BioValue e-EUBCE 2020

BioValue

Whole chain decentralized biomass valorization to advanced biofuels: development and assessment of thermochemical routes integrated to biomass production and biochemical routes

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Marseille, FRANCE

July 6 to 9, 2020

Brazil – EC coordinated call on Advanced Lignocellulosic Biofuels

HORIZON 2020 (H2020)
Work Programme 2016-2017
'Secure, Clean and Efficient Energy'

LCE-22-2016: International Cooperation with Brazil on Advanced Lignocellulosic Biofuels

European Commission (EC) and MCTIC/CONFAP/FAPESP

Project's goals

- Brazil-EU Cooperation for Development of Advanced Lignocellulosic Biofuels.
- Collection of literature, lab and pilot plant scale data for technical, economic, environmental and social assessment of different biomass production systems and biorefinery configurations for advanced biofuels.

Sub-challenges of the BioValue project

A	Gasification of bagasse, other biomasses and intermediate energy carriers to advanced biofuels. Fast pyrolysis of raw biomasses and lignin rich streams. Fischer-Tropsch synthesis and Stabilization of bio-oils.
B	Biomass production and feedstock diversification for advanced biofuels. Design and assessment of optimal logistic chains. Integrated market, value chain and sustainability assessment.
C	Biochemical processing and energy efficiency in advanced biofuels production – integration strategies with thermochemical routes.

BioValue

State Research Foundations – Technical and Financial Support

FAPESP

FAPEMIG

FACEPE

FAPERGS

Companies – Technical and Financial Support

BR PETROBRAS

suzano

Klabin

EMBRAER

Research Institutions – Technical Execution

CNPEM

UNICAMP

UFV Universidade Federal de Viçosa

UFU

VIRTUS IMPAVIDA UFPE

Universidade Federal de Santa Maria SEDES SAPIENTIÆ 1960

ipt INSTITUTO DE PESQUISAS TECNOLÓGICAS

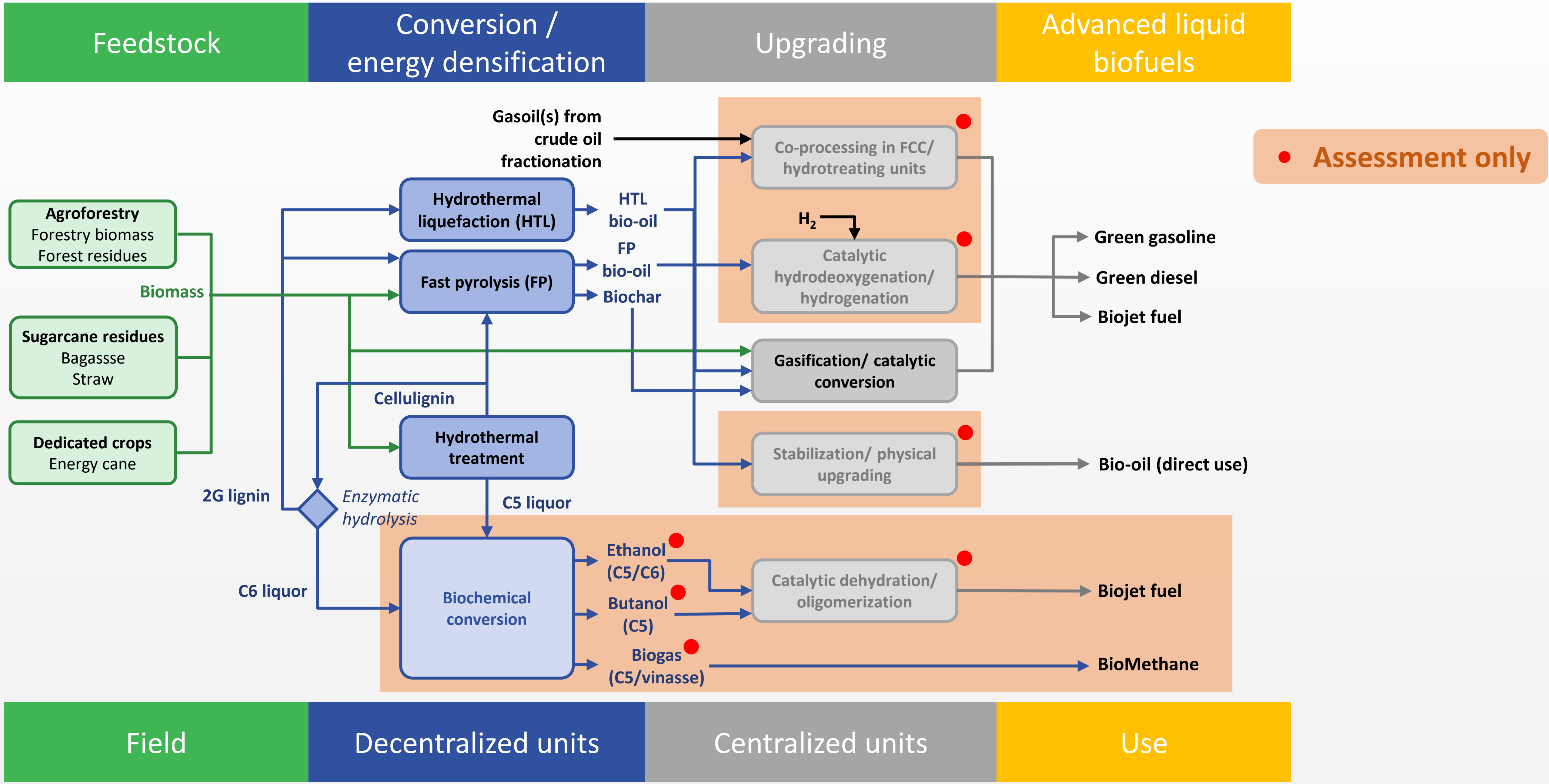
FEI

UNIFEI Universidade Federal de Itajubá

COPPE UFRJ

INSTITUTO NACIONAL DE TECNOLOGIA INT MINISTÉRIO DA CIÊNCIA, TECNOLOGIA E INOVAÇÃO

Production Chains – Technical integration



Technical high-lights

- Thermochemical and biochemical integrated routes to convert biomass in advanced biofuels will be studied and compared considering whole production chain;
- Logistics for feedstocks available in Brazil:
  - ✓ Residues (sugarcane and forestry)
  - ✓ Energy crops (conventional cane, energy-cane and eucalyptus);
- Energy densification in fast pyrolysis and HTL decentralized units;
- Gasification of biomasses and bio-oils in centralized units;
- Upgrading of syngas and bio-oils in centralized units;
- Biochemical processing and upgrading of biomass;
- Technical, economic, environmental and social assessment of production chains;
- Design and assessment of existing and potential logistic chains.

