IEA Bioenergy
Technology Collaboration Programme

Presentation of France
IEA TASK 34
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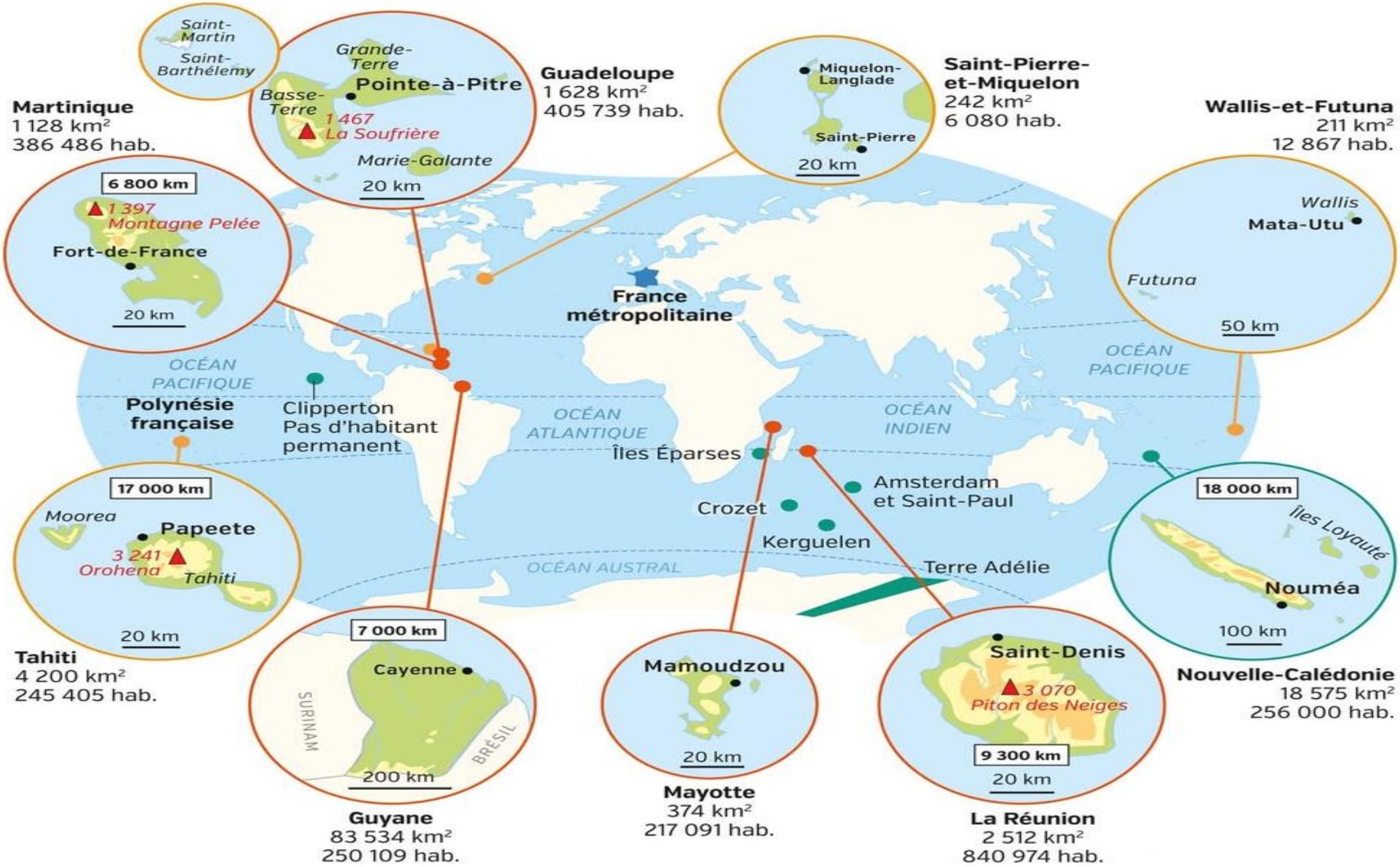
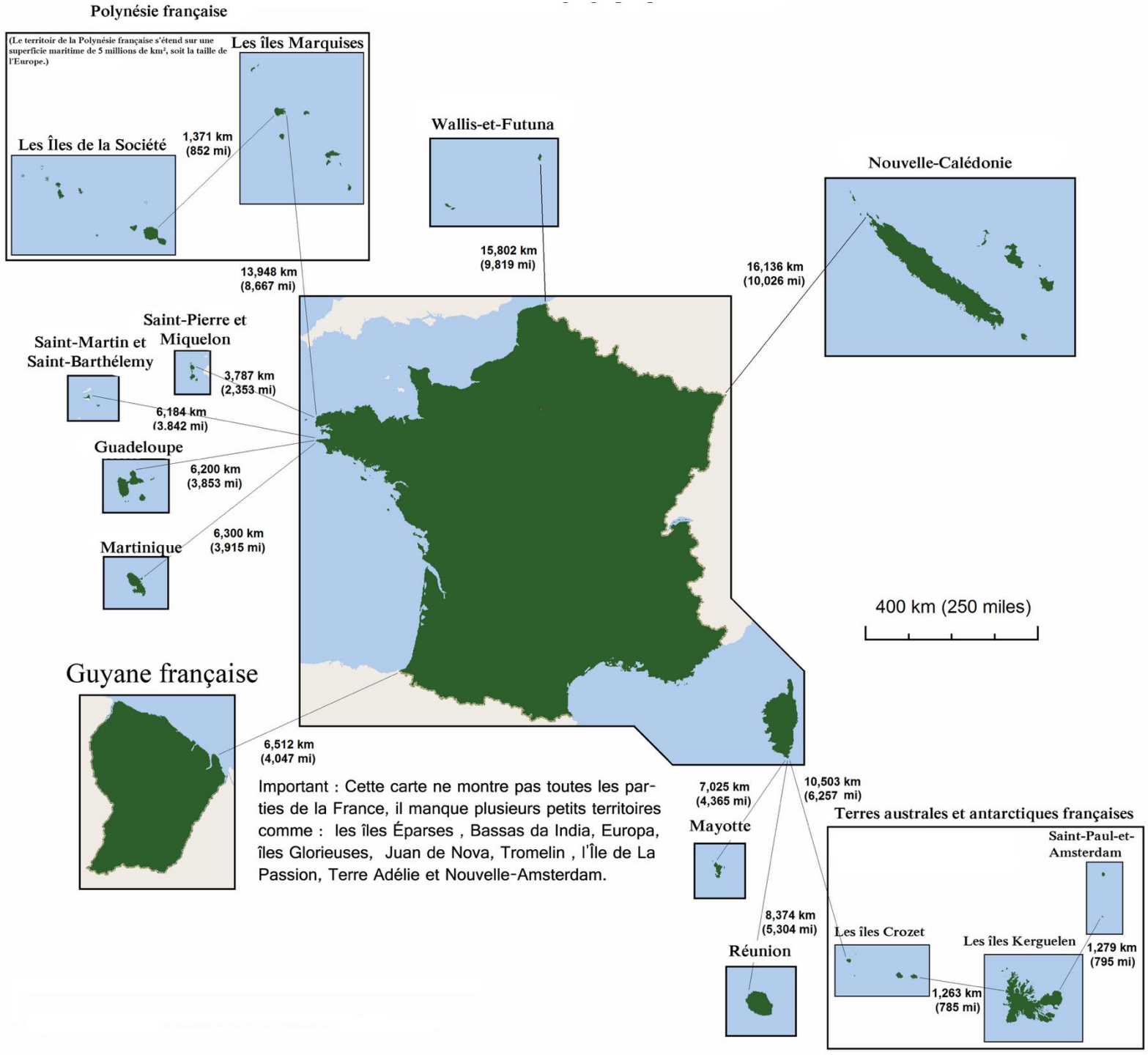
Professor in Chemical Engineering

