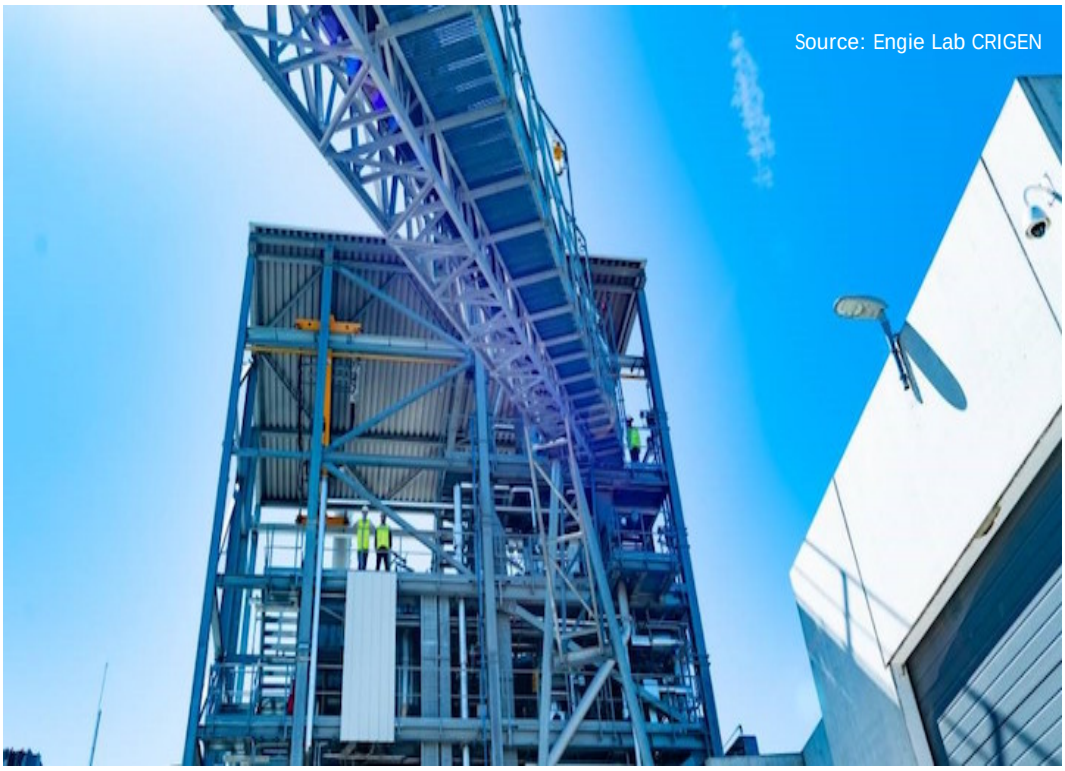
IEA Bioenergy
Technology Collaboration Programme

Biomass and waste pyrogasification in France

Country Report France 2020

IEA Bioenergy: Task 33

December 2020



Biomass and waste pyrogasification in France

Country Report 2020

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Introduction

This report provides an overview of current stakeholders, activities and implementations within the sector of thermochemical treatment (pyrolysis, gasification) of biomass and waste in France. The list of actors and projects cited does not claim to be exhaustive.

In this document, the term 'pyrogasification' is used in order to include both pyrolysis and gasification.

1. General Overview

I. PERSPECTIVES ON DECARBONISING OUR ENERGY CONSUMPTIONS

Gas is essential to the balance of the French energy mix and must therefore be decarbonised

Gas energy, associated with its transport and distribution infrastructures, constitute a key element of the current French energy system, giving it a great adaptability - thanks to a territorial network: to varying needs depending on the location - and thanks to important storage capacities: to the level of consumption. Widely networked on the territory, the gas grids make it possible to store around 130 TWh, i.e. a third of the current annual national consumption, and thus allow great flexibility in the distribution of production and consumption.

Beyond the reductions in energy consumption permitted by energy sobriety and efficiency actions, the increasing integration of renewable energy makes it possible to decarbonize the remaining uses: in particular, the joint development of several renewable gas production sectors (anaerobic digestion, pyrogasification, power-to-gas or hydrothermal gasification) comes in response to the urgent need to decarbonize our energy consumption and free us from fossil fuels. These production methods, based on the valuation of available territorial resources as close as possible to needs and on the emergence of new circular economy models, will make it possible to reach for carbon neutrality by 2050.

France has the resources to reach 100% of renewable gas in its grids by 2050

An ADEME study[1] published in 2018 demonstrates that a 100% renewable gas mix is possible by relying on a combination of renewable and low-carbon energy sources (biomass, wind, PV, etc.).

This report analyses the technological and economical feasibility conditions for a gas system based 100% on renewable gas by 2050 and proposes different development scenarios based on the resources available in our territories and on the prospects for a decline in our overall gas consumption by 2050.

Considering the conversion efficiencies, the theoretical potential of primary resources identified could produce up to 460 TWh_{LHV} of injectable renewable gas:

- 30% could be supplied with the mature anaerobic digestion process, which converts agricultural inputs, bio-waste and algae residues to produce up to 140 TWh of gas;
- 40% could be supplied by the pyrogasification process on wood and its derivatives, solid recovered fuels (SRF) and a small fraction of agricultural residues, to produce up to 180 TWh of gas;
- 30% could be supplied by power-to-gas in the context of a 100% renewable electricity mix aimed at maximizing the production of synthesis gas, ie 140 TWh of gas.

[1] « Un mix 100% gaz renouvelable en 2050 ? » - ADEME (2018)

According to this prospective study, the production potential of 460 TWh of injectable renewable gas is therefore more than sufficient to achieve a 100% renewable gas mix in 2050, by which time the total gas consumption of the network should reach around 286 TWh.

II. CURRENT SITUATION OF THE PYROGASIFICATION SECTOR IN FRANCE

Pyrolysis and gasification technologies allows to produce non-intermittent renewable with a great flexibility: they can be adapted to the resources and needs of the territories, allowing the development of new circular economy models or the implementation of decentralized production of fuels or renewable and low-carbon gas that can be injected into the grids.

The French gasification sector is dynamic and willing to contribute to the energy transition

French local stakeholders, whether they are managers of resources (biogenic residues, waste from activities, solid recovered fuels, etc.) or large energy consumers (industries), show a growing interest in these technologies, which provide a new response to the challenges they face.

With a wide variety of stakeholders, the sector relies on young innovative companies, SMEs, but also on waste managers (waste management unions, large companies) and major players in the French energy industry, including gas infrastructure operators.

Projects (some of which are presented later in this document) are currently multiplying according to very varied implementation plans, clearly illustrating the versatil and adaptable nature of this sector. In France, first-rate advances are to be welcomed: for example, the GAYA platform managed by Engie Lab CRIGEN recently announced that it had produced synthetic methane from SRF, an accomplishment that paves the way for new energy recovery processes for resources that lack outlets to date.

Concrete public support actions are still pending

The French Pluriannual Energy Programming recognizes the potential of pyrogasification without, however, making any significant commitment to its development.

In short, the actors today need:

- Regulations adapted to the technologies, capacities and aimed uses (in particular: biomethane, hydrogen, advanced biofuels productions);
- Financial support from public authorities allowing to launch the commercial development of the sector (eg. calls for projects for the production of bio/low carbon SNG injected into the gas networks , of hydrogen and of biofuels, CHP projects that use SRF, chemical recycling, etc.).

Despite public support being slow to be put in place, companies and communities are committed to support the sector and administrations are now working to establish strategic lines of support. An on-going ADEME study, which first results are expected in the first half of 2021, aims in particular at "guiding their choices of positioning and actions" related to pyrolysis/gasification support.

The current situation in France

1. The end of support for cogeneration units using biomass

The last French Pluriannual Energy Programming (PPE) ended support to biomass CHP:

"Given the cost of producing electricity from biomass, in order to optimize the overall cost of achieving renewable energy targets and to promote greater energy efficiency, support for these sectors will be reserved. to heat production. No biomass cogeneration call for tenders will be launched during the PPE period"

As presented in the document, some pyrogasification projects nevertheless benefited from the last call for projects aimed at supporting the establishment of cogeneration units from biomass.

2. Future opportunities for the production of hydrogen, methane and advanced biofuels

The stakeholders in the pyrogasification sector are waiting for the opportunities being developed within the framework of:

- The national hydrogen strategy: actions in favor of the support and traceability of hydrogen produced from the pyrogasification of biomass / waste
- Experimental contracts for innovative production of renewable gas: introduced in the Climate-Energy Law, these calls for projects should provide support for the establishment of the first industrial units for the production of synthetic methane from pyrogasification of biomass/waste.