Synergies with BECOOL

BIOMASS

WP1

Agricultural residues

Straw, by products, agroforestry

Sugarcane bagasse, straw, agroforestry

Dedicated annual lignocellulosic crops

Sunn hemp, fiber sorghum, hemp, kenaf

Dedicated perennial lignocellulosic crops

Giant reed, miscanthus, switchgrass

Energy cane, Sugarcane, Eucalyptus

Harvesting, pre-treatments

LOGISTICS

WP2

Describe biomass production logistics including exemplary logistic concepts

Develop and test logistical assessment tools for EU and Brazilian cases

Assess different biomass logistic concepts for EU and Brazil

PROCESSES & END-PRODUCTS

WP3

- Assessment and evaluation of biomasses, intermediate streams and advanced biofuels
- Gasification of raw and pretreated feedstocks, lignin and bio-oils
- Fast pyrolysis of raw and pretreated feedstocks and lignin
- Intermediate pyrolysis of raw and pretreated feedstocks and lignin: production of PO/Char
- Upgrading bio-oils: Hydrodeoxygenation (HDO) and co-processing in FCC
- Stabilization of bio-oils for gasification and for direct use
- Catalytic conversion of the gasification-derived syngas to advanced biofuels by the Fischer-Tropsch Synthesis (FT)
- Hydrothermal Liquefaction (HTL) of raw and pretreated feedstocks and lignin

WP4

- Feedstock pre-treatment for biochemical & thermochemical conversions (hydrothermal, ultrasound)
- Biochemical conversion of C5 liquor: use of C5 sugars (ethanol, butanol, biogas).
- Catalytic conversion of ethanol and butanol to biojet fuels

ADVANCES BIOFUELS INCLUDING AVIATION

WP5 – Integrated Market, Value Chain & Sustainability Assessment

WP6 – Dissemination, Exploitation & Data Management

WP7 – Coordination management

Synergies with BECOOL

- Comparison of different strategies for biomass production in Europe and Brazil.
- Logistic chains to deliver different biomasses from field to conversion plants.
- Brazilian and European technical approaches for gasification of biomass and intermediate energy carriers, including fast pyrolysis products and lignin rich streams; synthesis to advanced biofuels.
- Brazilian and European technical approaches for biochemical processing and energy efficiency in advanced biofuels production – integration strategies with thermochemical routes.
- Harmonization of data and methods to be used in assessing the sustainability of different Brazilian and European production chains
- Joint annual EU-BR technical and administrative/organizational meetings, including work packages leaders, researchers and Companies representatives of both consortia.

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e-EUBCE
2020

MINISTRY OF SCIENCE, TECHNOLOGY, INNOVATION AND COMMUNICATION

PÁTRIA AMADA BRASIL
BRAZILIAN GOVERNMENT

Work Package 1:

Biomass production and feedstock diversification for advanced biofuels

LNBR/UFV

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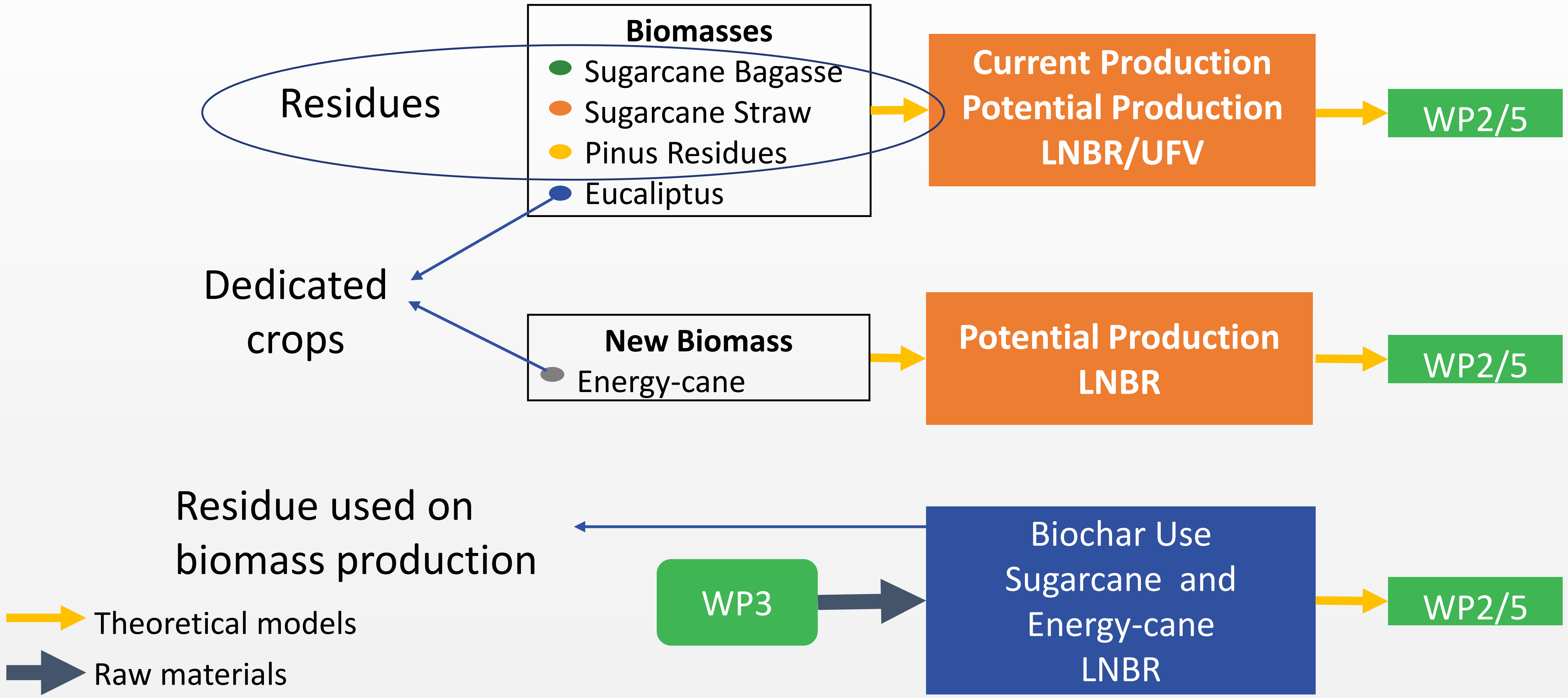
July 6 to 9, 2020

Biomass Determine representative information regarding the use of sugarcane bagasse, sugarcane straw, energy cane biomass, pinus residues and eucalyptus biomass



Bagasse is a lignocellulosic residue resulting from the extraction of sugarcane juice. Main destination of this residue in Brazil is the production of bioelectricity.

Sugarcane Straw

SUCRE

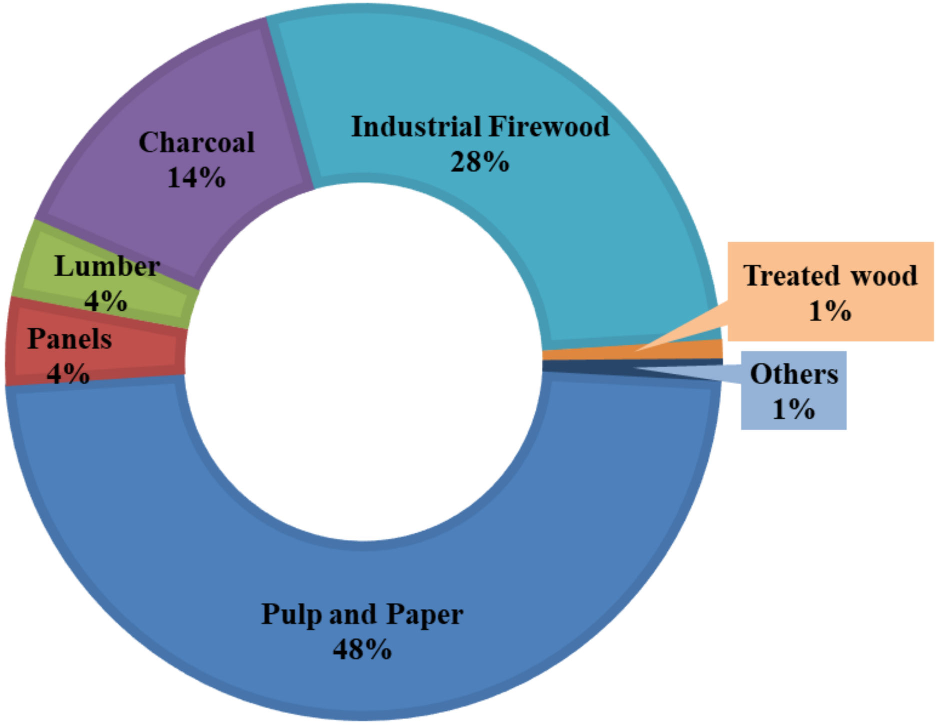
The **Sugarcane Renewable Electricity** (SUCRE) project goal is to avoid GHG emissions by producing and exporting to the grid sugarcane straw-based electricity assuming the replacement of natural gas power generation → increasing the collection and use of sugarcane straw as a complement to bagasse.