PhD in 2000 in School of Mines of Albi

Teaching in Master of Chemical Engineering Aix Marseille University	Mechanic, Modelling & Clean Processes Laboratory Aix Marseille University, CNRS, Ecole Centrale Méditerranée
2001 Gasification of biomass	Batch and Continuous bubbling Fluidised bed Characterisation of mineral residue Fate of inorganics Characterisation of fraction in biomass
2006 Wet Air Oxidation	Batch and continuous bubble column Kinetics Heat and Mass transfer
2009 Hydrothermal Liquefaction	Batch and continuous reactor Kinetics Mineral Phase
2022 Partial Oxidation in HTL	Batch Product characterisation


Saint-Martin
Saint-Barthélemy
Grande-Terre
Pointe-à-Pitre
Basse-Terre
1 467
La Soufrière
Marie-Galante
20 km
Guadeloupe
1 628 km²
405 739 hab.
Martinique
1 128 km²
386 486 hab.
6 800 km
1 397
Montagne Pelée
Fort-de-France
20 km
Miquelon-Langlade
Saint-Pierre
20 km
Saint-Pierre-et-Miquelon
242 km²
6 080 hab.
Wallis-et-Futuna
211 km²
12 867 hab.
Wallis
Mata-Utu
Futuna
50 km
France métropolitaine
OCÉAN PACIFIQUE
OCÉAN ATLANTIQUE
OCÉAN INDIEN
OCÉAN PACIFIQUE
OCÉAN AUSTRAL
Polynésie française
Clipperton
Pas d'habitant permanent
Îles Éparses
Amsterdam et Saint-Paul
Crozet
Kerguelen
Terre Adélie
17 000 km
Moorea
Papeete
3 241
Orohena
Tahiti
20 km
Tahiti
4 200 km²
245 405 hab.
18 000 km
îles Loyauté
Nouméa
100 km
Nouvelle-Calédonie
18 575 km²
256 000 hab.
7 000 km
Cayenne
SURINAM
BRÉSIL
200 km
Guyane
83 534 km²
250 109 hab.
Mamoudzou
20 km
Mayotte
374 km²
217 091 hab.
Saint-Denis
3 070
Piton des Neiges
9 300 km
20 km
La Réunion
2 512 km²
840 974 hab.