2. The French pyrogasification sector

I. PROFESSIONAL ASSOCIATIONS

1. Association Technique Energie Environnement - Club Pyrogazéification

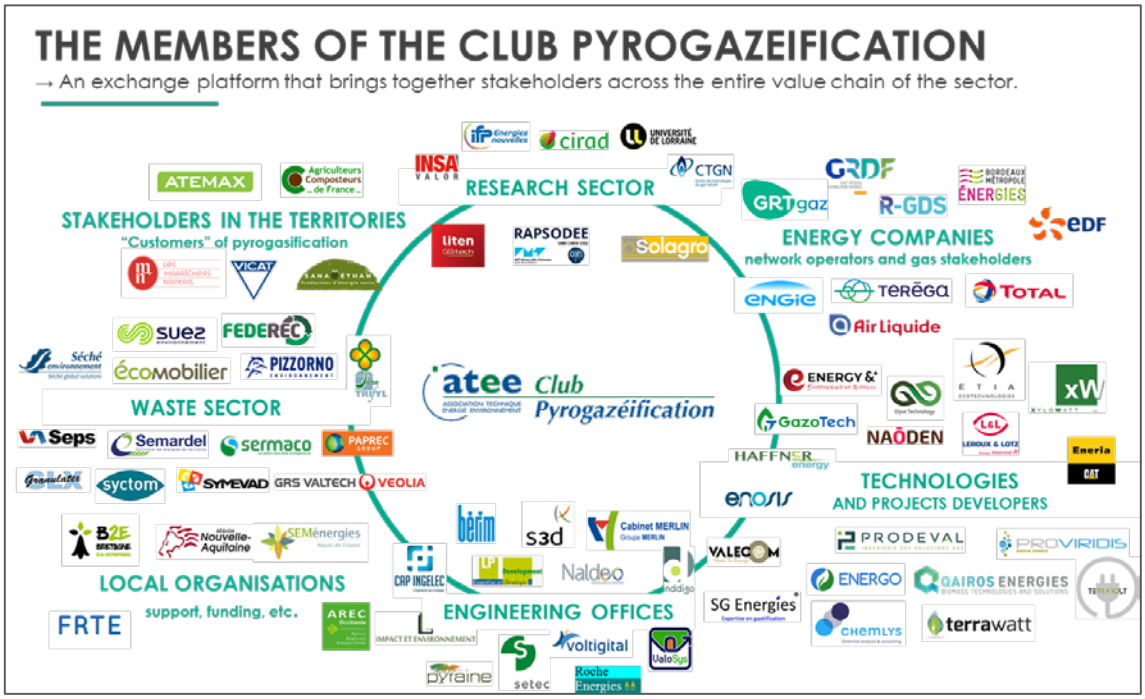
The “Pyrogasification Club” (French Club Pyrogazéification) is a professional association, part of the French Technical Association for Energy and Environment (ATEE), gathering the main stakeholders in the sector (pyrolysis/gasification of biomass and waste) across its entire value chain: biomass and waste managers, manufacturers, "end customers" (industries), equipment manufacturers, engineering offices, laboratories and researchers, gas network managers, major energy companies, etc.

The Pyrogasification Club was created in 2014 by stakeholders who wanted to bring the French sector together. In October 2019, the Club joined ATEE, the objectives of this merger being:

- Continue to structure and build up the sector;
- Strengthen the resources allocated to the Club’s activities;
- Strengthen the bond between the different "Green Gas" sectors, already represented at ATEE by the Biogas and Power-to-Gas Clubs.

The Club’s missions are:

- To structure and to lead a collaborative exchange platform by promoting the sharing of feedback and collaboration between members;
- To bring the common voice of stakeholders to the public authorities by relaying stakeholders' expectations and being a source of proposals to public authorities;
- To communicate, inform and maintain a sector regulatory and technical watch and to participate in events, to publish resources in order to raise awareness regarding the sector, to inform members by providing them with information on news of interest for the sector (ongoing consultations, legislative and regulatory changes, launch of a call for projects, etc.).



The Club Pyrogazéification's members list can be seen on the ATEE website[2].

Web: https://atee.fr/energies-renouvelables/club-pyrogazeification
Contact:
Madeleine ALPHEN – General Delegate of the Club Pyrogazéification (ATEE)
Tour Eve, 1 place du Sud, 92800 Puteaux - FRANCE
Email : m.alphen@atee.fr

2. Other associations:

Some other associations, such as the French Gas Association (AFG), support the development of the pyrolysis-gasification sector as a promising way to produce renewable/low-carbon gases to replace natural gas in the networks.

Web: https://www.afgaz.fr/pyrogazeification/

II. RESEARCH INSTITUTES

1. Atomic Energy and Alternative Energies Commission (CEA) - LITEN

The French Atomic Energy and Alternative Energies Commission (CEA) is a public scientific, technical and industrial research body (EPIC). As a major actor in research, development and innovation, the CEA operates in four areas: defense and security, low-carbon energies (nuclear and renewable), technological research for industry and fundamental research. Relying on a recognized expertise capacity, the CEA participates in the establishment of collaborative projects with numerous academic and industrial partners.

Having initially developed skills in the recovery of cellulosic biomass by gasification, LITEN, a CEA Tech institute, then turned to alternative waste treatment processes with a high calorific value: household waste, food residues and sewage sludge, for example.

[2] https://atee.fr/nous-decouvrir/annuaire-adherents/entreprises?club=33&secteur=All&region=All&az=All&keys=&page=0

CEA Liten's expertise in gasification processes (thermochemical route) covers all stages of resource treatment.

The GENEPI R&D Platform: Gasification Equipment for New Energy dedicated to a Platform of Innovation[3]
In order to have relevant research equipment to meet national and international production objectives for the recovery of bioresources for the production of energy and in particular of advanced biofuel (liquid or gaseous), the GENEPI project consists of developing an experimental entrained flow gasification tool capable of operating at high pressure and high temperature, associated with a preparation unit (roasting and grinding). A tool for modelling and simulating the operation of the gasifier under development at CEA Grenoble could be validated using the results obtained on this equipment. Winner of the second wave of the call for projects for equipment of excellence of the Future Investment Plan, the GENEPI project, led by CEA Liten, CIRAD and the RAPSODEE Laboratory of the Albi School of Mines - Carmaux, received a subsidy of € 3.85 million, for the development of a unique research platform dedicated to the development of innovative and efficient sectors of energy production from bioresources.

Established on the CEA site in Grenoble, the GENEPI platform includes 5 equipment dedicated to the grinding, drying, torrefaction and gasification of bioresources in an entrained flow reactor. The purpose of this platform is to provide French industry with the means to develop competitive processes and products. Open to research projects with external industrial and academic partners, several large-scale operations are underway, in particular on the pre-treatment and gasification of solid recovered fuels (SRF) and the torrefaction of forestry and agricultural resources.

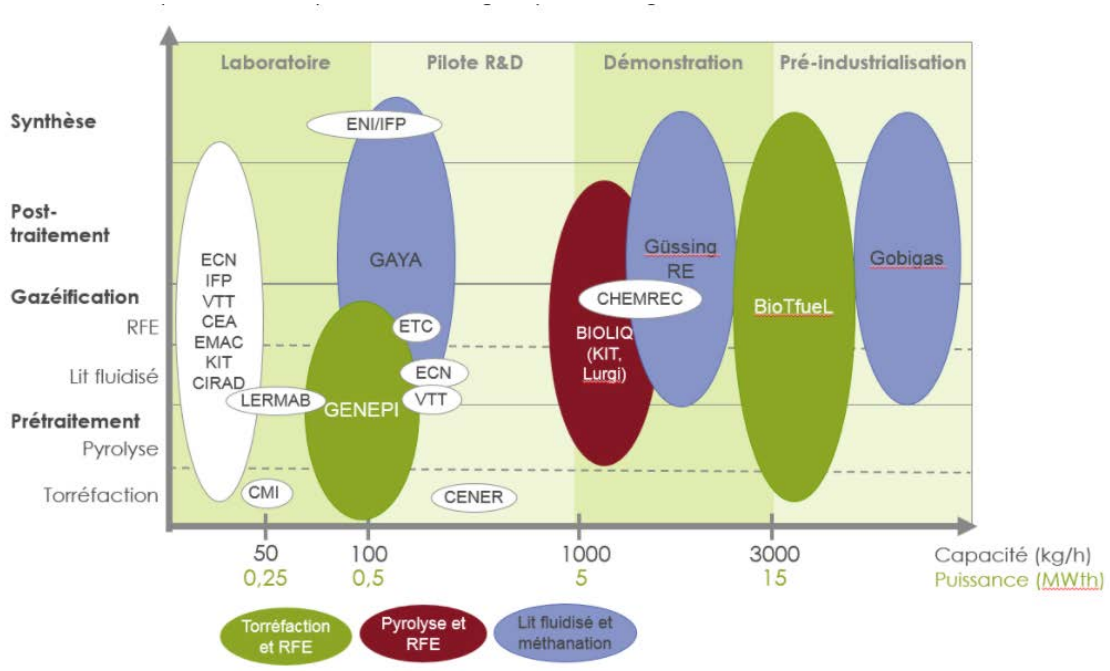


Figure 1 - Positioning of the GENEPI R&D platform in the European sector (source: CEA LITEN)

The Labs
The Bioresource Preparation Laboratory (LPB) works on the characterization, preparation and pre-treatment of the resource with a view to its thermochemical conversion. The labs work on technologies of drying, grinding, roasting and pyrolysis of biomass and waste.

