Advanced Smoldering Technology: Waste to Electricity

500 tons/day

with an electric generation capacity up to 8000 kWp

1. Brief Overview

The advanced smoldering technology is a “no flame” oxidation technology that allows the thermal destruction of organic compounds while recovering inert materials and completely avoiding environmental pollution.

i. Technology: Advanced Smoldering
ii. Process Temperature: $\simeq 400$ °C
iii. Sterilization Capability: Thermal Destruction of viruses and bacteria
iv. Heat Recovery Capability: > 90% of the feedstock LHV
v. Metals Recovery Capability: >90% of the feedstock metal content
vi. Inert Ash: Typical $\simeq$ 3% of the feedstock weight
vii. Air Pollution Level: 0% dioxins, furans

2. The Process

a. The feedstock is loaded into a static ADVANCED SMOLDERING CELL, when the cell is full, the cell is closed and the smoldering process starts.
b. The system continuously controls the oxidation process, avoiding the formation of any type of flame in order to not allow the formation of any smoke.
c. The process slowly progresses until all the organic compounds content of the feedstock is transformed into a synthetic fuel gas.
d. During this phase we do not have any formation of smoke or flying ashes, allowing the production of a high quality synthetic fuel gas.
e. The synthetic fuel gas is then burned into a combustion chamber, achieving the same environmental effect that we have when we burn the natural gas.
f. The high temperature heat produced by the system is then transformed into a medium temperature heat and, if required, into electricity.
g. The CO^2 and water produced during the oxidation can be used for green houses.

h. The ash is removed from the cell and the metals are collected for their valorization.
i. The cell is ready for the next cycle.

3. The Process: Elaboration

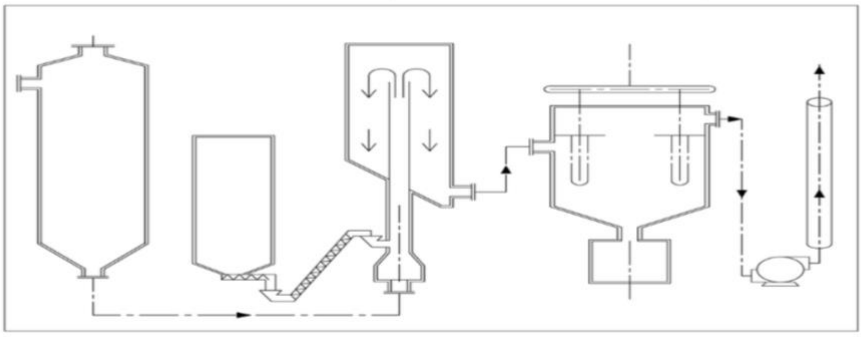
EXHAUST GAS FILTERING TRAIN

Even if the smoldering technology, burning without flames, do not produce pollutants like fine powders or dioxins, for safety reasons, each plant module is equipped with a filtering system.

The total exhaust gas to be filtered is:	*158'100*	*cubic meter /h*	*divided into:*	*13*	*modules*
Each filtration module manage:	*12'162*	*cubic meter /h*	*of exhaust gas at:*	*250*	*°C*

Each filtration system consists of:

n.1	*Gas cooler*	*to reduce the input gas temperature*
n.1	*Sorbalite Reactor*	*reacting with hydrated lime and active carbon*
n.1	*Bag air filter*	*to eliminate the reactor by products*
n.1	*Tail fan*	*to maintain the system under low pressure*
n.1	*Chimney stack*	*to evacuate the exhausts gasses*



ENERGY RECOVERY SYSTEM

*To recover the energy content of the feedstock the plant uses **ORC** turbines.*