Polynésie française
(Le territoir de la Polynésie française s'étend sur une superficie maritime de 5 millions de km², soit la taille de l'Europe.)
Les îles Marquises
Les Îles de la Société
1,371 km
(852 mi)
Wallis-et-Futuna
15,802 km
(9,819 mi)
Nouvelle-Calédonie
16,136 km
(10,026 mi)
13,948 km
(8,667 mi)
Saint-Pierre et Miquelon
Saint-Martin et Saint-Barthélemy
3,787 km
(2,353 mi)
6,184 km
(3.842 mi)
Guadeloupe
6,200 km
(3,853 mi)
Martinique
6,300 km
(3,915 mi)
400 km (250 miles)
Guyane française
6,512 km
(4,047 mi)
Important : Cette carte ne montre pas toutes les parties de la France, il manque plusieurs petits territoires comme : les îles Éparses , Bassas da India, Europa, îles Glorieuses, Juan de Nova, Tromelin , l'Île de La Passion, Terre Adélie et Nouvelle-Amsterdam.
7,025 km
(4,365 mi)
10,503 km
(6,257 mi)
Mayotte
Terres australes et antarctiques françaises
Saint-Paul-et-Amsterdam
8,374 km
(5,304 mi)
Les îles Crozet
Les îles Kerguelen
1,279 km
(795 mi)
Réunion
1,263 km
(785 mi)

Overview of biomass and organic waste in France

Public policy :

Since 2015 : « Energy Transition for Green Growth Act » (LTECV)

Public Policy lead by the ADEME ("French Agency for Ecological Transition")
(DENA in Germany, DOE in the US, DEA in Danemark…)

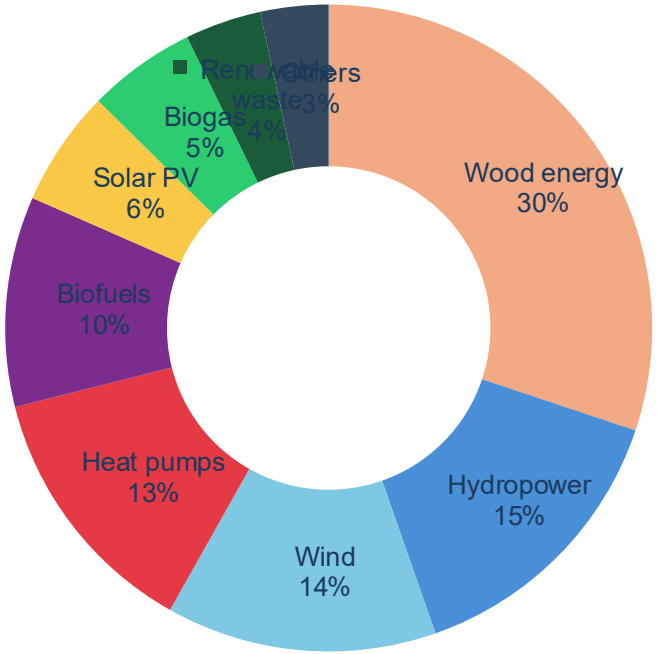
ADEME helps to have the picture to set the final destination (“carbon neutrality in 20250”)

But not the road to use to go up to 22 Mtoe of gas (~60%?) and liquid fuel (~40%?)

Actual Use and Potential

Renewable Energy in France (2023)

Primary energy consumption: 33.4 Mtoe



Source	%	Mtoe
Wood energy	30.1	10.04
Hydropower	14.5	4.84
Wind	13.5	4.50
Heat pumps	12.9	4.30
Biofuels	10.5	3.50
Solar PV	5.8	1.93
Biogas	5.4	1.80
Renewable waste	3.8	1.27
Others	3.4	1.13
TOTAL	(~50%) 100.0	~16 33.36

For comparison :
55 nuclear reactors produces 84 Mtoe primary energy
(28 Mtoe of electricity)