The Bioresources Thermo-Conversion Laboratory (LTCB) works on the recovery of biomass and waste into energy (heat, electricity), 2G and 3G biofuels and molecules of interest for chemistry. It has developed strong skills in

[3] Source: CEA website - https://www.cea.fr/cea-tech/liten/genepi/Pages/Projet/detail.aspx

the gasification processes and technologies of dry (fixed bed, fluidized bed, entrained flow reactor) and wet (hydrothermal liquefaction, supercritical water gasification) resources. It is equipped with many analytical devices allowing to characterize the products (gas, bio-oil, bio-crude, char), study the reaction kinetics, analyse the organic and inorganic gases present in the fumes and their interactions with the materials.

2. Interprofessional Committee for Wood-Energy (CIBE)

The Interprofessional Committee for Wood-Energy (CIBE) was created in 2006. It coordinates and supports the players in collective and industrial wood heating to professionalize practices, train professionals and promote high and medium-power boiler rooms to public and private decision-makers.

It brings together 150 companies, owners (public and private), professionals in the wood industry and the world of energy.

In 2019, CIBE carried out a status study on wood gasification in France at the request of ADEME, the French ecological transition agency.

Web: https://cibe.fr/

3. Center for International Cooperation in Agronomic Research for Development (CIRAD)

The Center for International Cooperation in Agronomic Research for Development is the French organization for agricultural research and international cooperation for the sustainable development of tropical and Mediterranean regions.

BioWoodEB: Technical diagnosis of biomass pyrolysis and gasification processes
Along with its knowledge of the processes, CIRAD has developed expertise in the collection, sampling and analysis of products from pyrolysis and gasification.

This skill is essential for evaluating the operation of a reactor, for diagnosing faults and for optimizing processes. It also makes it possible to measure the potential environmental impacts of the processes. A portable sampling line has been specially designed in Montpellier to analyze permanent gases in situ and sample condensable products. This skill has been implemented with private companies in France, Europe, Brazil and China.

Web:
https://www.cirad.fr/
https://ur-biowooeb.cirad.fr/expertises-produits/expertises-biomasse-energie/diagnostic-procedes-de-pyrolyse-gazeification-de-biomasse

4. IFP Energies Nouvelles

IFP Energies Nouvelles (IFPEN) is a major player in research and training in the fields of energy, transport and environment. From research to industry, technological innovation is at the heart of its action. IFPEN operates in four main areas: Sustainable mobility, Renewable energies, Responsible fuels, Climate, environment and circular economy.

IFPEN research teams work on one or more of three complementary objectives:

- Developing economical transport with low environmental impact,
- Producing fuels, chemical intermediates and energy from renewable sources,
- Producing fuels and chemical intermediates with low environmental impact from fossil resources.

Among others, IFPEN works on the BioTfuel project, described later in this document.

Web: https://www.ifpenergiesnouvelles.fr/

5. IMT Mines Albi - RAPSODEE

The RAPSODEE laboratory (Albi Research in Process Engineering for Divided Solids, Energy and the Environment) has been associated with CNRS[4] since 2001 as a UMR (joint research unit). The laboratory's activities are structured into two research groups that conduct research in the fields of energy (renewable energies: solar and biomass), the environment and particulate engineering with particular emphasis on sustainable processes: more intense, more energy efficient, more environmentally friendly and safer.

THE VALTHERA PLATFORM

Located near the city of Albi, VALTHERA is a technological platform specializing in the development of high energy efficiency thermal processes for the recovery of residues and by-products of biomass transformation. These abundantly available resources can be valued in the form of energy or value-added materials.

VALTHERA offers a technological offer including thermal processes (drying, combustion, gasification, etc.) using, in certain cases, a renewable energy source (solar). It also offers high-performance equipment for the treatment of emissions and various pollutants.

The platform has a role of disseminating to companies, and in particular SMEs wishing to complete research and development programs, to demonstrate the feasibility of the project or to extrapolate a process.

Web:
https://www.imt-mines-albi.fr/fr/rapsodee
https://www.imt-mines-albi.fr/fr/plateforme-valthera

6. INSA VALOR – PROVADEMSE platform

INSAVALOR is the Research & Development, Valuation and Continuing Education subsidiary of INSA (national institute of applied sciences) Lyon. INSAVALOR promotes relations between laboratories and companies looking for technological solutions, skills and training for their innovative projects.

Its role: to identify the needs of companies in terms of knowledge and technology, training and mobilize scientific teams in order to bring out innovative responses.

The platform PROVADEMSE

PROVADEMSE is the technological innovations platform of INSAVALOR, the subsidiary of valorisation of the INSA (Applied Sciences National Institute) of Lyon. Their experts help and support the development of ecotechnologies in being a linking unit between research and industry. They develop and experiment technical and innovative solutions regarding the remediation of soils and sediments, as well as the waste repurposing into materials and energy. Certified by the competitiveness cluster AXELERA in 2008, PROVADEMSE has been highly supported since its creation by the Ministry of Industry, DRRT, the Region Rhône-Alpes-Auvergne, the Metropole of Lyon and the FEDER funds.

Areas

PROVADEMSE expertise covers the entire technical process from on-site sampling to support for implementation on an industrial scale, providing concrete solutions in the following areas:

- Waste characterization and management
- Environmental characterization
- Soil and sediment decontamination
- Waste recovery into new materials
- Valorization of waste into energy resources

[4] French Scientific Research National Center

- Industrial and territorial ecology

Expertise
- Characterization of waste with a view to optimizing their management
- Soil and sediment treatment feasibility study
- Assessment of the potential for integrating waste into new construction materials for building or civil engineering
- Production of alternative energies from waste by thermal or biological means

Means
The technological platform has substantial equipment available for studies from a laboratory scale to a trial scale. This allows them to carry on to the industrialization scale. PROVADEMSE provides the skills of engineers, researchers and technicians on one hand, and technical resources, laboratories, testing platforms and equipment on the other.

Technical means:

- Equipment for sorting, grinding, drying on an industrial scale, bio-physico-chemical and ecotoxicology laboratory
- Heat treatment pilot (desorption, pyrolysis), biological treatment pilot, washing pilot
- Leaching and percolation laboratory, pilot scale and demonstrator evaluation devices (lysimeters, road boards)
- Pre-industrial scale gasification pilot and methanization pilot

Web:
https://recherche.insavalor.fr/plateformes-technologiques/provademse
https://www.provademse.com/homepage

7. SOLAGRO

Solagro is an association company specializing in engineering, consulting and training in the fields of agriculture, environment and energy. Their approach combines support for achievements (studies and project management assistance), foresight, training and R&D.

The diversity of their levels of intervention, from individual projects to European public policies, allows Solagro to combine proximity and perspective in the advice they provide to their contacts. Their independence from any equipment supplier or manufacturer guarantees their sponsors results guided exclusively by sustainability objectives (economic, social and environmental).

Study: Towards 100% renewable gas in France in 2050? (2018)
At the start of 2018, ADEME, GRDF and GRTgaz published the results of a study on the feasibility of a "100% renewable gas mix in 2050" (cited in part I.1 of this document). Solagro carried out this work with great interest with the support of an expert in "gas" infrastructures. This study is a continuation of ADEME's work to concretely explore the feasibility and conditions for implementing the energy transition in France.

The summary of the study is available on the ADEME website.

Web:
https://solagro.org/index.php
https://solagro.org/vers-un-gaz-100-renouvelable-en-france-en-2050-40-actu-81

8. University of Lorraine – LERMAB

LERMAB is a multidisciplinary research laboratory of the University of Lorraine linked to INRAE Nancy-Lorraine as USC (Unit under contract). It has two main locations in Vandoeuvre within the Faculty of Science and Technology and Epinal in the ENSTIB (Engineer's school of Wood Science and Timber technology), and partly in

Longwy in IUT.

The permanent staff consists of just over 40 academics with expertise in different scientific fields (physical and organic chemistry, mechanics, chemical engineering, biology). The non-permanent staff has about 40 graduate students, post-docs, contract scientists and undergraduate trainees (BS and MS).

With the various scientific skills of the staff, LERMAB is developing a research on wood and natural fibers, ranging from the molecular level to the macroscopic level of the material, even til wooden structures.

By its specific position related to the multidisciplinary nature of its research on wood, LERMAB is playing a special role as an interface between academic research and wood industries. Basic and applied research is developed through collaborations with different Technology transfer centers such as Critt Bois or CETELOR (for textile industry) within the cluster 'Fibers'.

Research activities

The laboratory's activities structured around wood material are divided into three main research axes in which each LERMAB teacher-researcher is involved according to their skills and initial training.

- "Materials and Processes" axis
- "Chemical Valorization, Energy and Processes" axis
- "Energy, Mechanics, Wood Construction" axis

The consistency of this structuring lies in the fact that each of the proposed axes brings together research activities with relatively similar purposes based on a well-identified disciplinary skills base providing scientific cohesion to each axis. Transversal actions between each of these axes then come to complete the device allowing to have a multidisciplinary multi-scale and multi-physical approach of a research project when this proves necessary.