- **Straw recovery and processing technology operational and in use**
- **Economic feasibility**
- **Assurance of the agri-environmental integrity**
- **Adequancy of the regulatory and legal framework**
- **Project results dissemination**

Main uses of commercial forest in Brazil

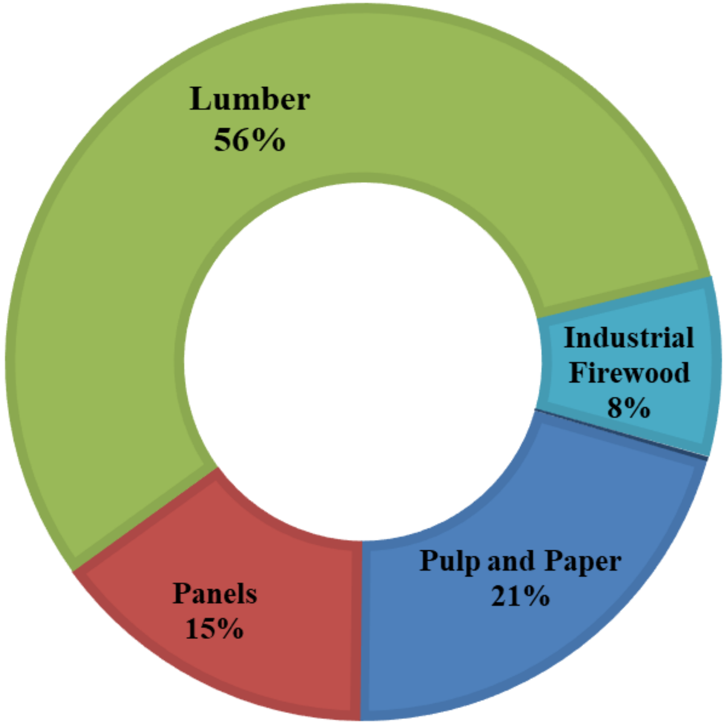
Eucalyptus

Total 166 million m³



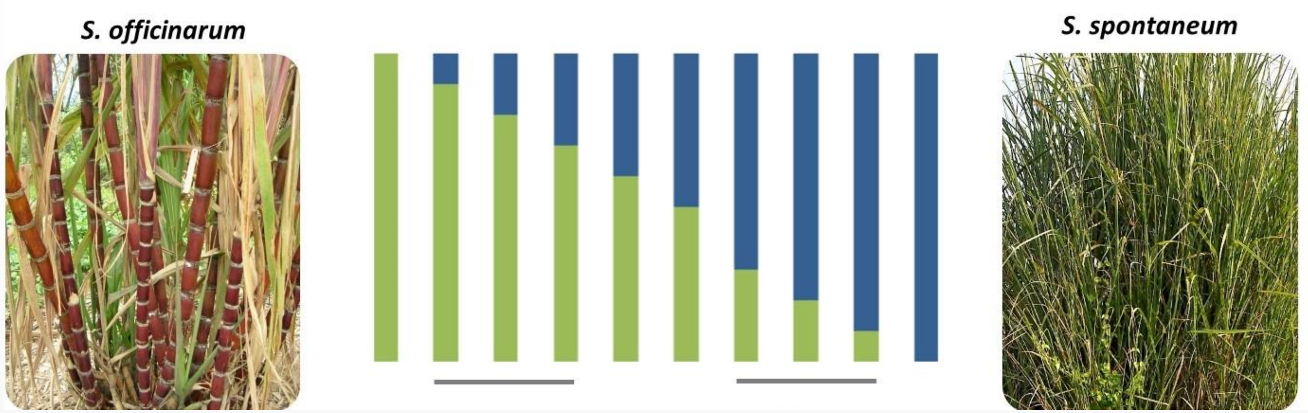
Pinus

Total 49 million m³



Source: IBA, 2018

Energy Cane varieties are obtained by crossover between *Saccharum officinarum and Saccharum spontaneum, which exhibt high fiber content and robustness*



S. officinarum

Commercial sugarcane

Energy cane type 1

Energy cane type 2

ENERGY CANE IS A NEW CROP IN BRAZIL AND THERE IS NO SIGNIFICANT AREAS IN COMERCIAL SCALE

Biochar Effects of recycling on soil quality and on soil greenhouse gas emissions

Residue

Bio-oil

Biochar

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PÁTRIA AMADA BRASIL BRAZILIAN GOVERNMENT

Work Package 2 – Design and assessment of optimal logistic chains

Integrated Market, Value Chain and Sustainability Assessment

LNBR / UFPE

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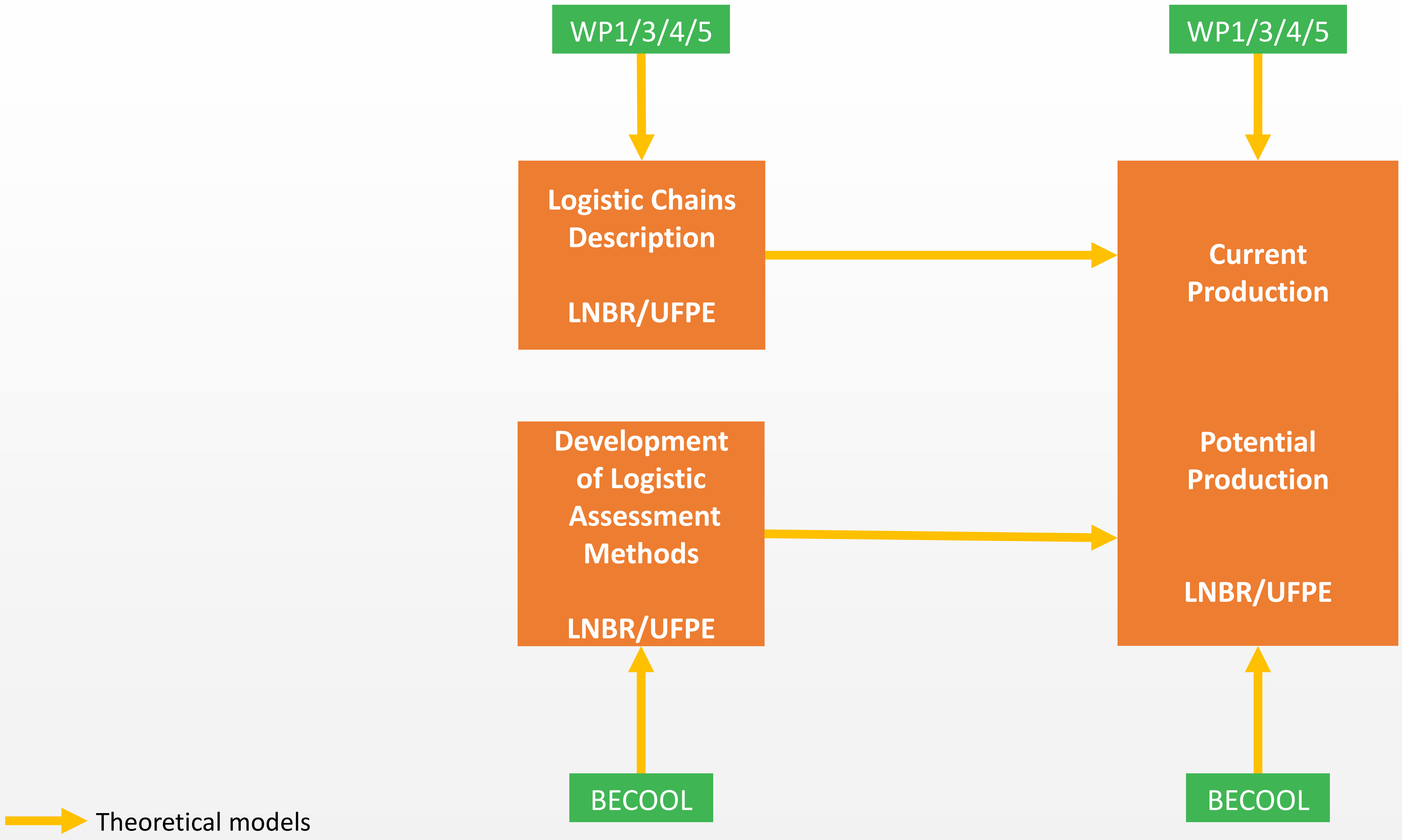
WP1/3/4/5
WP1/3/4/5
Logistic Chains Description
LNBR/UFPE
Current Production
Potential Production
LNBR/UFPE
Development of Logistic Assessment Methods
LNBR/UFPE
BECOOL
BECOOL
Theoretical models