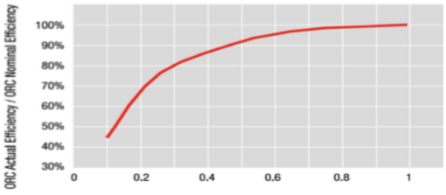
ORC technology is similar to a traditional steam turbine, but with a single, important difference. instead of using water vapor, the ORC system vaporizes a high-molecular-mass organic fluid, resulting in excellent electric performance and severe! key advantages: slower turbine rotation, lower pressure and no erosion of metallic parts and blades.
The ORC turbogenerator uses medium-to-high-temperature thermal oil to preheat and vaporize a suitable organic working fluid in the evaporator. The organic fluid vapor rotates the turbine, which is directly coupled to the electric generator, resulting in clean, reliable electric power.
The exhaust vapor flows through the regenerator, where it heats the organic liquid and is then condensed in the condenser and cooled by the cooling circuit. The organic working fluid is then pumped into the regenerator and evaporator, thus completing the closed-cycle operation.

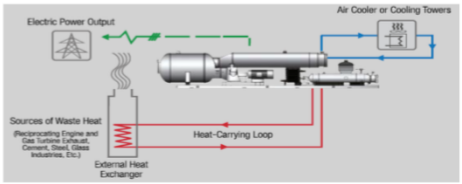
ENERGY PLANT DATA

Installed electric power:	***8.00***	***MW***
Expected electric production:	*67'396*	*MWh/year*
Installed thermal power:	*22.41*	*MW*
Expected thermal production:	*196'329*	*MWh/year @ 90°C*
Carbon Dioxide production	*9'080*	*cm/h @ 20°C 1 bar*

Thermal Oil outlet temperature	*300 - 320 °C*
Thermal Oil inlet temperature	*170 - 200 °C*
Cooling water temperature (in-out)	*25 / 40 °C*
Net active electric power efficiency	*23% - 25%*
Electric Generator	*400V 50Hz*

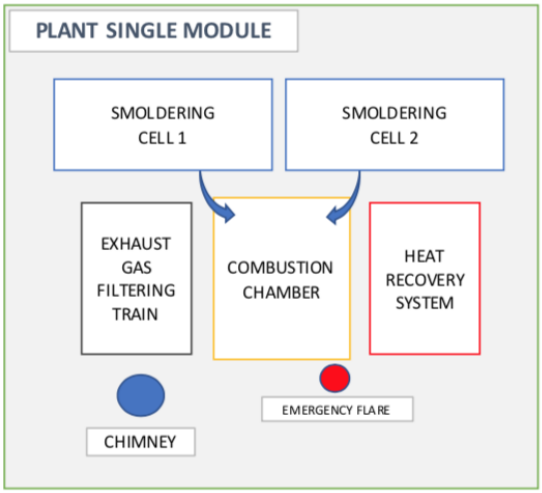
PARTIAL LOAD EFFICIENCY





PLANT SIZE

TECHNOLOGY			OCCUPIED AREA	
Smoldering plant MODULE	500	ton/day	7'728	sq. meters
Electric generator	8'000	kWp	1'200	sq. meters
Buildings	*12*	*m high*	*4'291*	*sq. meters*
Green House	-	sq. m. cultivated	-	sq. meters
TOTALS			**8'928**	**sq. meters**



The system consists of: **13 MODULES**

Each module contains:
- 2 SMOLDERING CELLS
- 1 COMBUSTION CHAMBER
- 1 EMERGENCY FLAIR
- 1 EXHAUST GAS FILTERING TRAIN
- 1 CHIMNEY
- 1 HEAT RECOVERY SYSTEM

Important notice:

The plant DO NOT need any bunker for the feedstock storage cause the smoldering process is a batch process that uses the smoldering cells to stock the feedstock as soon as it arrives to the plant.