Chemical, Energy and Process Recovery

The "Chemical, Energy and Process Recovery" axis aims to replace part of fossil fuels with renewable resources. The common point of the research carried out in this area concerns the valorisation of lignocellulosic biomass for applications in the energy and chemical fields. The research themes included in this axis concern the biorefinery, the development of building blocks for chemistry, the synthesis of bio-based molecules (surfactants, solvents, etc.), the chemical recovery of extractables, the production of energy by dry routes (combustion, gasification and pyrolysis) and wet routes (liquefaction, bioethanol…).

Web:
http://lermab.univ-lorraine.fr/
http://lermab.univ-lorraine.fr/presentation-generale

III. OPERATING UNITS AND PROJECTS

ATEMAX PROJECT

Atemax, a subsidiary of the Akiolis group specializing in the collection and recovery of waste and meat by-products, has identified gasification as a solution for recovering its waste and decarbonising its energy uses.

Located in St Langis-Lès-Mortagne in Orne, the Atemax plant manufactures animal fat and protein flour from the treatment of various meat wastes (animal carcasses from farms and the food industry) collected in 20 different departments. Each waste is attached to a sanitary category: category 1 being considered “at risk”, category 1 flour must be destroyed.

To date, category 1 flour is used and recovered in the form of heat in cement kilns. However, truck transport to the cement plants, located within a 200 to 300 km radius of the Atemax plant, represents a significant

financial and environmental cost to the company.

The installation of a gasifier, with an investment of between 12 and 15 M €, aims to convert 29,300 tonnes of category 1 flour into syngas and will lead to the creation of a job dedicated to the maintenance of the installations. The syngas would be used on site to decarbonise the energy consumption of the company and to produce and sell electricity by cogeneration. This project is currently under study, the facilities should be launched by the end of 2022.

This animal meat-and-bone meal (described today as ultimate waste) recovery process already exists in Europe but would be a first in France. In a very competitive context, such a circular economy scheme has many advantages for this industry: empowerment through the management of its own waste which becomes a resource, reduction in carbon and pollutant emissions through the decarbonization of its energy uses and the elimination of waste transport by truck, the savings made on the purchase of energy (the consumer becomes a producer) and the additional income through the resale of the electricity produced.

The environmental authorization application file for this project was submitted in October 2020.

Web:
https://www.atemax.fr/fr
https://atee.fr/actualite/des-farines-animales-valorisees-en-gaz-une-premiere-en-france-et-un-modele-deconomie

DALKIA – DALL ENERGY: ROUEN HEATING NETWORK

In 2017, the city of Rouen launched a consultation with a view to renewing the public service delegation contract relating to the heating network of the cities of Rouen (part of it), Bihorel, Bois-Guillaume and Darnétal. This perimeter, corresponding to a significant extension of the historical network, now constitutes the “Petite Bouverie” heating network.

The innovative proposal from Dalkia, the historical delegate of this network created in the 1960s, was adopted for the concession and operation of this heating network. Through this renewal, the Metropolis aims to achieve the energy transition of the network with the creation of biomass boilers, and to expand it significantly. The duration of the public service delegation is scheduled for 24 years.

In December 2020 took place the lighting of the first flame of the new 17MW wood boiler. This installation includes a Dall Energy (Danish company) broad spectrum biomass boiler, which is based on a staged combustion boiler (updraft gasification and separate gas combustion). This allows the combustion of so-called "singular" biomass composed of bark, dry products, flax stems, wet willow pruning, bocage wood. This type of biomass comes mainly from the territory of the metropolis.

The boiler is combined with a "Terraotherm" condenser and a flue gas scrubber for 5.4 MW.

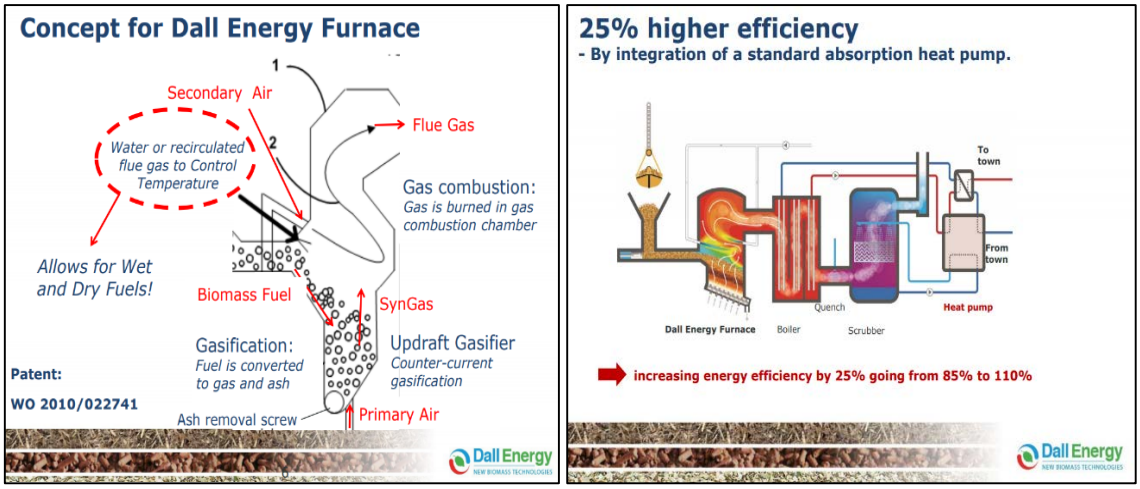


Figure 2 - Concept for Dall Energy Furnace (left) and Integration of a standard absorption hear plant (illustration: Dall Energy)

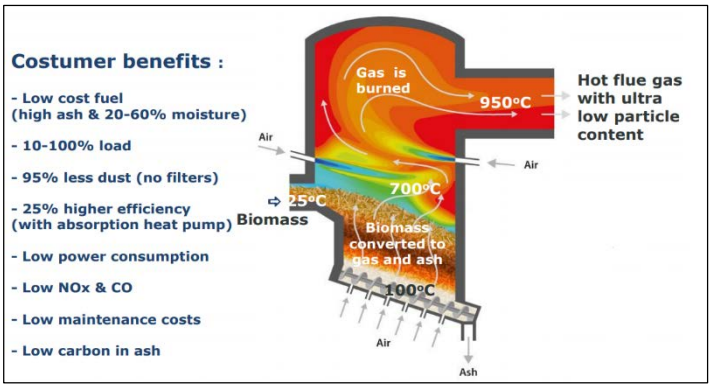


Figure 3 - Biomass Gasification Furnace (source: Dall Energy)

Web:
https://dallenergy.com/fr/
https://www.dalkia.fr/fr/espace-presse/dossier-de-presse/developpement-verdissement-reseau-chaleur-rouen

ENERGY&+: 2 BIOMASS GASIFICATION PROJECTS (CHP)

The Energy & + company markets the German Spanner Re² gasification technology in France and offers flexible, scalable and reliable electric thermal micro-cogeneration plants from 10kW to several MW.

Energy&+ activities

- Technical and economic support from A to Z: integrated design office which ensures the design and technical engineering of projects
- Design & Installation of anaerobic digestion unit
- Design | Installation | Operation & Maintenance of Biomass Boiler
- Design | Installation | Operation & Maintenance of Wood Gasification: electric and thermal cogeneration plant. Flexible, scalable and reliable. From 50kW to several MW (wood A, wood waste)

Gasification projects

At the end of 2019, Energy &+ was the winner of the call for tenders of the Energy Regulatory Commission on biomass cogeneration: 2 projects are validated and currently in the funding phase:

- ElecBox 56 (Augan, Morbihan): 820 kWel
  - 12 Spanner Re² cascading units
  - Cogeneration unit: 816 kWel – 1600 kWth
- ElecBox 63: 2040 kWel

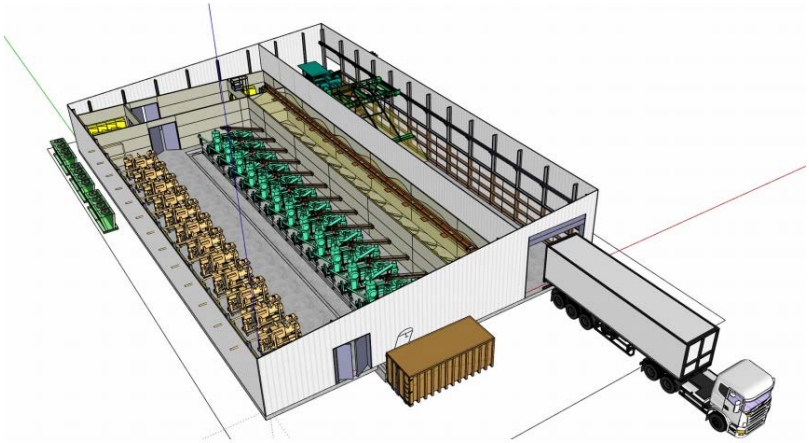


Figure 4 - ElecBox 56 project (source: Energy&+)