Quantification of the availability of currently produced biomass options in Brazil (sugarcane bagasse, sugarcane straw, eucalyptus chips and pine residues) **based on the maps of the current production systems** and industrial facilities for the selected biomass options.

Based on these maps, it will be possible to estimate the **amount and transportation distances** of biomass to bioenergy conversion facilities.

Transportation systems (e.g. modals, fuel consumptions, emissions, etc.) will be modeled based in the description of most common current systems with information from industry and literature.

E**stablish plausible scenarios** for the potential **expansion of biomass production** (currently produced biomasses + energy cane) considering **key land use restrictions** (e.g. agroecological zoning, soil types, infrastructure, distances, etc.) **and future demands of aviation fuels**.

A special logistic analysis will be performed, considering the biojet demand of the 3 major airport hubs in Brazil.

The complete assessment of the logistic systems will be based in the combination of **cost-supply and environmental impact curves** for the three components:

(a) transport of biomass and intermediate products,

(b) biomass conversion systems (including scale of conversion facilities)

(c) transport of products from the conversion unit to consumers.

Based in this assessment, will be **identified the most suitable logistics options** based in the combination of the cost-supply and environmental impact curves **considering exemplary case studies for logistic systems in different regions of Brazil**.

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BIOVALUE

***Work Package 3* – Study of Thermochemical Processes**

UFU/UNIFEI/IPT/FEI/UFPE/UFRJ/INT/UNICAMP-IQ/UFSM

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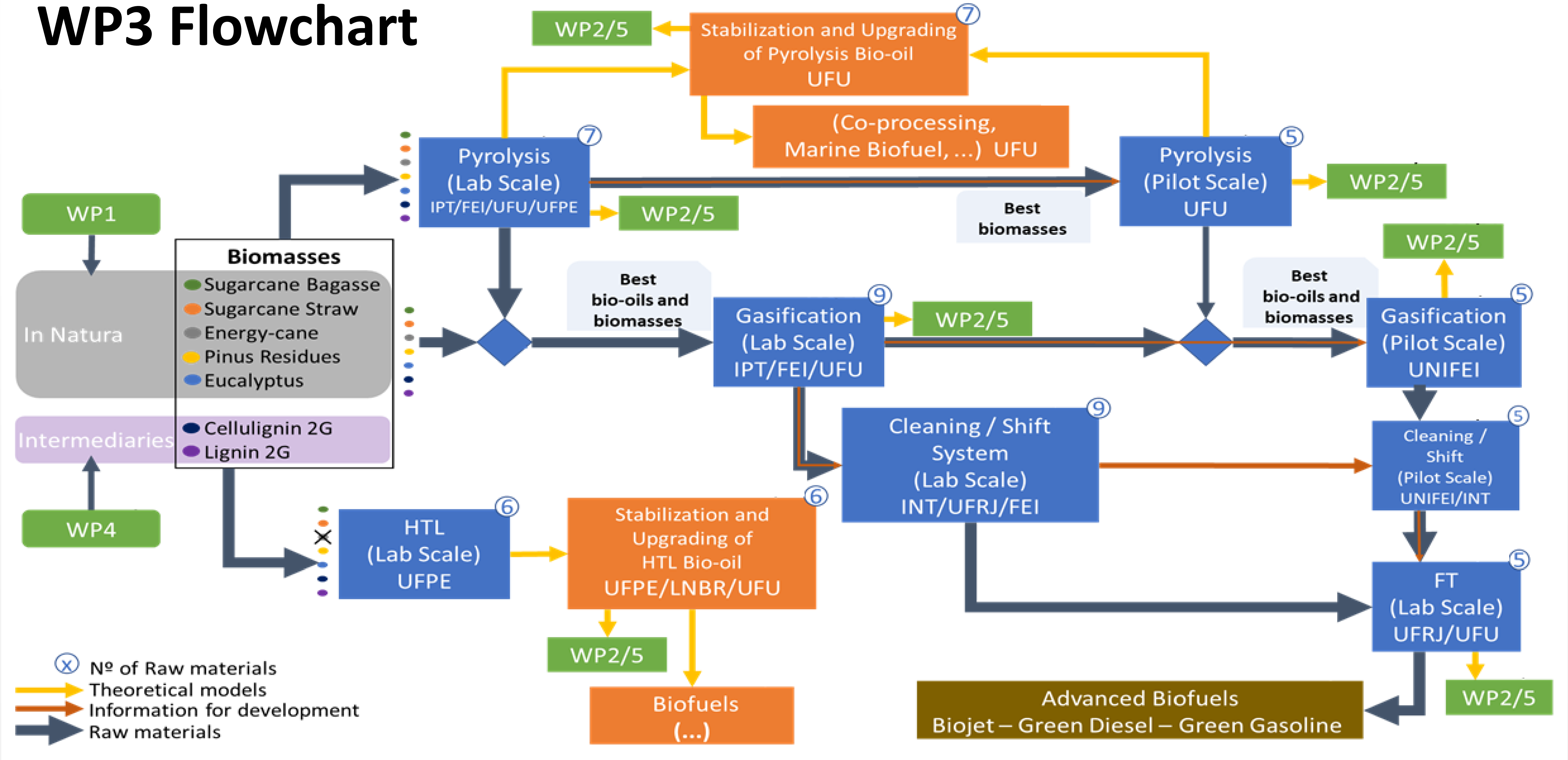
July 6 to 9, 2020

WP3 Flowchart



Fast Pyrolysis Bench Scale Studies (IPT/UFU)