FEEDSTOCK CHARACTERISTICS

The system can manage any kind of feedstock having at least the following characteristics:

- **a humidity content up to 50%**
- **an energy content from 2 kWh/kg**
- **a solid residue up to 30%**
- **a maximum dimension of: 2 x 1 x 0.5 meters**

NO PRETREATMENT IS REQUIRED
NO HOMOGENIZATION IS REQUIRED
NO SCREENING IS REQUIRED

Unsorted Municipal Solid Waste

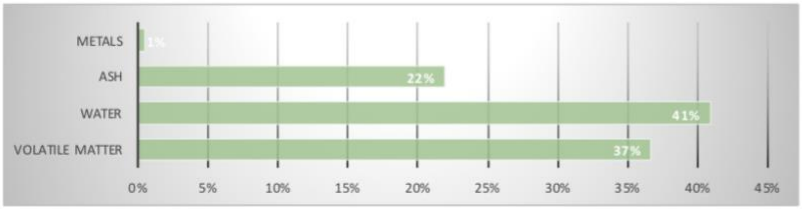
Agricultural Waste

Waste Tires

Waste Plastics

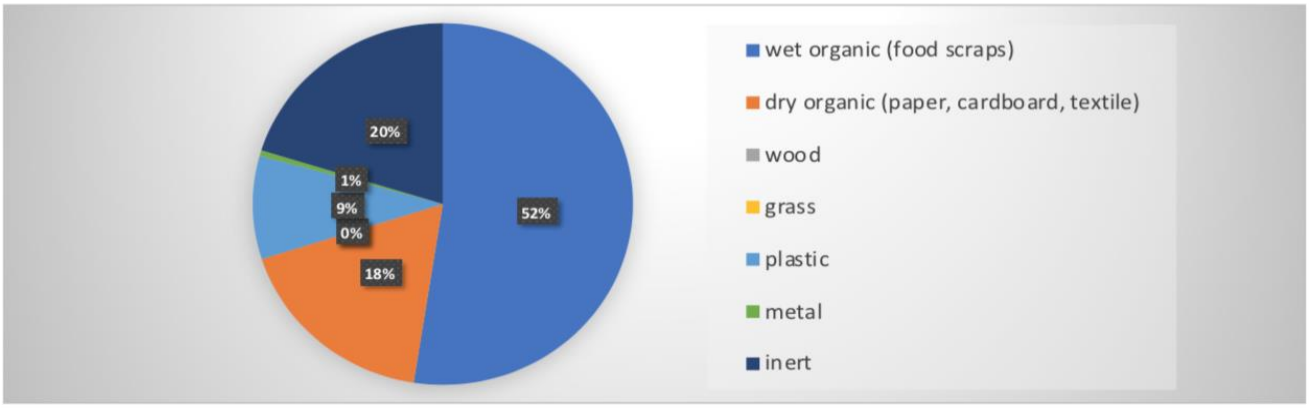
FEEDSTOCK COMPOSITION CALCULATION

For calculation porpoises, the feedstock is divided in its basic components: wet organic, dry organic, wood, grass, plastic, metals and inert.
Each component is then characterized according its content of moisture, volatile matter and inert ash (silicates and metals).
The feedstock composition is then characterized according to its basic components:

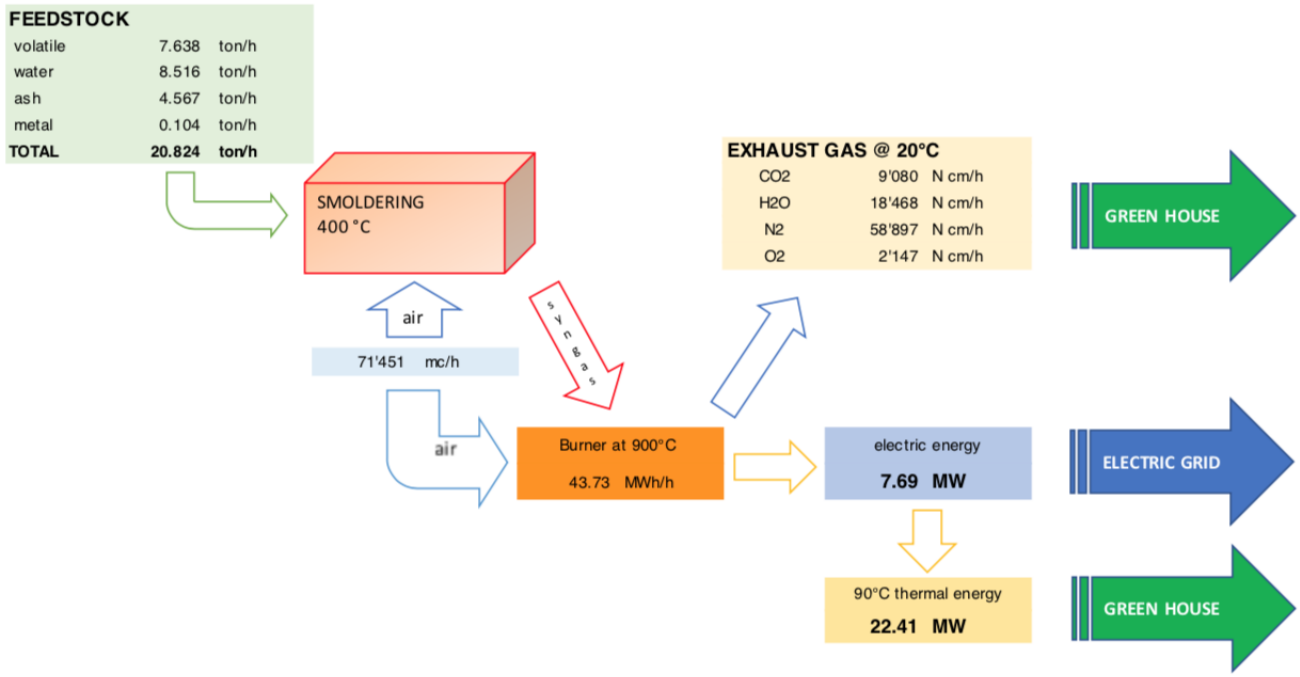


FEEDSTOCK COMPOSITION

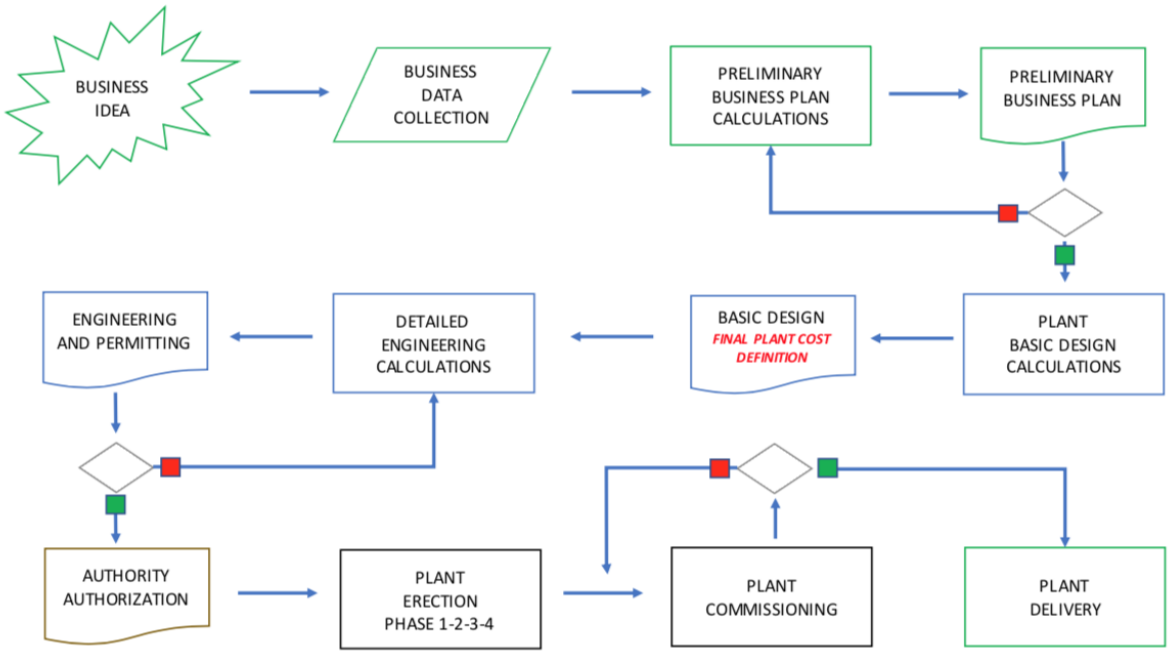
FEEDSTOCK COMPONENTS	*FEEDSTOCK ELEMENTARY COMPOSITION*					FEEDSTOCK COMPOSITION				
	Inert	*Moisture*	*C*	*H*	*O*	Composition	Volatile	Water	Ash	Metal
	wt%	*wt%*	*wt%*	*wt%*	*wt%*	%	wt%	wt%	wt%	wt%
wet organic (food scraps)	*4%*	*70%*	*14%*	*2%*	*11%*	52%	14%	37%	2%	0%
dry organic (paper, cardboard, textile)	*8%*	*7%*	*46%*	*6%*	*33%*	18%	15%	1%	1%	0%
wood	*1%*	*30%*	*34%*	*4%*	*30%*	0%	0%	0%	0%	0%
grass	*4%*	*50%*	*24%*	*3%*	*20%*	0%	0%	0%	0%	0%
plastic	*4%*	*10%*	*72%*	*10%*	*4%*	9%	8%	1%	0%	0%
metal	*100%*	*0%*	*0%*	*0%*	*0%*	1%	0%	0%	0%	1%
inert	*90%*	*10%*	*0%*	*0%*	*0%*	20%	0%	2%	18%	0%
						100%	**37%**	**41%**	**22%**	**1%**