These 2 projects aim to produce heat for the drying of related wood, upstream of a production unit of densified wood logs:

- beneficiaries of guaranteed additional remuneration for electricity production
- engineering studies and permits in progress
- start of construction planned for the first half of 2021
- planned commissioning 2nd half of 2022

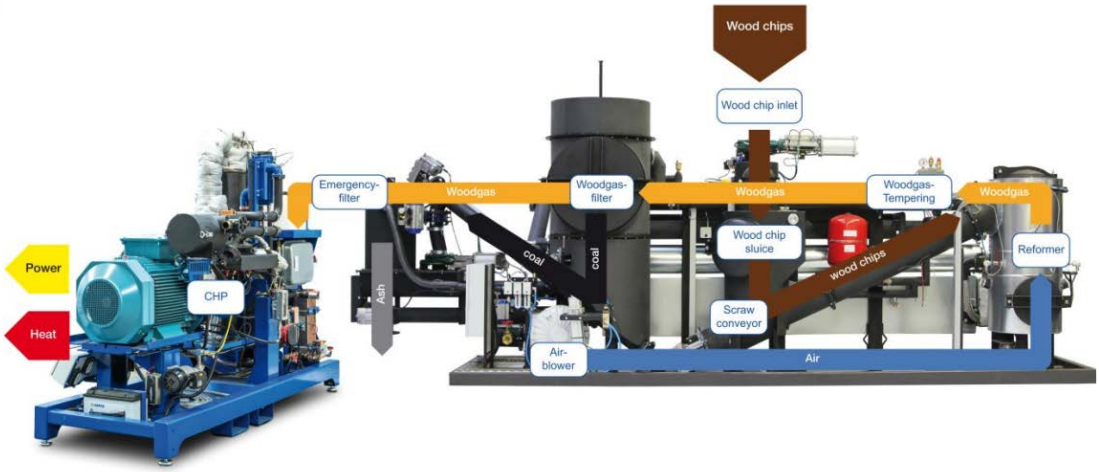


Figure 5 - Gasification and cogeneration processes (source: Energy&+)

Fuel specifications - technical prescription

- Type: forestry chip, crushed pallet, woody fraction of green waste
- size inserts G30-G40
- maximum humidity 12%
- fine particles max 30% (less than 4mm)

- drum crusher / conical screw, 40mm grid
- no contaminants such as sand, stones, earth, nails

Web :
https://energy.bzh/
https://energy.bzh/gazeification/

ENGIE - GAYA & SALAMANDRE: SNG PRODUCTION FROM BIOMASS AND SRF

The R&D GAYA project aims at developing an innovative, competitive and sustainable pathway to produce bio-SNG from dry biomass thermochemical conversion. To prove the economic, technical and environmental relevance of this pathway, a consortium led by ENGIE and gathering expertise from various industry, academic and private research centres was created in 2010.

One of the main assets of the project is the construction of a semi-industrial demonstration plant located in Saint-Fons, near Lyon (France). The GAYA R&D platform (400 kWth SNG output) is designed to produce bio-SNG from lignocellulosic biomass gasification. Gasification is performed in a FICFB (Fast Internally Circulating Fluidized Bed) reactor. Then, a series of low-temperature gas cleaning technologies eliminate trace components from syngas, namely scrubbers to remove heavy tars, and adsorption to capture light tars as well as inorganic compounds such as hydrogen sulphide or ammonia. Finally, the purified syngas is converted into synthetic natural gas (SNG) through a fluidized-bed catalytic methanation reactor developed by ENGIE.

This experimental platform is a powerful tool to provide feedback and quick wins for the industrialization. Optimal operating conditions are explored for specific technologies to increase the carbon conversion into bio-SNG and the process availability. Furthermore, given its size, the project will help validate the distributed control system and identify possible monitoring simplification. The know-how developed during the commissioning and the start-up phases, and the demonstration of gasification of different types of biomass feedstock will also contribute to significant reduction of the bio-SNG production costs. In addition, the research program plans to improve the environmental benefits and to lower the bio-SNG production costs through the tests of alternative technological configurations made possible thanks to the flexible design of the platform.

Figure 6 - The GAYA platform and the R&D shelter for online gas measurements (photo: Engie Lab CRIGEN)

ENGIE produces renewable gas from solid non-recyclable waste gasification

ENGIE has revealed at the end of 2020 that the GAYA semi-industrial Research & Development platform took a historic step forward on November 17, 2020, when the 600kW gasifier produced renewable gas from solid recovered fuel (SRF). The synthesis gas (syngas) resulting from this first conversion is then purified to transform

it into biomethane using a catalytic methanation process.

Figure 7 - The demonstration platform GAYA (photo: Tenerrdis)

Inaugurated in October 2017, the first injection of biomass into the gasifier and production of purified synthesis gas on the GAYA platform took place in November 2018, while the first production of biomethane from forest biomass a year later in November 2019. This latest milestone saw biomethane produced from solid recovered fuel (SRF).

In the absence of dedicated recycling channels, the SRF is produced from non-hazardous waste such as wood, paper, cardboard, and plastic. The SRF is gasified at a very high temperature to produce synthesis gas with a high calorific value.

The synthesis gas resulting from this first conversion is then purified to transform it into biomethane using a catalytic methanation process.

ENGIE's demonstrator which has a capacity of approximately 600 kWth in incoming biomass and waste converted into 30-40 Nm3/hour of biomethane, has validated the integrated operation of the entire chain of innovative technologies under industrial conditions. This configuration maximizes the production of renewable gas.

The SALAMANDRE project: a first industrial unit in Le Havre

ENGIE says that it also plans to build a first industrial unit in Le Havre:

The GAYA platform is in line with the targets set by the French Law on Energy Transition for Green Growth, which aims for a 50 percent reduction in the quantity of waste going to landfill by 2025 compared with 2010 and a 30 percent reduction in fossil fuel consumption in 2030 compared with 2012, with a view to preserving the environment and strengthening France's energy independence.

Based on the work already undertaken, ENGIE says that it plans to build the first industrial unit in Le Havre, France, starting in 2023, the SALAMANDRE project. From 2026, this will allow 70 000 tonnes of non-recyclable waste per year to be used to produce up to 150 GWh of renewable gas.

In addition, the multi-energy process will allow the production of 45 GWh of renewable heat to meet urban and industrial needs. As an alternative to landfill, which is due to be phased out, the GAYA chain is positioned as the channel of reference for making use of non-recyclable waste to produce a storable RNG, which can substitute for fossil natural gas and as such, has multiple uses.

Sources and references:

- Guideline Report - Gas analysis in gasification of biomass and waste, IEA Bioenergy Task 33
- https://bioenergyinternational.com/research-development/engie-produces-renewable-gas-from-solid-non-recyclable-waste-gasification

ELYSE TECHNOLOGY – CARBOGREEN

At the start of 2020, Elyse Technology installed on the PIICTO platform (Marseille – Fos) its new Combigreen demonstrator dedicated to the energy recovery of secondary raw materials, via a pyrogasification process.

Elyse Technology has developed a vacuum pyrolysis process: CARBOLYSE ™. Accompanied by many players in the research part, the company has filed for European patents, and in around twenty countries outside Europe for this new process. The incoming waste is first dehydrated under vacuum at 100°C. They then go into the vacuum carbolysis phase at 500°C, then the gas is condensed and recovered for the production of electricity. The residues of this process are oils and activated carbon, which can in turn serve as fuel. This type of unit could contribute to solutions for the recovery of waste produced by industrial processes as well as to the local production of "green" energies which, according to the wishes of the Aix-Marseille-Provence metropolis, must cover 100% of energy consumption needs of the territory by 2050. This pyrogasification process allows the recovery of a large panel of waste in a single industrial unit (common industrial waste, plastics, wood, biomass, etc.) while consuming less energy, in particular thanks to an innovation in the circulation of hot gases inside the unit. Its modular design and compactness can facilitate its construction and integration into an industrial environment.

Figure 8 - CARBOLYSE demonstrator on the PIICTO Platorm - Marseille-Fos (photo: ELYSE Technology)

The demonstrator, installed since March 2020, is testing and verifying its proper functioning in order to be able to enter the operational phase by the end of 2020. The next stage is the construction of a factory identical to the demonstrator but with two lines, with commissioning targeted for early 2022.

Web:
https://www.elyse-technology.com/

ETIA

ETIA is a French engineering group specialized in innovation, equipment, and processes for continuous thermal treatment. ETIA designs and provides plants for processing biomass, food products, and industry residues, which are widespread in the sectors of environment, agro-food and energy.

ETIA proposes solutions for waste and residue valorization. Their work is designing innovative industrial processes (R&D, engineering, design, marketing, sales and customer support) and their offer includes:

- Expertise in creating high added value products from your biomass and waste
- Delivery of turn key production plants for biomass and waste valorisation
- Feasibility studies and analysis
- Pilot plants and research services

ETIA's portfolio covers more than 150 delivered machines in 35 countries on 5 continents.