GOALS

Evaluate pyrolysis of crude biomasses under different reaction conditions

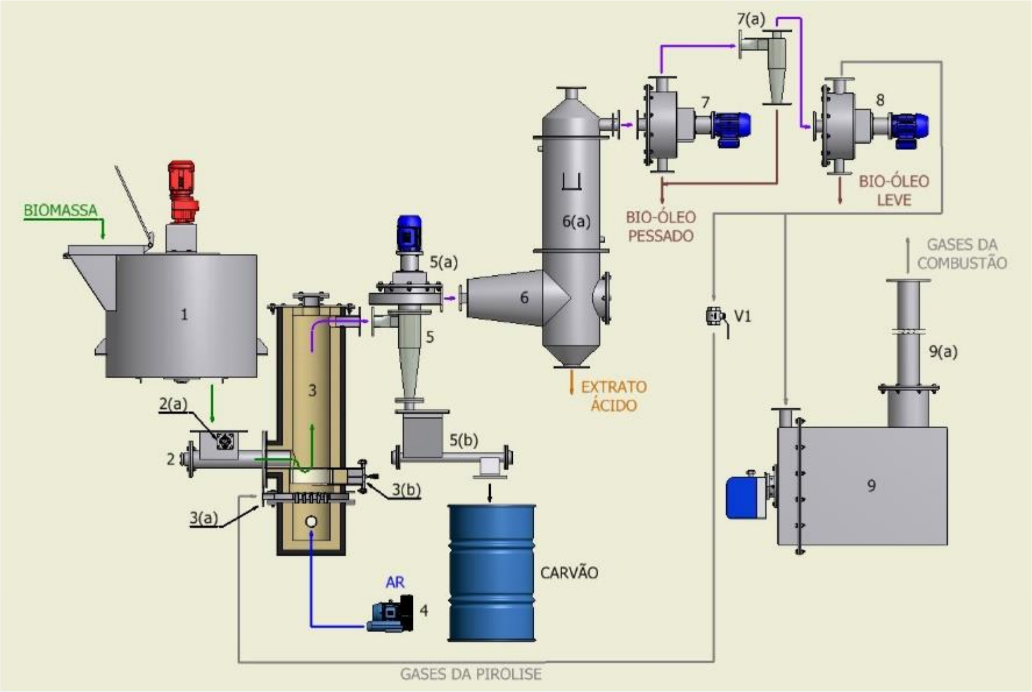
Crude biomasses:

- Sugarcane bagasse
- Sugarcane straw
- Forestry residue (pinus)
- Eucalyptus
- Energy-cane

Pyrolysis conditions:

- Fluidized gas (N_2 and O_2/N_2)
- Temperature (450-550^o C)
- Feeding flow
- Biomass/gas feeding ratio

Oxidative Fast Pyrolysis in Pilot Scale (UFU) – Bubbling Fluidized Bed Reactor



10-30 kg/h (dry biomass)

GOALS

Evaluate oxidative fast pyrolysis of crude biomasses under different reaction conditions

Crude biomasses:

- Sugarcane bagasse
- Sugarcane straw
- Forestry residue (pinus)
- Eucalyptus
- Energy-cane

Pyrolysis conditions:

- Fluidized gas (Air)
- Temperature (400-600º C)
- Feeding flow
- Recycled ratio

Hydrothermal Liquefaction (HTL) Studies (UFPE)

Parr Reactor, Model 4576, 250 mL, T_{max} = 500 ºC, P_{max} = 5000 psi, 2500 rpm

GOAL

Evaluate HTL of crude biomasses and intermediate streams under different reaction conditions

Crude biomasses:

- Sugarcane bagasse
- Sugarcane straw
- Forestry residue (pinus)
- Eucalyptus

Intermediaries:

- Cellulignin 2G
- Lignin 2G

Reaction conditions:

- Solvent (H_2O and/or ethanol)
- Temperature (200 to 400 °C)
- Pressure (system)
- Biomass/solvent ratio
- Catalyst

Gasification Bench Scale Studies (IPT)

GOALS

Evaluate gasification of crude and processed biomasses under different reaction conditions for modelling and pilot plant optimization

Crude biomasses:

- Sugarcane bagasse
- Sugarcane straw
- Forestry residue (pinus)
- Eucalyptus
- Energy-cane

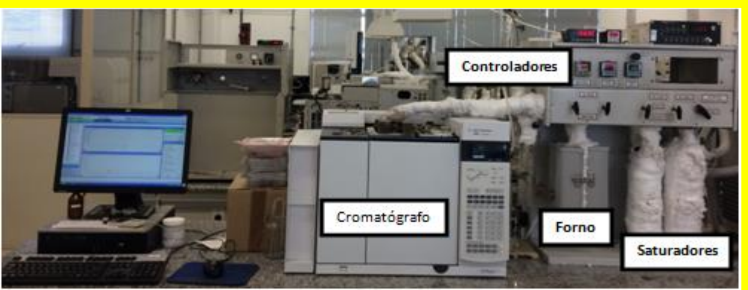
Processed biomasses:

- Lignin and/or cellulignin
- Pyrolysis bio-oil

Gasification (reaction) conditions:

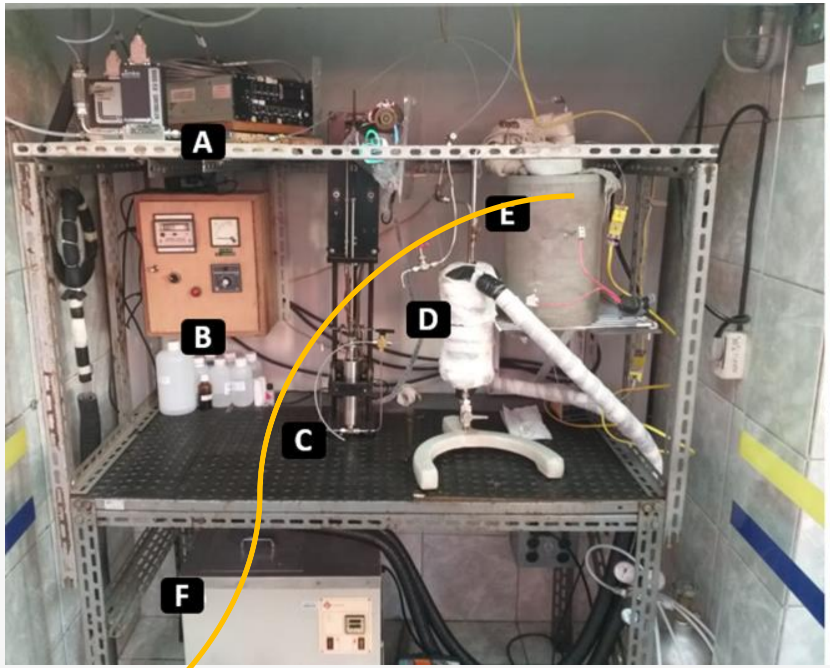
- Fluidized gas (Air, O_2 and/with H_2O)
- Temperature (850º C max)
- Feeding flow
- Biomass/gas feeding ratio
- With and/or without Cleaning apparatus

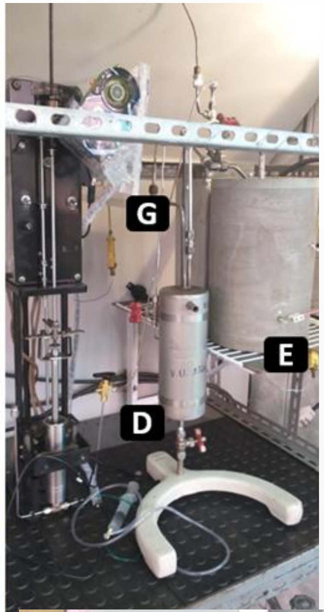
Gas Cleaning and Conditioning Studies (INT/UFRJ)

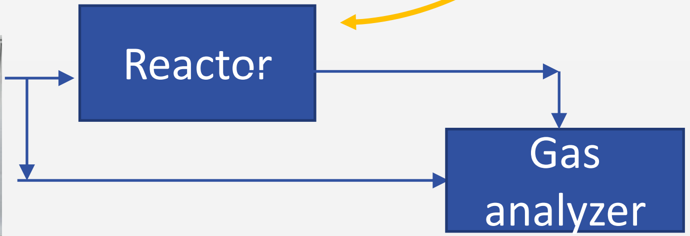


Gas Cleaning and Conditioning Studies (FEI)

(A) Mass flow controllers
(B) Pre-heater controller
(C) Microfeeder MF-2 pump equipped with , digital flow controller
(D) Condenser
(E) Catalytic Reactor
(F) Cryostatic bath
(G) Preheater/vaporizer
(H) Gas Chromatograph equipped with FID & TCD (CP7429 Select Permanent Gases/CO_2)







