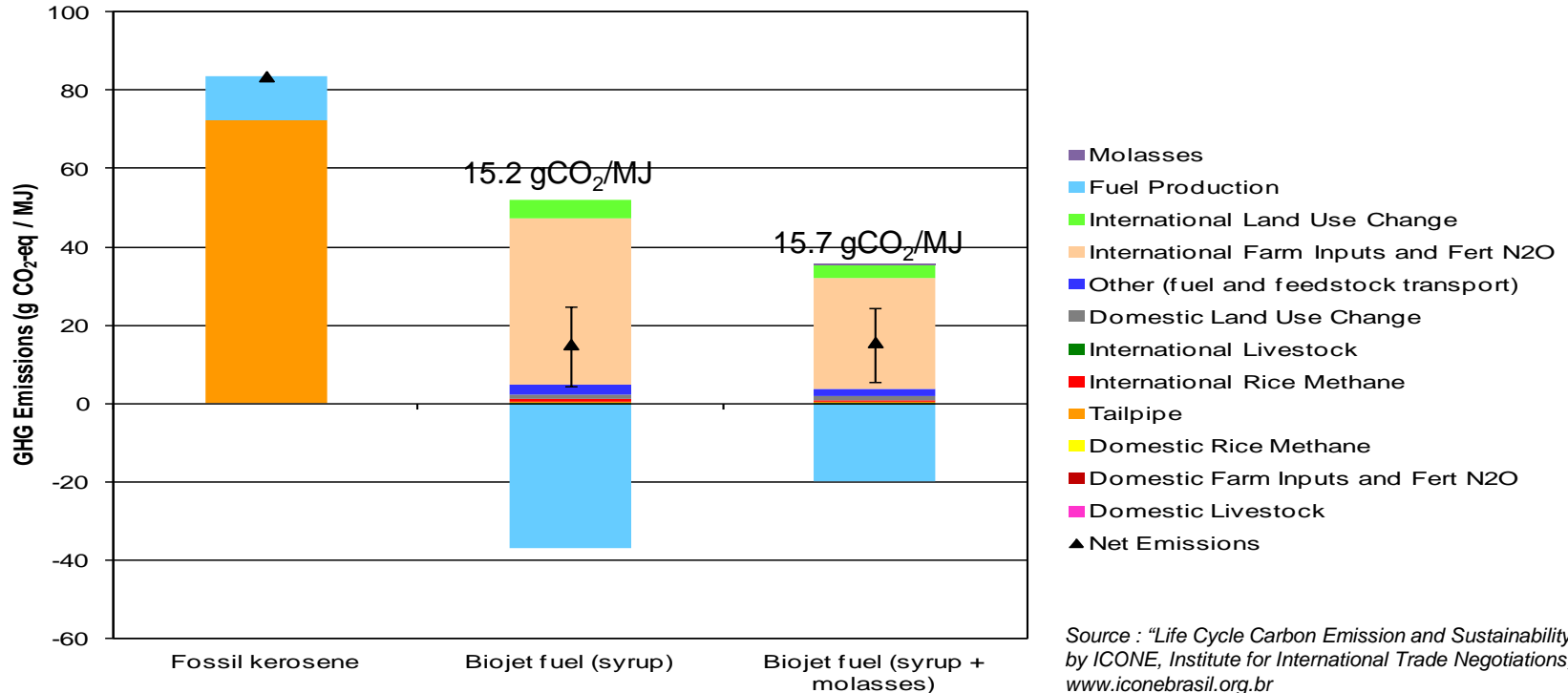
Source : Total from FAO Stats



# DSHC – Fossil Jet Fuel Blend

- ▶ **Farnesane aviation grade is a highly pure single molecule iso-paraffinic grade**
  - § Defined by stringent specifications that meet already approved alternative blending components for jet fuel
  - § Purity (and the process) is controlled by analytical methods developed on purpose
- ▶ **Physical and performance properties of farnesane are consistent with C<sub>15</sub> iso-paraffin and superior in some aspects to usual blending components for jet fuel**
  - § Low freezing point (< -100°C)
  - § High thermal stability above 380°C
  - § High net heat of combustion (44.0 MJ/kg)
- ▶ **Blends of farnesane in jet fuel up to 20 vol.% are behaving as conventional jet fuel**
  - § Blends meet the requirements of Aviation Turbine Fuels Containing Synthesized Hydrocarbons
  - § Fit-for-purpose properties are in the range of conventional jet fuel