ETIA's patented, electrically heated screw conveyor - Spirajoule - is a universal tool for heat treatment of bulk products and residues. Thanks to its flexibility, ETIA has developed multiple applications across various domains of industry:

- Biochar production
- Bio-coal and bio-coke production
- Wood Vinegar Production
- Pyrolysis of plastics
- Synthetic Methane and hydrogen (Synthane process)
- Waste to energy
- Sewage Sludge Treatment
- Waste rubber valorization
- Energy Storage
- Steam Sterilisation
- Calcination

The Spirajoule pyrolysis process : Continuous heating of organics and minerals

Spirajoule® is a dedicated equipment for a continuous thermal treatment in temperatures up to 850°C, basing on a hollow shaft screw conveyor heated by a low voltage current. The screw is made from electrically conductive material and is connected to an electricity power supply.

Electricity is conveyed from the power supply by the specially design components located at both sides of the screw. The passage of electronic current through the conductor (screw) generates heat, which is as a result of Joule heating (also known as Ohmic heating or resistive heating).

Figure 9 - The Spirajoule pyrolysis technology (picture: ETIA)

Synthane

Synthane is a pilot project for the production of synthetic methane from the pyrolysis of waste (renewable or not) in Compiègne. The project is based on ETIA's high temperature pyrolysis technology coupled with catalytic methanation.

Web:

https://etia-group.com/

https://www.vowasa.com/solutions?subpage=etia-land-based

https://atee.fr/evenement/webinaire-pyrogazeification-une-filiere-au-service-de-la-transition-energetique

GAZOTECH

GazoTech is a provider of gasification systems that convert various feedstocks into 'syngas' that can directly power gas engines or dual-fuel burners to generate clean electricity and/or heat – while still meeting the toughest emissions standards.

The GazoTech model combines well-proven gasification technology (over 900 references) developed by the Indian company Ankur Scientific Energy Technology and further optimized with engineering and full customer support.

By converting low-value feedstocks into high-value energy and biochar, Ankur gasification systems can transform over 50 types of biomass – from agricultural wastes (e.g. rice husks, sugarcane stalks) to MSW and old tires – into green energy and profits.

Ankur Scientific Energy Technologies

- Created in 1986, India (Gujarat)
- Focused on gasification, the company has developed significant know-how on the subject
- 4 different types of gasifiers:
    - WBG (Woody Biomass Gasifier): wood / waste wood – 5 to 2200 kg/h
    - FBG (Fine Biomass Gasifier): fine biomass (grape marc, etc.) / green waste – 5 to 2200 kg/h
    - Pyro-Gasifier (PG): wood / fine biomass (produces up to 25% of biochar) – 5 to 2200 kg/h
    - MSWG (Municipal Solid Waste Gasifier): residual household waste solid / recovered fuels – 560 to 2200 kg/h
- tested more than 500 different biomass and selected more than 50 "gasifiable" biomasses
- has sold in 33 years more than 1000 units, the majority of which in South-East Asia and small capacities
- the design of the installations is of the "agricultural" type, very simple and robust
- relatively "light" gasifier maintenance given the design and simplicity of the equipment used

Figure 10 - Ankur: More than 1000 references in 35 countries around the world (picture: Ankur)

GazoTech first project in France

- Location: Aude department
- Type: industrial plant
- Valuation: Natural gas substitution
- Client: Distillery
- Capacity:
  - Incoming load: 340 kg/h
  - Heat: 1.2 MW
- Inputs: used grape marc
- Commissioning: December 2021

Web:

http://www.gazotech.com/

https://atee.fr/evenement/webinaire-pyrogazeification-une-filiere-au-service-de-la-transition-energetique

https://www.ankurscientific.com/

HAFFNER ENERGY – R-HYNOCA

The French start-up Haffner Energy has developed the HYNOCA® process, which produces renewable hydrogen through thermolysis and steam cracking of biomass. This process produces hydrogen intended in particular for mobility (purification of H2 according to customer needs from 90 to 99.997%). Haffner Energy's ambition is to make its process, which is already free from fossil CO2 emissions, a real carbon sink thanks to the recovery of by-products: biochar can be used in agriculture to enrich soil and CO2 (contained in syngas and captured during the hydrogen purification step) finding various valuation routes, especially in the food industry.

- VitrHydrogen: a first pilot using the HYNOCA® process was put into operation in Vitry-le-François (Marne) in May 2019. A first commercial station should be put into service on the site in 2021. It will produce 120 kg of hydrogen per day from 500 tonnes of wood pellets per year. These pellets will gradually be replaced by forest chips and eventually by biogenic residues from local activities, so far little valued (agricultural and forestry residues, poultry droppings, cereal straw, etc.)

- R-HYNOCA: born of a partnership between Haffner Energy and R-ENR (a subsidiary of R-GDS), this project aims to develop an industrial demonstrator to produce 720 kg of hydrogen per day from local biomass. This production should make it possible to supply a fleet of around 55 buses in the Strasbourg Eurometropolis. The installation of this demonstrator is planned by 2021.

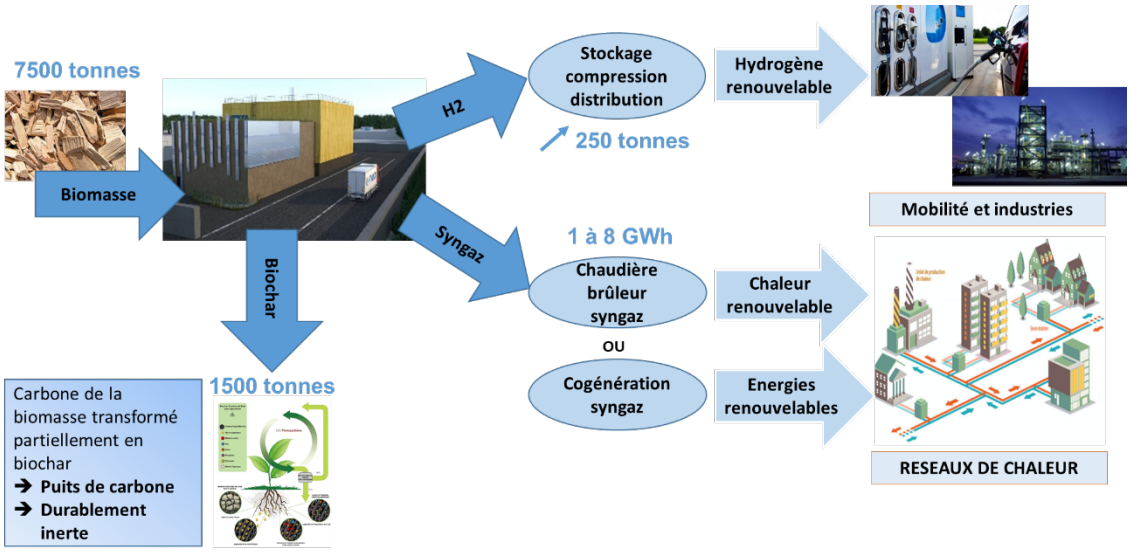


Figure 11 - The R-HYNOCA value chain (illustration: HAFFNER Energy)

Website: https://www.haffner-energy.com/

HYMOOV

With its project, the start-up HYMOOV pursues a threefold ambition: to constitute an alternative to the landfill of waste of wood, to preserve natural resources and to develop the energy autonomy of the territory. Concretely, Hymoov is embarking on the challenge of recovering wood waste, thanks to the pyrogasification process, to produce renewable gas that can be injected into the network. Based in Montoir de Bretagne in Loire Atlantique, Hymoov plans to recover a volume of waste of around 15,000 t/year, corresponding approximately to the annual gas consumption of 3,000 households (33,000 MWh/year).

The particularity of this project is that it exploits a synergy between gasification and power-to-gas: the oxygen resulting from electrolysis will be used as an oxidizing agent in the gasification process.

LEROUX&LOTZ – SYNNOV

The Synnov Déchets industrial unit in Villers sous Montrond (Doubs), under commissioning, enables the recovery of biomass from building waste. The installation with a capacity of 7 MWe and 12 MWth will produce electricity which will be fed into the network and heat to cover the needs of neighboring industries.

