



(C96) The green transition of Intensified Processes: The Hydrothermal Reactor of the BioFairNet Pilot Site 1

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BIOECONOMY AND CIRCULAR ECONOMY FAIR NETWORK

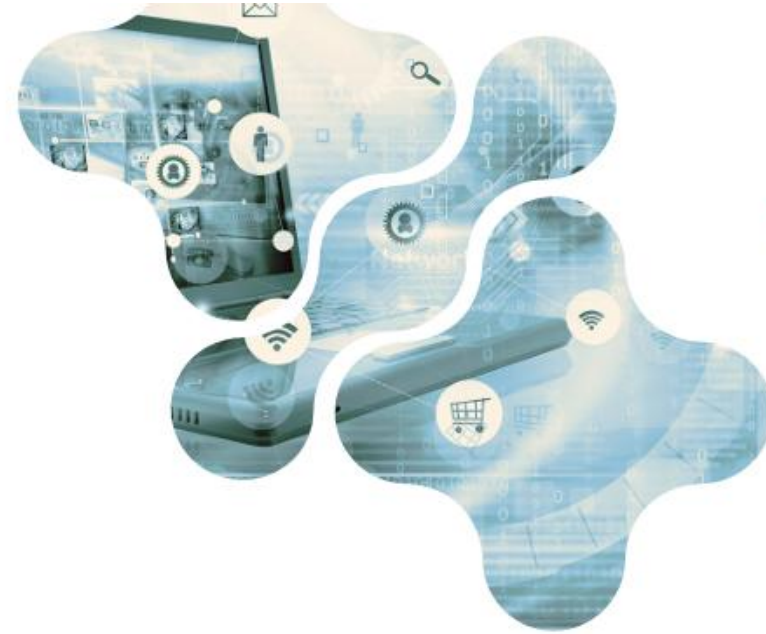
DIGITALLY FAIR AND ACCESSIBLE NETWORK FOR
REDUCING GHG-INTENSIVE ACTIVITIES WITH CIRCULAR
AND BIOECONOMY MODELS.



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BACKGROUND

In the face of urgent climate and environmental challenges, industries like agriculture and mining need to undergo deep transformation. BIOFAIRNET aims to support this shift by connecting stakeholders in a digital cooperative network that empowers fair and inclusive bio-circular transitions.



MAIN OBJECTIVE

To support GHG-intensive sectors (specifically agriculture and mining) in transitioning to a fair, sustainable, and circular bioeconomy through a digital cooperative network that enables co-creation, knowledge sharing, and stakeholder engagement.

5 PILOT AREAS



LESVOS GREECE

Agriculture and agrifood production (olive cultivation, waste management).



REUNION ISLAND

Transitioning coal plants to biomass energy.



NOVA SCOTIA CANADA

Cooperative development in family farming and mining.



QUEBEC CANADA

Sustainable agricultural initiatives.



REPUBLIC OF KENYA

Agricultural cooperatives (dairy, coffee) and gender-inclusive practices.

Lesvos island



- Third biggest Greek island
- Vibrant food production industry
- Population ~ 100k
- Locally available biomass residues

30 FOR 2030

WE SELECTED 30 ISLANDS AND ISLAND GROUPS! BECOMING RENEWABLE ISLANDS UNTIL 2030!



#CE4EUislands
Clean energy for EU islands

Available liquid biowaste in Lesvos

- 45 three-phase olive presses with ~ 100 t of OMWW per hour of operation. (Vakalis et al., 2021)
- 18 dairy production facilities and it is calculated that 26.387 cubic meters of whey from dairy farm are available per year. (Chatzimaliakas et al., 2021)
- Residues from the alcoholic beverage industry with smaller quantities; 6t of Anise from ouzo production (Altiparmaki et al., 2022); Winesludge from the processing of 20.746 kg of grapes (Vasileiadou et al., 2022)
- A sludge AD plant has been projected to be developed with a capacity of 17.500 tons per year.

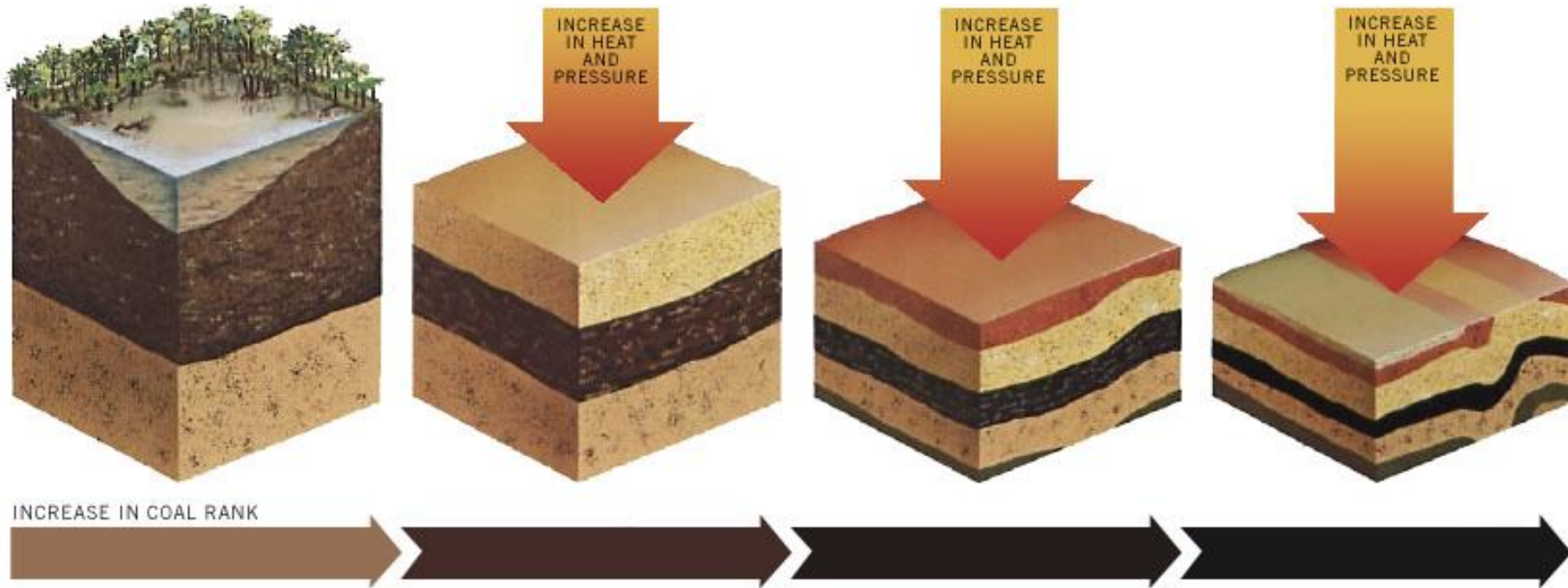
Proposed solution for a complicated waste mix