MASS & ENERGY DATA



PLANT DEVELOPMENT PROCESS



Advanced Smoldering Technology: Waste to Electricity

1000 tons/day

with an electric generation capacity up to 16000 kWp

1. **Brief Overview – Same as 500 tons/day**
2. **The Process – Same as 500 tons/day**
3. **The Process: Elaboration**

EXHAUST GAS FILTERING TRAIN

Even if the smoldering technology, burning without flames, do not produce pollutants like fine powders or dioxins, for safety reasons, each plant module is equipped with a filtering system.

The total exhaust gas to be filtered is:	*316'200*	*cubic meter /h*	*divided into:*	*25*	*modules*
Each filtration module manage:	*12'648*	*cubic meter /h*	*of exhaust gas at:*	*250*	*°C*

Each filtration system consists of:

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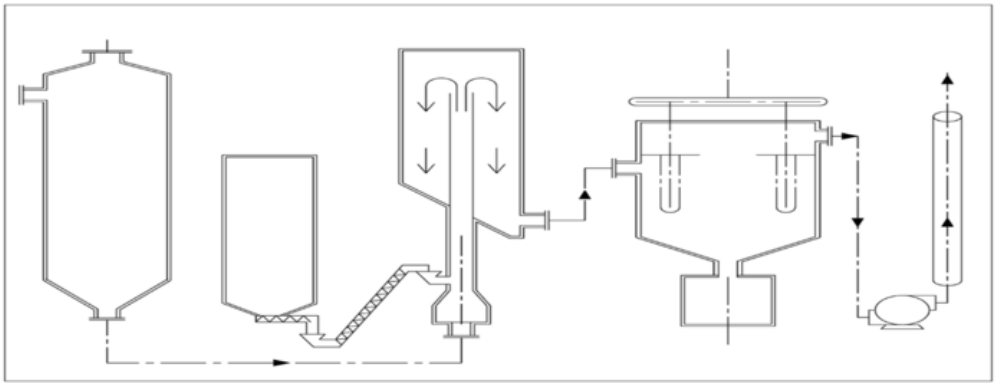

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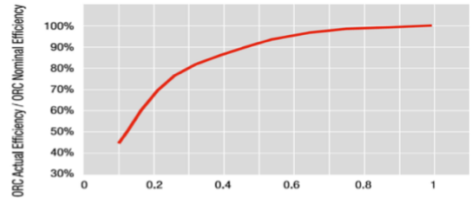
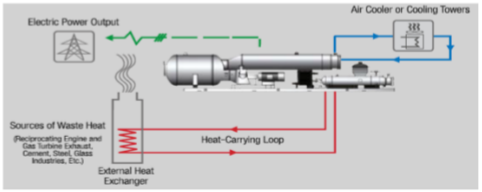
The exhaust vapor flows through the regenerator, where it heats the organic liquid and is then condensed in the condenser and cooled by the cooling circuit. The organic working fluid is then pumped into the regenerator and evaporator, thus completing the closed-cycle operation.