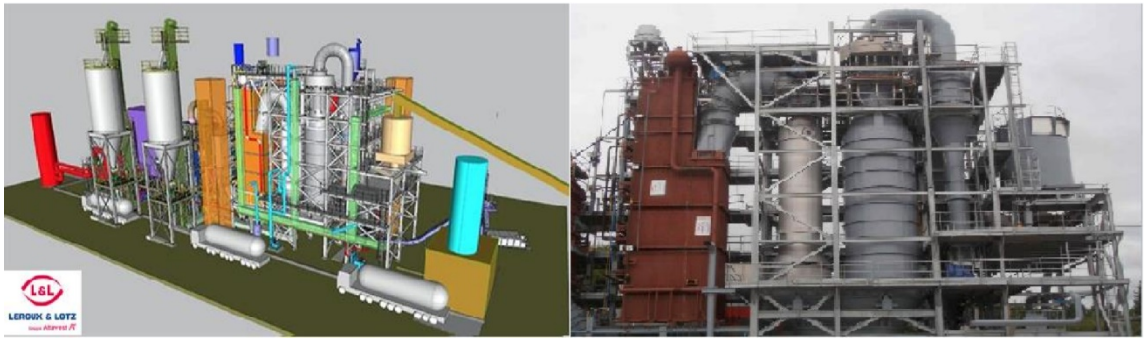


Figure 12 - The Synnov unit (picture: Leroux&Lotz)

Waste is collected locally and transformed into a fuel made up of biomass and shredded material from sorting centres that cannot be recycled. 45,000 tonnes of waste can thus be recovered each year, enabling an annual production of 52 GWh of electricity and 90 GWh of heat. The savings in terms of CO2 emissions compared to an equivalent installation running on natural gas are estimated at 39,140 tCO2, or the annual emissions of around 25,000 cars.

Web:
https://www.lerouxlotz.com/recherche-developpement/
https://www.bioenergie-promotion.fr/wp-content/uploads/2018/07/cibe2018-IIt-gazeification-biomasse-rev1.pdf

LEROUX&LOTZ, TERRAWATT, GRTgaz – TITAN V

Figure 13 - Leroux&Lotz Innov'Energy platform near Nantes (picture: Leroux&Lotz)

Industrial demonstration project for biomethane production from waste (biomass, SRF, sludge):
The project mobilizes a recognized gasification industrialist, Leroux & Lotz, and the start-up TERRAWATT, which has developed a biological methanation process allowing significant cost reductions compared to conventional processes. The Titan V project started an important phase of development in January 2020, with the installation of the biological methanation unit which thus connects to the already existing gasifier on the Innov'Energy R&D platform of Leroux & Lotz, in Nantes.

Web:
http://www.grtgaz.com/uploads/tx_obfilecommunique/CP-Titan5-29012020.pdf
https://www.lerouxlotz.com/recherche-developpement/
https://terrawatt.fr/

NAODEN

Naoden is a French manufacturer and integrator of heat and electricity production solutions using biomass downdraft gasification.

Naoden's solutions:
- Nobilis :
  - Thermal use: greening the use of gas for the thermal process
  - 330 kW thermal
  - Gas recovered on a mixed or 100% syngas burner
- Imperium:
  - Cogeneration, CHP: simultaneous production of electricity and heat

- 160 kW thermal - Heat recovered in hot water 80/60 ° C
- 90 kW electric - Electricity self-consumed or injected into the grid

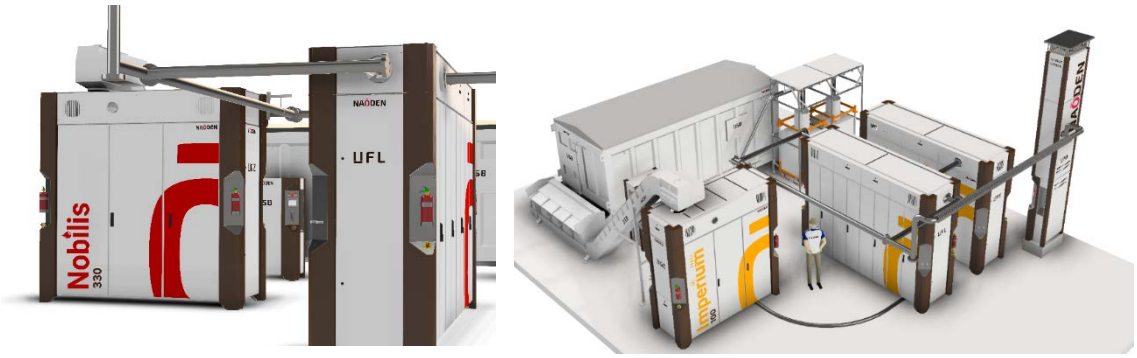


Figure 14 - Nobilis and Imperium solutions (picture: Naoden)

Naoden's units and projects:

1. Côteaux Nantais unit:
   - Client: Industrial
   - Imperium demonstration unit
   - Commissioning: 2nd semester 2017
   - Location: Vertou (44)
   - Pilot demonstration project.
   - Type of input: Shredded pallet / box, forest chip, fruit stones.
   - Electric power: 30 kWel
   - Thermal power: 60 kWth
   - Number of hours of operation: 2,000 hrs / year.
   - Annual electricity production: 60 MWh / year
   - Annual heat production: 120 MWh / year
   - Objectives:
     - Produce electricity and heat
     - Recover waste produced on site (pallets, fruit stones)
     - Validate the NAODEN concept on an industrial level
   - What Naoden did:
     - Installation of an IMPERIUM plant comprising:
       - A biomass storage unit
       - A transfer set
       - A gasifier (UGZ pilot)
       - A 30 kWe syngas cogeneration unit (6-cylinder V8 engine)
   - Customer benefit:
     - Reduction of gas consumption
     - Electricity resale
     - Reduction of waste produced on site

Figure 15 - Imperium unit in Vertou (picture: Naoden)

2. Kerval Centre Armor unit:
   - Client: local community
   - Imperium
   - Commissioning: 2nd semester 2019
   - Location: Ploufragan (22)
   - Testing platform
   - Type of input: Wood class A, class B, CSR
   - Electric power: 90 kWel
   - Thermal power: 160 kWth
   - Number of hours of operation:> 1000 h / year
   - Annual electricity production: 90 MWh / year

- Annual heat production: 160 MWh / year
- Objectives:
  - Study the gasification of fuels produced on the site
  - Project the economic model on community equipment
- What Naoden did:
  - Installation of an IMPERIUM plant comprising:
  - A biomass storage unit
  - A set of transfer
  - A gasifier
  - A gas filtration module
  - A 90 kWe syngas cogeneration unit
- Customer benefit:
  - Waste recovery on site
- Tested inputs:
  - Operation validated with 100% class A wood
  - Operation validated with 100% class B wood
  - Tests validated with 30% SRF + 70% wood B (Kerval)
  - 100% SRF valued on a certain typology

Figure 16 - Naoden unit at Kerval Centre Armor (picture: Naoden)

2021 Projects:

- 1 Imperium cogeneration plant delivered in the first half of 2021 in Eastern France
- 1 plant made up of 4 gasification units delivered in the first half of 2021 in Western France
- 2 industrial projects being finalized for delivery at the end of 2021

To learn more about Naoden projects, see the web references below.

Web:

http://www.naoden.com/

https://atee.fr/evenement/webinaire-pyrogazeification-une-filiere-au-service-de-la-transition-energetique

PLAINERGIE

In May 2019, the Plaine de l'Ain Community of Communes (CCPA), the Mixed Syndicate of the Plaine de l'Ain Industrial Park (SMPIPA), GRTgaz, Séché Environnement, ENOSIS, PROVADEMSE, INSAVALOR platform, and the DEEP laboratories and LISBP from INSA Lyon and Toulouse, signed a collaboration agreement to develop the

“PLAINÉNERGIE” project.

PLAINÉNERGIE aims to develop a first experimental industrial facility for the treatment and energy conversion of a wide range of residual waste collected within the CCPA and PIPA (Parc Industriel de la Plaine de l'Ain) and not otherwise recovered, to produce renewable gas that can eventually be injected into the existing gas network.

This project combines two key technologies for the recovery of waste: pyrogasification coupled to a biological methanation process.

An initial phase conducted in the laboratory has been launched: it aims to characterize the waste deposits, to adapt and optimize the pyrogasification and biological methanation processes. PLAINÉNERGIE then plans a phase of preliminary tests on pilot equipment within the PROVADEMSE technological platform simulating an industrial environment. Third, an in-depth test campaign is to be followed with the implementation of a pre-industrial pilot installation. Finally, in view of the performance observed on the latter, PLAINÉNERGIE could give rise to the construction of an experimental industrial unit located in the Plaine de l'Ain Industrial Park, designed in a logic of short circuit and duplicable on other territories.

Web:
http://www.grtgaz.com/medias/communiques-de-presse/detail-actus/article/plainenergie-transformer-nos-dechets-residuels-en-gaz-renouvelable.html

QAIROS ENERGIES

Qairos Energies is a young bioeconomy company based in Sarthe (France). Qairos aims to design and implement a model, based on circular economy, for the production of green gas (methane and/or hydrogen) from biomass. Its project is supported by many agricultural and agrifood, industrial and regional politicians. It aims to produce renewable gases for communities (methane), for mobility (hydrogen) and for industry and agrifood (carbon dioxide).

A first production unit by gasification of intermediate crops (hemp) will start its commercial activity in 2022. This model is acclaimed by partner farmers: intermediate crops enrich the soils (nitrogen and carbon storage) and resale of these additional harvests constitutes an additional income contribution.

In addition to this first establishment, Qairos Énergies offers a decentralized production solution (supply radius of 35 km) and duplicable, while respecting the specificities of each territory (economic, social, biomass quality).