Adjust H_2/CO ratio for FTS by WGS reaction

Gasification Pilot Scale Studies (UNIFEI)

GOALS

Evaluate gasification of crude and processed biomasses under different reaction conditions using NEST Pilot Plant

Crude biomasses:

- Sugarcane bagasse
- Sugarcane straw
- Forestry residue (pinus)
- Eucalyptus
- Energy-cane

Processed biomasses:

- Lignin and/or cellulignin
- Pyrolysis bio-oil

Gasification (reaction) conditions:

- Fluidized gas (Air, O_2 and/with H_2O)
- Temperature (800-1000^{o} C)
- Feeding flow
- Biomass/gas feeding ratio
- With and/or without Cleaning apparatus

Fischer-Tropsch Synthesis Studies (UFRJ/UFU)

GOAL

Evaluate different catalysts and reaction conditions to optimize advanced biofuels

Catalysts:

- Cobalt-based (UFRJ)
- Iron-based (UFU)

Fischer-Tropsch Synthesis (reaction) conditions:

- Fixed Bed (bench reactor)
- Temperature (200-300^{o} C)
- WHSV
- H_2/CO and CO/CO_2/light gases ratios

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Work Package 4

Biochemical processing and energy efficiency in advanced biofuels production

UFV/UFPE/UFSM/LNBR

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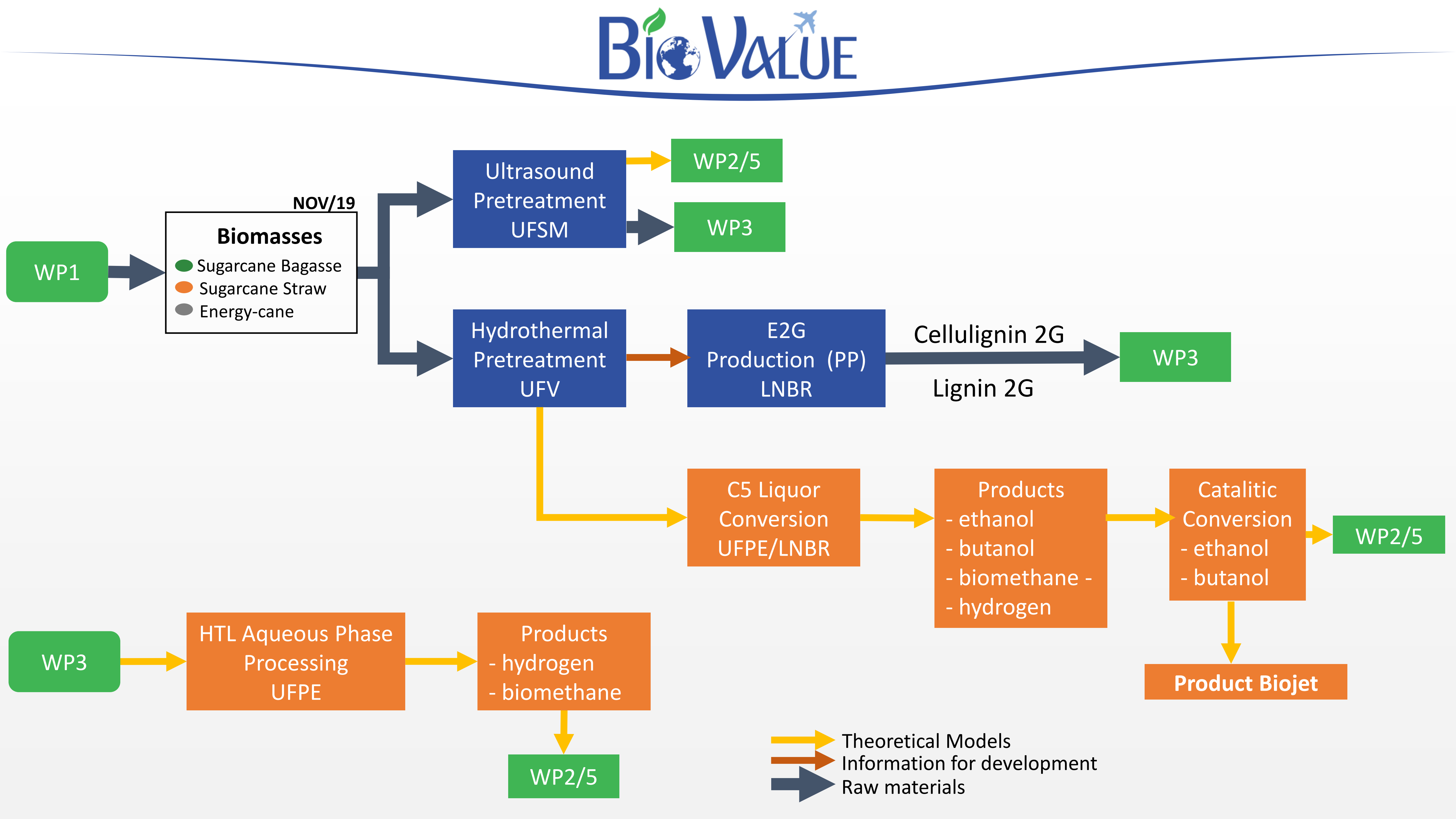
July 6 to 9, 2020

WP4 - Biochemical processing & energy efficiency in advanced biofuels production

- WP4 aims at exploring different strategies to integrate biochemical and thermochemical routes in sugarcane biorefineries (2G and/or 1G).

- Collection of literature, industry and lab scale data on **pretreatment and biochemical conversion processes**, allowing the assessment of different biorefinery configurations for advanced biofuels.



WP1
NOV/19
Biomasses
Sugarcane Bagasse
Sugarcane Straw
Energy-cane
Ultrasound Pretreatment UFSM
WP2/5
WP3
Hydrothermal Pretreatment UFV
E2G Production (PP) LNBR
Cellulignin 2G
Lignin 2G
WP3
C5 Liquor Conversion UFPE/LNBR
Products
- ethanol
- butanol
- biomethane -
- hydrogen
Catalitic Conversion
- ethanol
- butanol
WP2/5
Product Biojet
WP3
HTL Aqueous Phase Processing UFPE
Products
- hydrogen
- biomethane
WP2/5
Theoretical Models
Information for development
Raw materials

Liquid hot water treatment

Grinding, 20 and 80 mesh sieving, extractives removal.

The study will be performed with and without extractive removal.

Moisture < 10%

Biomass residues
Sugarcane straw and bagasse
Energy sugarcane

Water

Liquid hot water treatment (HLT)
120 – 200 °C, 30 – 80 min, biomass/water ratio
Study using experimental design

Solid residues
(celulignin)

E2G – Production (PP)
LNBR

WP3

Liquid residues
(C5 liquor)

C5 Liquor conversion
UFPE/LNBR

BioValue

Chemical characterization

UFV
Universidade Federal de Viçosa

Universidade Federal de Santa Maria
1960

Solid residues
(Celulignina)

Lignin soluble and insoluble
Structural carbohydates
Ashes and minerals
Metais
Cloro
Enxofre