ENERGY PLANT DATA		
Installed electric power:	***16.00 MW***	
Expected electric production:	*134'793*	*MWh/year*
Installed thermal power:	*44.82*	*MW*
Expected thermal production:	*392'658*	*MWh/year @ 90°C*
Carbon Dioxide production	*18'159*	*cm/h @ 20°C 1 bar*

Thermal Oil outlet temperature	*300 - 320*	*°C*
Thermal Oil inlet temperature	*170 - 200*	*°C*
Cooling water temperature (in-out)	*25 / 40*	*°C*
Net active electric power efficiency	*23% - 25%*	
Electric Generator	*400V 50Hz*	

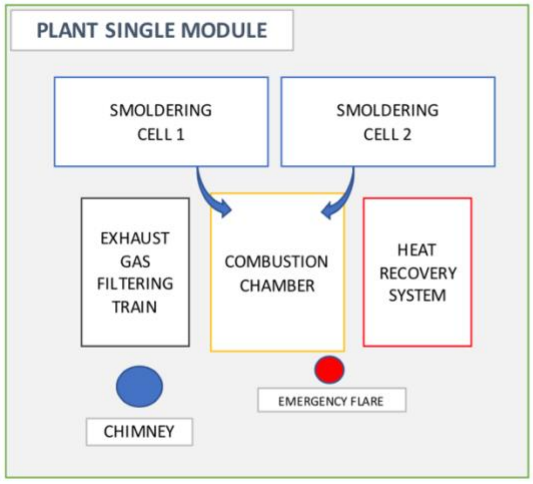
PARTIAL LOAD EFFICIENCY





PLANT SIZE

TECHNOLOGY			OCCUPIED AREA	
Smoldering plant MODULE	1'000	ton/day	14'862	sq. meters
Electric generator	16'000	kWp	2'400	sq. meters
Buildings	*12*	*m high*	*8'345*	*sq. meters*
Green House	-	sq. m. cultivated	-	sq. meters
TOTALS			**17'262**	**sq. meters**



The system consists of: **25 MODULES**

Each module contains:
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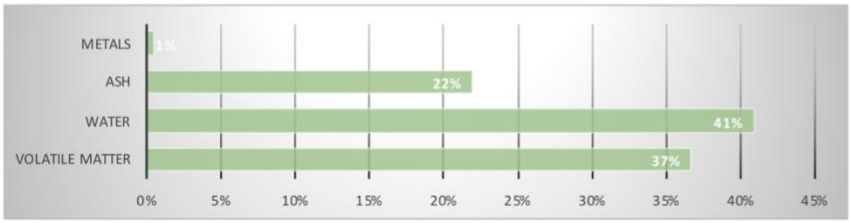