Web:
https://qairos-energies.com/

SYCTOM, SIAAP – COMETHA PROJECT

Faced with the difficulties encountered by the water and waste treatment sectors, whose activities generate ultimate waste for which the return to the ground after material recovery becomes more and more complex, when it is not prohibited, Syctom (a French mixed union in the Île-de-France region specializing in the treatment and recovery of household and similar waste) and SIAAP (interdepartmental union for sanitation in the Paris area) jointly launched the Cométha innovation partnership, which aims to develop new technical solutions to meet current challenges.

The overall objective of the innovation partnership launched by the two communities is to have a high-efficiency co-methanization treatment unit for sludge from wastewater treatment plants and the residual organic fraction of household waste, allowing: maximization of energy recovery, minimization of the production of by-products and optimization of their recovery and, more generally, optimization of carbon conversion.

The project includes the complete co-methanization sector, including additional technical equipment allowing the management of by-products, in particular digestates. The solutions chosen by Syctom and SIAAP at this stage incorporate thermochemical treatment technologies (high temperature pyrolysis, hydrothermal carbonization) for the transformation of these by-products.

Web:
https://www.cometha.fr/
https://www.syctom-paris.fr/accueil.html
https://www.siaap.fr/

TOTAL – BIOTFUEL PROJECT

A 2nd generation biodiesel and biokerosene development project**:**
The BioTfueL project aims to develop and market a complete chain of processes allowing the thermochemical production of biodiesel and 2nd generation biokerosene. The high-quality biodiesel and biokerosene produced will be free of sulfur and aromatic compounds. They can be used, alone or as a mixture, in all types of diesel engines and aircraft turbojets.

BioTfueL will develop technologies for converting lignocellulosic biomass (straw, forest residues, dedicated crops, etc.) into synthetic fuels, by validating their technical and economic feasibility on demonstration facilities, and by optimizing energy and environmental balances.

At the end of the BioTfueL project, the process chain can be transposed to an industrial scale. The quality of the fuel obtained, its full compatibility with current fuels, combined with the BioTfueL approach based on co-treatment, should ensure a global market for the process chain.

Key data about the BioTfueL project

- Partners: Axens, CEA, IFP Energies nouvelles, Avril, thyssenkrupp, Total.
- Budget: 178.1 million euros, including 33.2 million of public funding.
- Date of commercialization of the process chain: by 2021
- Location of the biomass pretreatment pilot: Avril site in Venette.
- Location of the gasification, purification and synthesis pilot: near Dunkerque

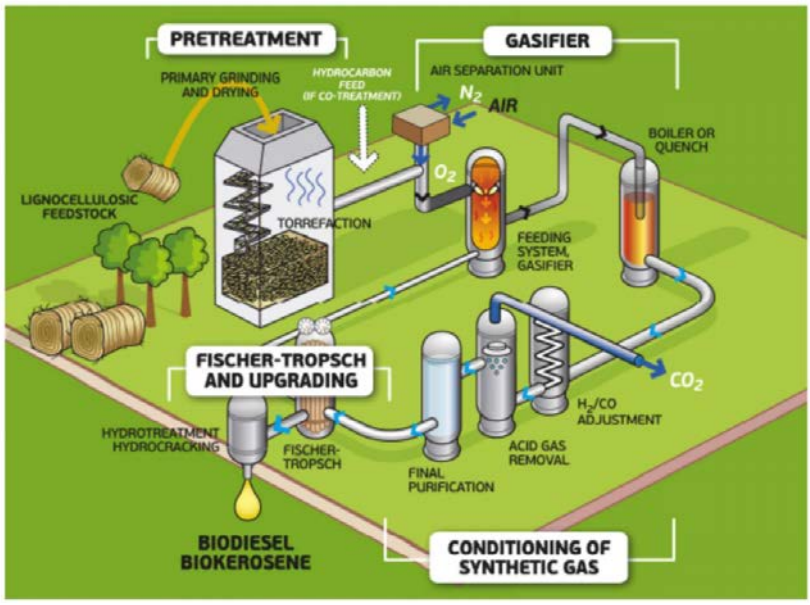


Figure 17 - The BioTfuel™ Project - Overall pathway

Web:
https://www.total.com/fr/expertise-energies/projets/bioenergies/biotfuel-convertir-residus-vegetaux-carburant

XYLOWATT

The Belgian company Xylowatt developed the NOTAR® reactor, a patented technology that produces a clean tar free syngas from natural and recycled wood biomass gasification.

Xylowatt company profile:

- Active since 2001 – 15 people
- XYLOWATT designs, delivers and operates **Biomass to Energy** plants, converting natural and recycled woodchips into valuable and renewable syngas
- Head quarter in Belgium (Louvain-la-Neuve, south of Brussels)
- Turnkey Project – from A to Z

The NOTAR reactor:

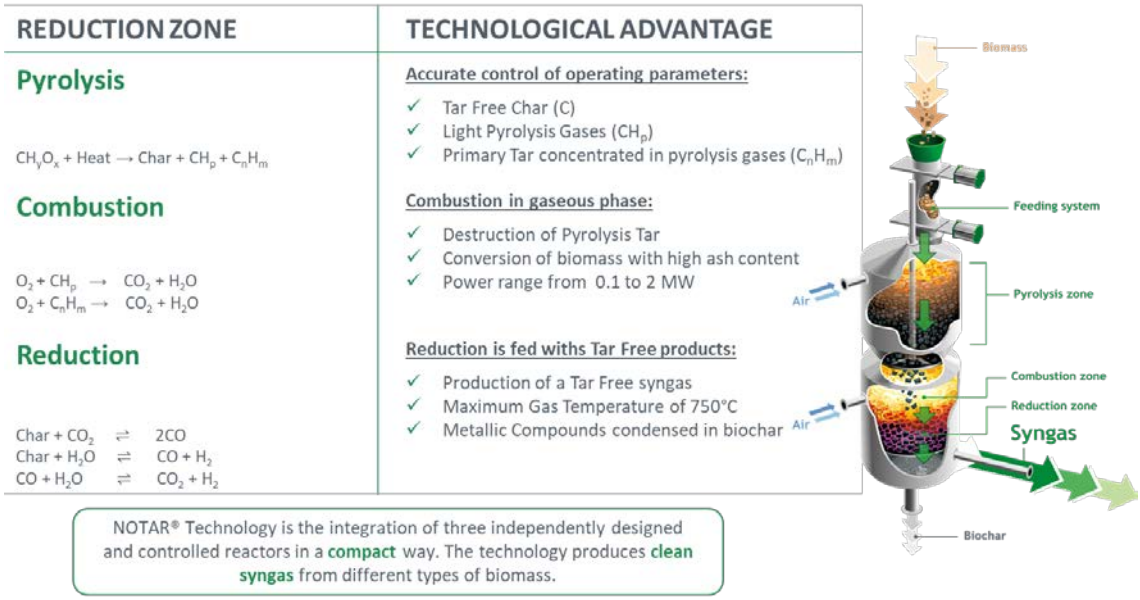


Figure 18 - The NOTAR reactor (illustration: Xylowatt)

Figure 19 - The NOTAR reactor (illustration: Xylowatt)

Xylowatt References:

Project Key Data	
Location	Mont-Godinne Hospital, Belgium
Owner	Special Purpose Vehicule (MGGE)
Application	Combined Heat & Power (Jenbacher J320S) for hospital energy consumption
Capacity	750kW$_e$ + 1200kW$_{heat}$ + 400kW$_{Cold}$
Technology	NOTAR v.3
Feedstock	Natural and recycled woodchips
Commissioning	Q1-2018

Project Key Data	
Location	University Catholic of Louvain-La-Neuve (UCL), Institute of Mechanics, Materials and Civil Engineering, Belgium
Evaluation/R&D scope	• Optimizing operational parameters to various types of woodchips and biomasses • Industrial benchmark for commercial purposes
Capacity	150 kW$_{th}$ syngas power LHV
Technology	NOTAR
Feedstock	Various
Commissioning	Start operation in 2010

Project Key Data	
Location	Champagne Area (France)
Owner	Glass bottles manufacturer
Application	Direct use of syngas for fossil fuel substitution in industrial process
Capacity	950 kW$_{th}$ syngas power
Technology	NOTAR v.2
Feedstock	Woodchips from vineyards pruning branches and obsolete vine stocks
Commissioning	Q1-2015

Project Key Data	
Location	Tournai, Belgium
Owner	Tournai City
Application	Combined Heat & Power (MTU G12) for swimming-pool energy consumption
Capacity	260kW$_e$ + 475kW$_{heat}$
Technology	NOTAR v.2
Feedstock	Natural woodchips
Commissioning	Q4-2009

Figure 20 - Xylowatt references (illustration: Xylowatt)

Figure 21 - Xylowatt references (illustration: Xylowatt)

Web:

https://www.xylowatt.com/

https://atee.fr/evenement/webinaire-pyrogazeification-une-filiere-au-service-de-la-transition-energetique

Further Information

IEA Bioenergy Website
www.ieabioenergy.com

Contact us:
www.ieabioenergy.com/contact-us/