KEY RESEARCH ACTIVITIES

Most players meet in

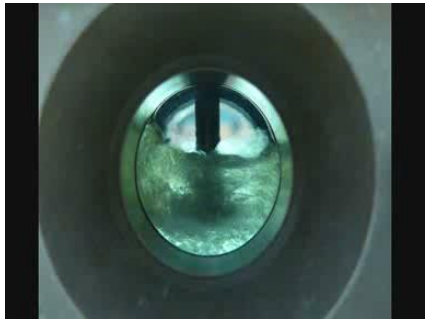
GDR Thermobio

M2P2 Aix en Provence

Continuous reactor (6L/h), Multi injection system (including solids)

Calorimetry for high pressure

Batch reactors with cells and without



LRGP Nancy

Pyrolysis since 1970's. Lédé & Villermaux were pioneers on the concepts of ablative pyrolysis, cyclone pyrolysis reactor and on the study of the softening behaviours of biomass upon pyrolysis.

Various reactors: fluidized, fixed, stirred, screw... at different scales: from g to kg scale. We operate the reactors from vacuum to 150 Bar.

Heat transfers from reactors to biomass particles, mass transfers and hydrodynamics, and kinetics.
Various analytical techniques notably: on-line mass spectroscopy, (in-situ) NMR of bio-oil and chars, GC/MS, etc.

Reflux (like a "distillation" packed bed) is of high interest to control the molecular weight of liquids from plastics pyrolysis (to convert waxes to liquids).

Softening and charring behaviours of various biomasses for the first time by in-situ rheology and in-situ NMR.

CIRAD Montpellier (International Centre for Agricultural Research for Development)

- Actively involved in pyrolysis research for over 40 years.
- Recognized expertise in bio-oil analysis.
- Members, (some abroad) with expertise in fixed-bed reactors operating under autothermal or allothermal conditions and fluidized bed
- 600 m² experimental platform. lab-scale pyrolysis reactors for batch experiments (ranging from a few milligrams to 20 grams of biomass), as well as pilot-scale reactors capable of processing up to 10 kilograms of biomass in batch or continuous mode.
- A dedicated characterization laboratory supports detailed analysis of charcoal properties and bio-oil composition. Both laboratory and pilot reactors are also equipped to perform char activation.
- mobile sampling system allowing on-site measurements

GEPEA Nantes

- Continuous Hydrothermal liquefaction Pilot
- Microalgae recator

CEA[2] Liten - Grenoble

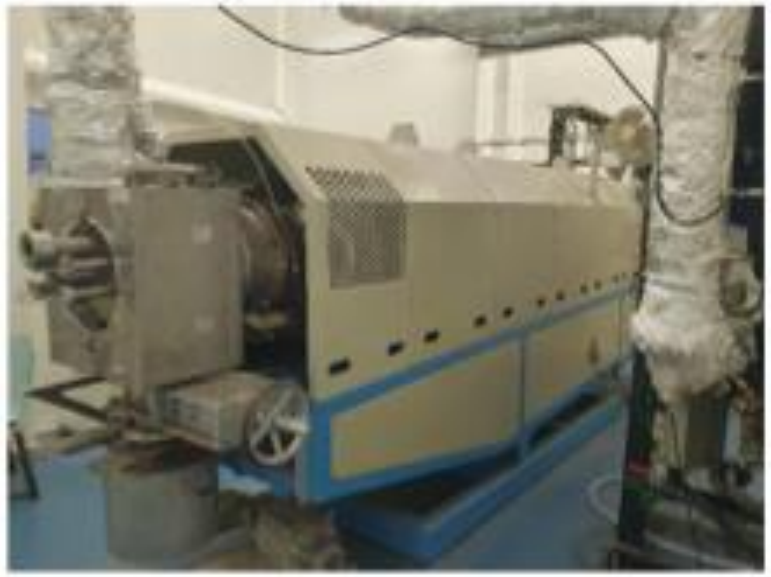
HTL. directly linked to Microalgae culture

Continuous reactor : 0,5 L; 2-3 L/h; RPA (300 rpm)

Technical and economical evaluation

RAPSODEE Albi

- Rotating Reactor : Up to 10 kg/h of biomass in pellet form, up to 900°C under different atmospheres, Residence time and solid/gas/wall contact can be adjusted



Liquéfaction :

Batch reactors of 5 mL and 500 mL
250°C < T < 600°C, P < 400 bar

- Small scale home made TGA for mechanistic studies

IFP*EN*- Lyon

- Catalytic hydropyrolysis (on going with very few information right now)

- Devlopment of calalyst for many applications

and patented processes for biomolecules as BioTcaT with their commercial subsidiary *Axens*

Others :

- Catalysts :

A lot of lab of chemistry are acting in the catalyst development for hydrotreatment

- TOTAL énergies : studying DTL and hydrotreating

- Charcoal producer : use of the liquid fraction (Bordet, Demio)

- Eiffage : Bituminem

Merci

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