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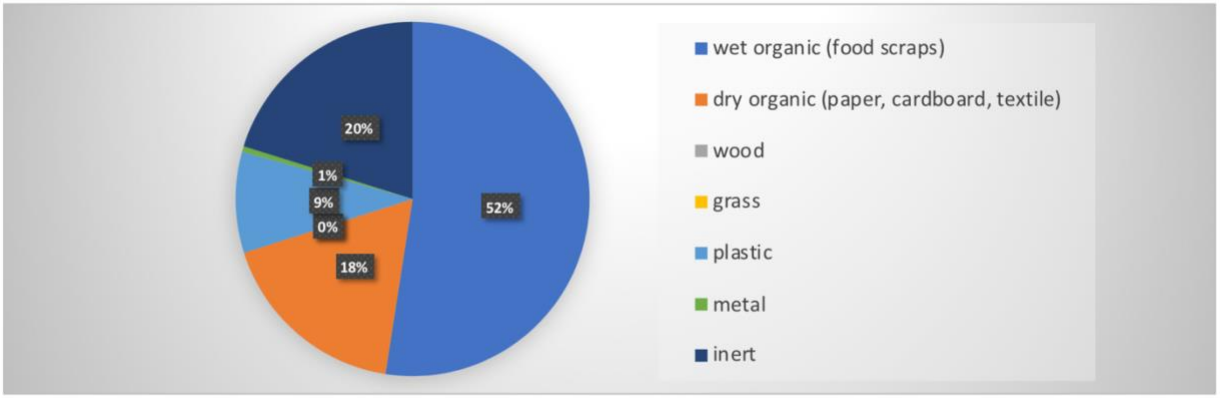
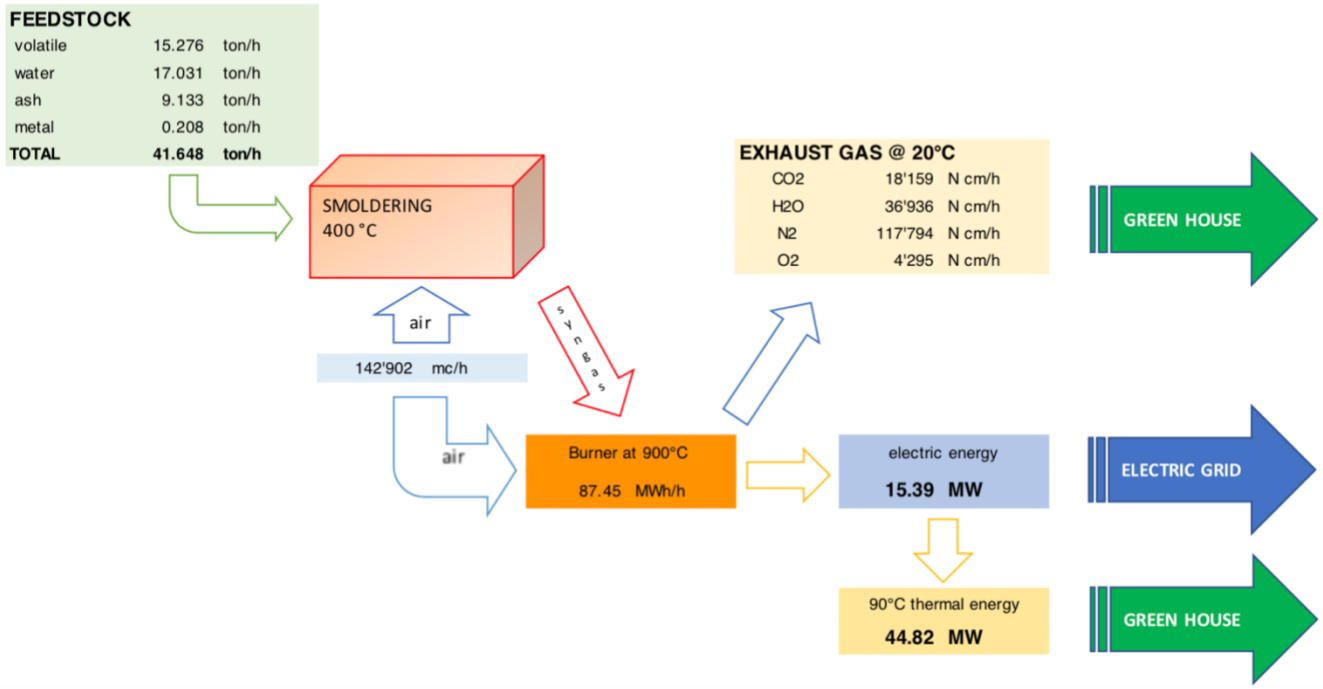


MASS & ENERGY DATA



PLANT DEVELOPMENT PROCESS