# GHG Emissions : a Reduction of 82 % has been calculated vs. Fossil Jet Fuel



Source : "Life Cycle Carbon Emission and Sustainability Analysis" by ICONE, Institute for International Trade Negotiations, [www.iconebrasil.org.br](http://www.iconebrasil.org.br)

# Air Total International, Present in More Than 75 Countries Worldwide

- § Supplies jet fuel or operates in more than **300** international airports
- § Leader in Europe: **>15%** market share and in Africa: **>30%** market share
- § **>300** customers (airlines, brokers, armies, industries) and **1.5** million aircraft refuelings per year

## 2010 Jet Fuel Global Market Demand



Sources : Wood Mackenzie & Tecnom

# Total Moving Towards Alternative Energy

- § **Total is fully engaged in the fight against climate change**
- § **Total develops new energies** that emit fewer greenhouse gases to complement hydrocarbons so as to meet the increasing global demand for energy
- § **High energy density liquid fuels (oil products and biofuels) to remain dominant** in the long term for long-haul, heavy transport (trucks, ships and planes)

## A world leader in solar photovoltaic

- › Through a 66% stake in US company SunPower
- › Leveraging the Group's access to market
- › Getting ready for industry recovery and seizing market opportunities

## Producing bio-molecules on an industrial scale

- › Differentiating through technology development
- › Reaching industrial scale for advanced biofuels
- › Getting ready for next generation biofuels (e.g. lignocellulosis, algae)

# Amyris-Total Partnership Leveraging Expertise

- ▶ A specific partnership model to develop the whole value chain integrated from biomass to finished products

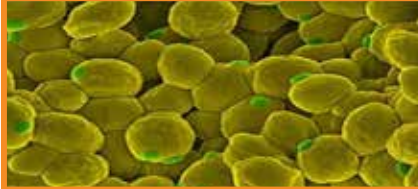
Technology, industrial and business capabilities

## Feedstock sourcing



- ▶ 1<sup>st</sup> generation in Brazil on sugar cane
- ▶ **Leading to 2<sup>nd</sup> generation**

## Synthetic biology



- ▶ Bio-engineering of micro-organisms
- ▶ R&D network

## Fermentation and chemical processes



- ▶ Track record for strain improvement
- ▶ Scale-up and industrial chemistry

## Trading & marketing



Fuels      Special fluids  
Lubricants Chemicals

- ▶ Competitive molecules
- ▶ Access to markets

§ **Differentiating technology:** broad R&D collaboration (~\$100M)

§ **Lab-to-market** development: **joint** industrialization & commercialization

§ Strategic alignment: Total has ~**19% equity** of Amyris

# Amyris-Total Renewable Jet Fuel Partnership

- § **Total and Amyris are committed to a renewable jet fuel joint development program that is developing new pathways for renewable hydrocarbons**
- § To develop an effective platform for converting plant sugars into a sustainably-produced renewable hydrocarbon jet fuel that outperforms petroleum-derived fuel in both exhaust emissions and GHG reduction, without compromising on performance quality

## Suitability

## Sustainability

## Commercialization

- Compliant with Jet A/A-1 fuel specifications
- Drop-in properties for seamless operation
- Low GHG lifecycle
- Produced from sustainable biomass feedstock
- Air Total International global distribution
- Partnering with OEM and airlines

- ▶ **Produce drop-in jet fuel with competitive performance properties to petroleum jet fuel with added renewable benefit**
- ▶ **Acquire OEM acceptance**
- ▶ **Achieve ASTM regulatory validation in key markets**



**TOTAL**



AMYRIS®

**Merci !**