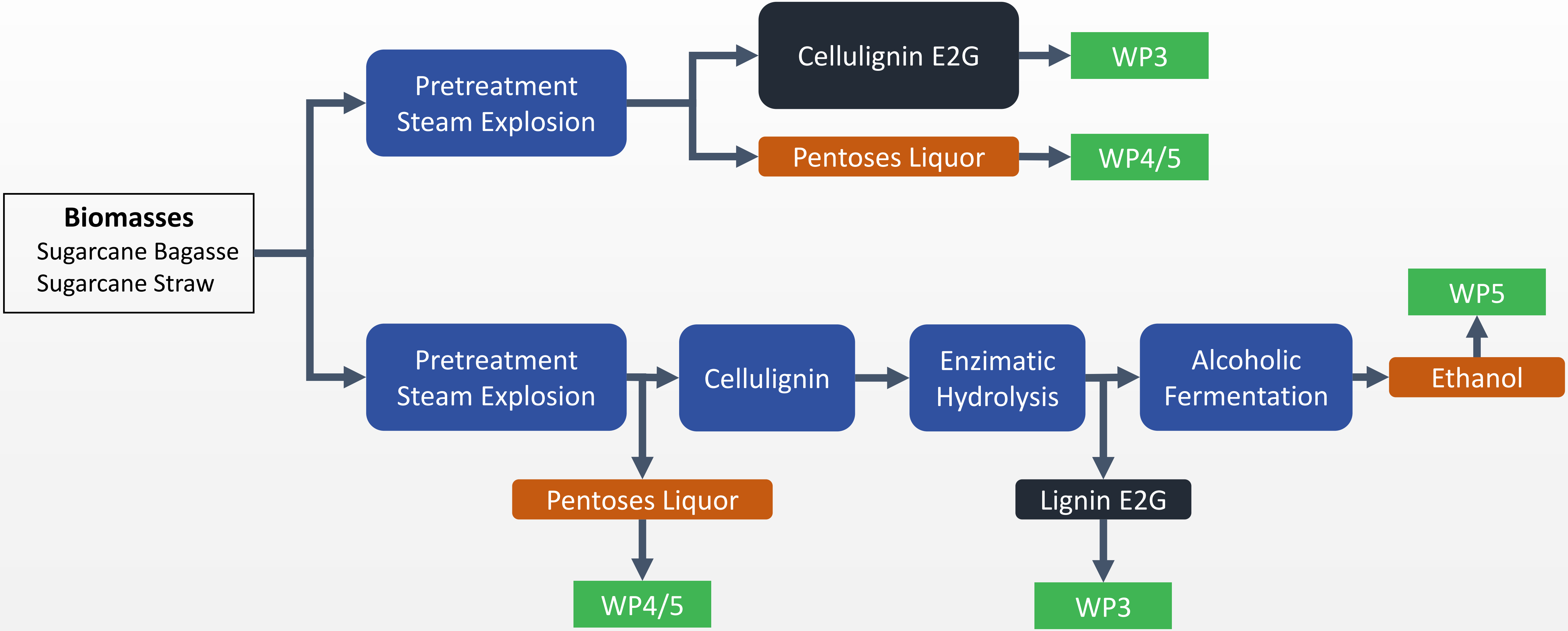
Biomass residues
Sugarcane straw and bagasse
Energy sugarcane

Moisture
Extractive
Lignin soluble and insoluble
Structural carbohydrates
Ashes and minerals (metais, cloro e enxofre)

Liquid residues
(C5 Carbohydrate)

Lignin soluble
Structural carbohydrates
Furanics
pH
Conductivity
Acids
Minerals (metais, cloro e enxofre)

Flow Diagram for the Production of Cellulignin E2G and Lignin E2G in LNBR/CNPEM Pilot Plant (Campinas, SP)



Process Development Pilot Plant (E2G)
LNBR/CNPEM

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Work Package 5

Integrated Market, Value Chain and Sustainability Assessment

LNBR/UFPE/UNICAMP-FEQ/UFU

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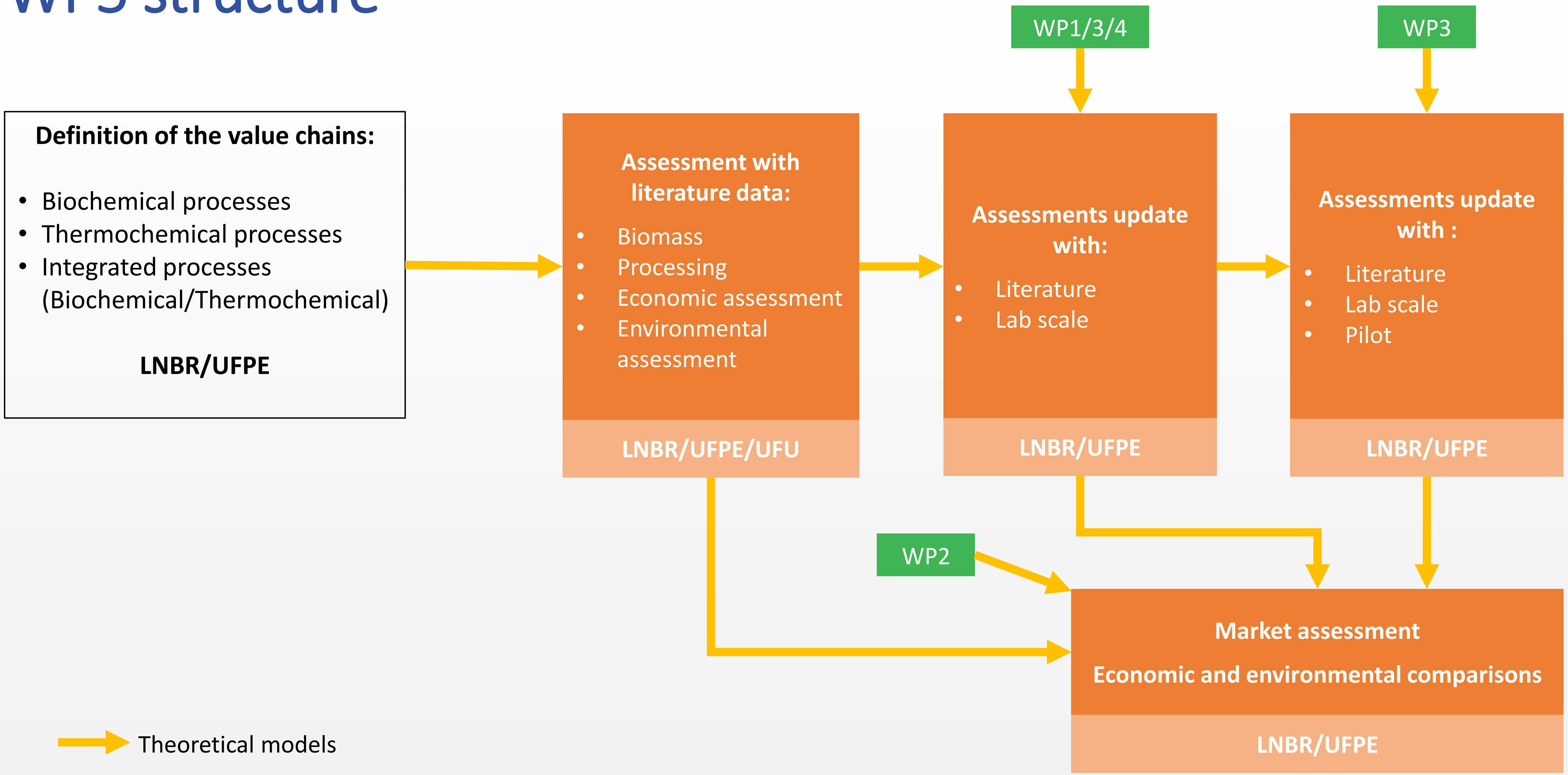
July 6 to 9, 2020

WP5 structure



Example: Definition of a value chain

Biomass

Sugarcane (bagasse)
Sugarcane (bagasse + straw)
Sugarcane (straw)
Energy cane (bagasse)
Eucalyptus
Forest residues (Pinus)
Cellulignin
2G Lignin

Energy densification

Fast pyrolysis (bio-oil)
Fast pyrolysis (bio-oil + biochar)
Slow pyrolysis (biochar)
HTL
None

Processing

Gasification + Cleaning/upgrade + FT
Co-processing
HDO
Stabilization

Sustainability assessment: Virtual Sugarcane Biorefinery (VSB)

model integration

sustainability impacts

- Assess and compare biorefinery alternatives
- Assess stage of development of new technologies
- Optimize impacts

BioValue

VSB structure

Modeling and Simulation

CanaSoft

- Pre-planting
- Soil preparation
- Planting
- Cultivation
- Harvesting
- Sugarcane transport

Biorefinery Simulation (Aspen Plus®)

- Sugars extraction
- Juice treatment
- Fermentation
- Distillation
- Cogeneration
- Others (process-dependent)

Logistics & Use

- Distribution and commercialization
- Fuel efficiency
- Emissions

Integrated Sugarcane Chain

Sustainability Assessment

Economic analysis

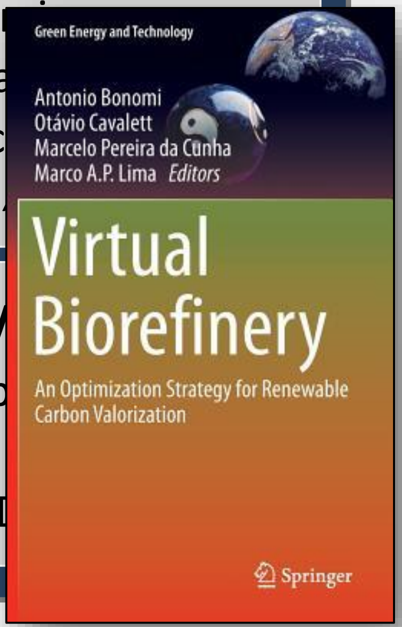
- Investment
- Internal rate of return
- NPV/investment
- Production costs

Environmental analysis

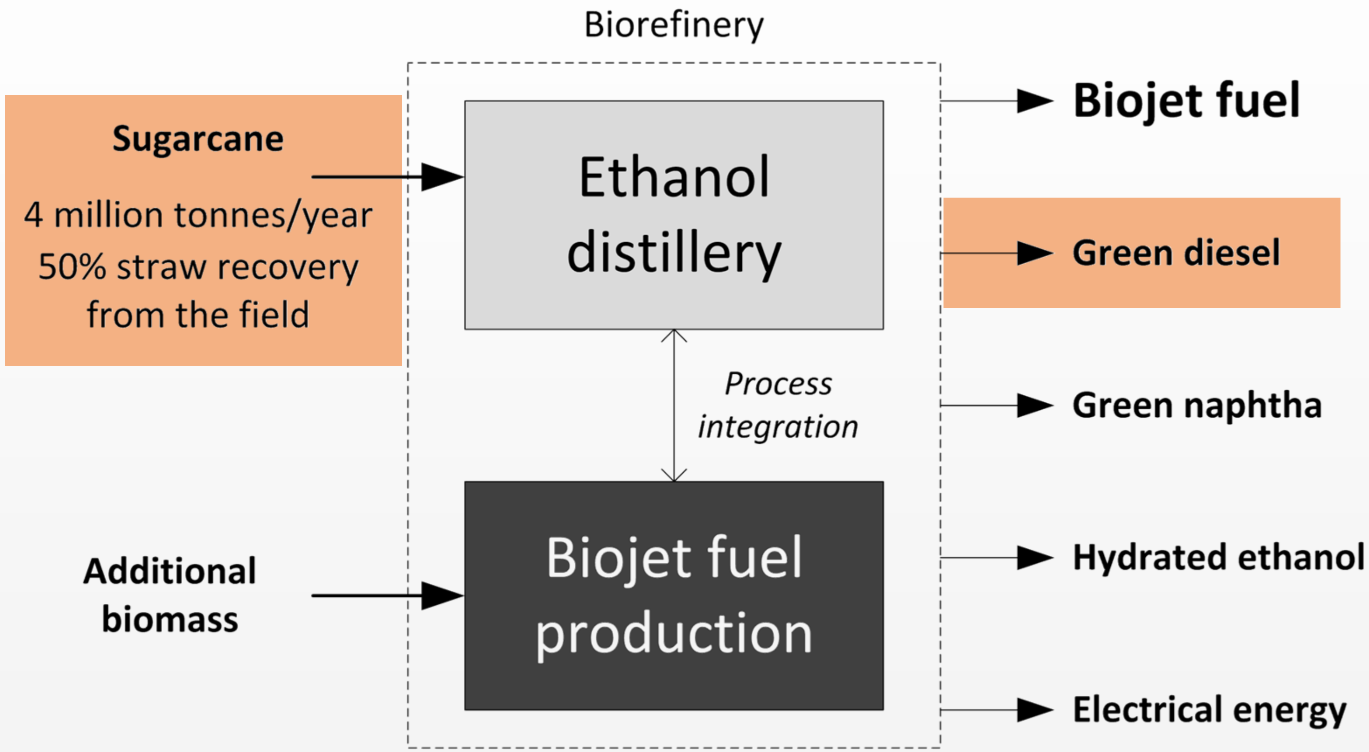
- Global war
- Energy bala
- Local (toxic acidification)

Social analy

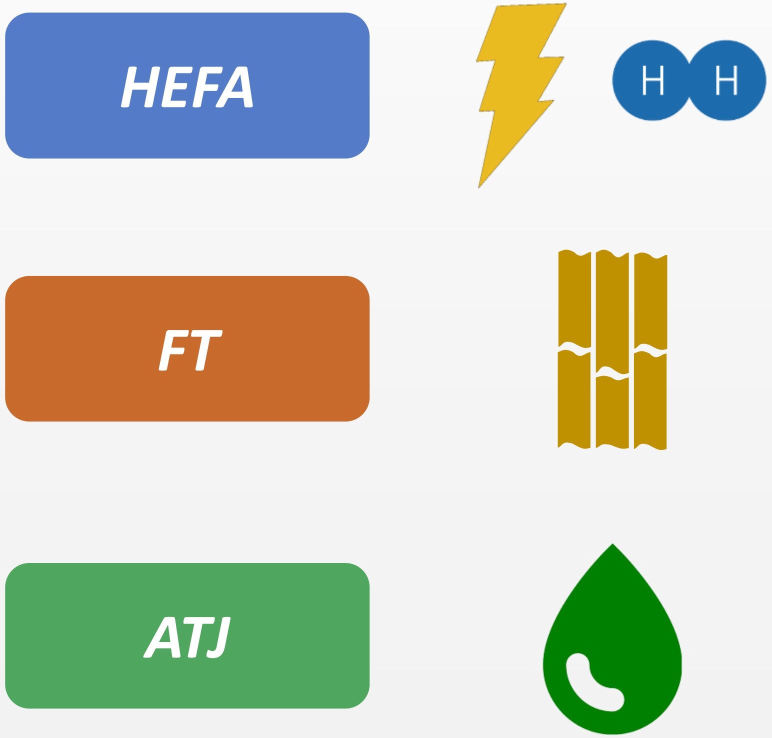
- Created job
- Accidents
- Sectorial HI



Example: Biojet Fuel production – Integration is the solution



Limits for integration:
defining plant capacity



- Base sugarcane mill: 4 MTC/year
- Biorefineries are self-sufficient in terms of energy

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BRAZILIAN GOVERNMENT

Work Package 6

Dissemination, exploitation and data management

UFPE/LNBR

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Objectives

- Organize conferences, webinars and site visits.
- Publish scientific papers, press releases and newsletters.
- Raising awareness on the Project and alternativities of producing advanced biofuels.
- Disseminating the results of the Project.
- Establish a Brazilian-European “summer” school for sustainability assessments.
- Supporting the activities of other WPs for management and exploitation of results.
- Design and implement a strategy for the management of Intelectual Property.

THANK YOU!

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