- Wastewater and industrial water with high water content:
 - Have several challenges when treated with biotechnologies
 - Can not be processed efficiently with conventional thermal technologies
- Available lignocellulosic biomass is of low quality
 - HHV, molecular structure, moisture content, sizing
- The available feedstock has seasonal variability
- **The technology of Hydrothermal Carbonization has been utilized in order to treat the mixed waste**

Basic talking points

- **The technology of Hydrothermal Carbonization (HTC)**
 - Fundamentals
 - Methods of Analysis
 - Preliminary Results
- **The upgrades of the BioFairNet Pilot Site**
 - The HYDROPYR process (and first preliminary results)
 - *Green transition of HTC as an intensified process*

CHANGES IN RANK OF COAL



PEAT

Carbon content: 60%
Volatile matter: > 53%
Average calorific value: 1600kj/kg.
Moisture content: >75% (in-situ).



BROWN COAL

Carbon content: 60 - 71%
Volatile matter: > 53 - 49%
Average calorific value: 2300kj/kg.
Moisture content: >35% (in-situ).



Sub-bituminous Coal

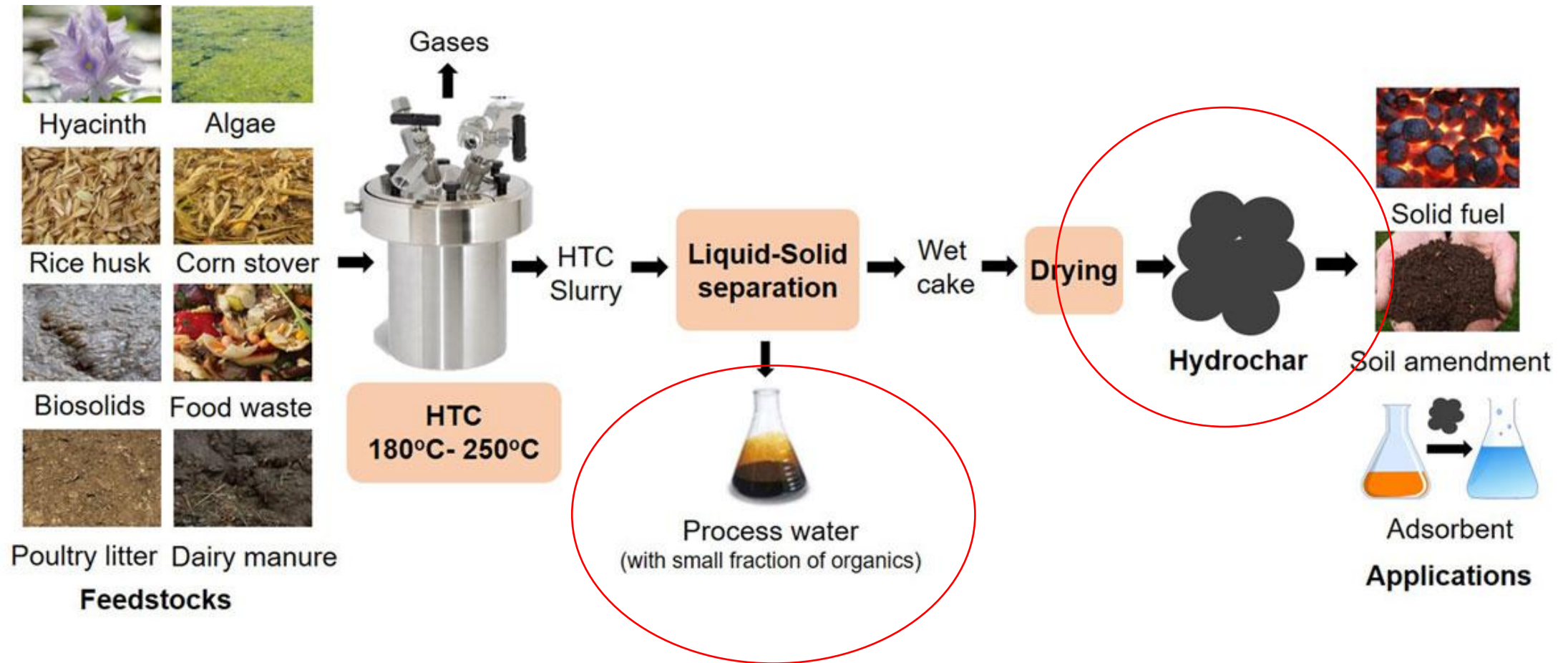
Carbon content: 71 - 77%
Volatile matter: > 49 - 52%
Average calorific value: 29300kj/kg.
Moisture content: 25 -10% (in-situ).



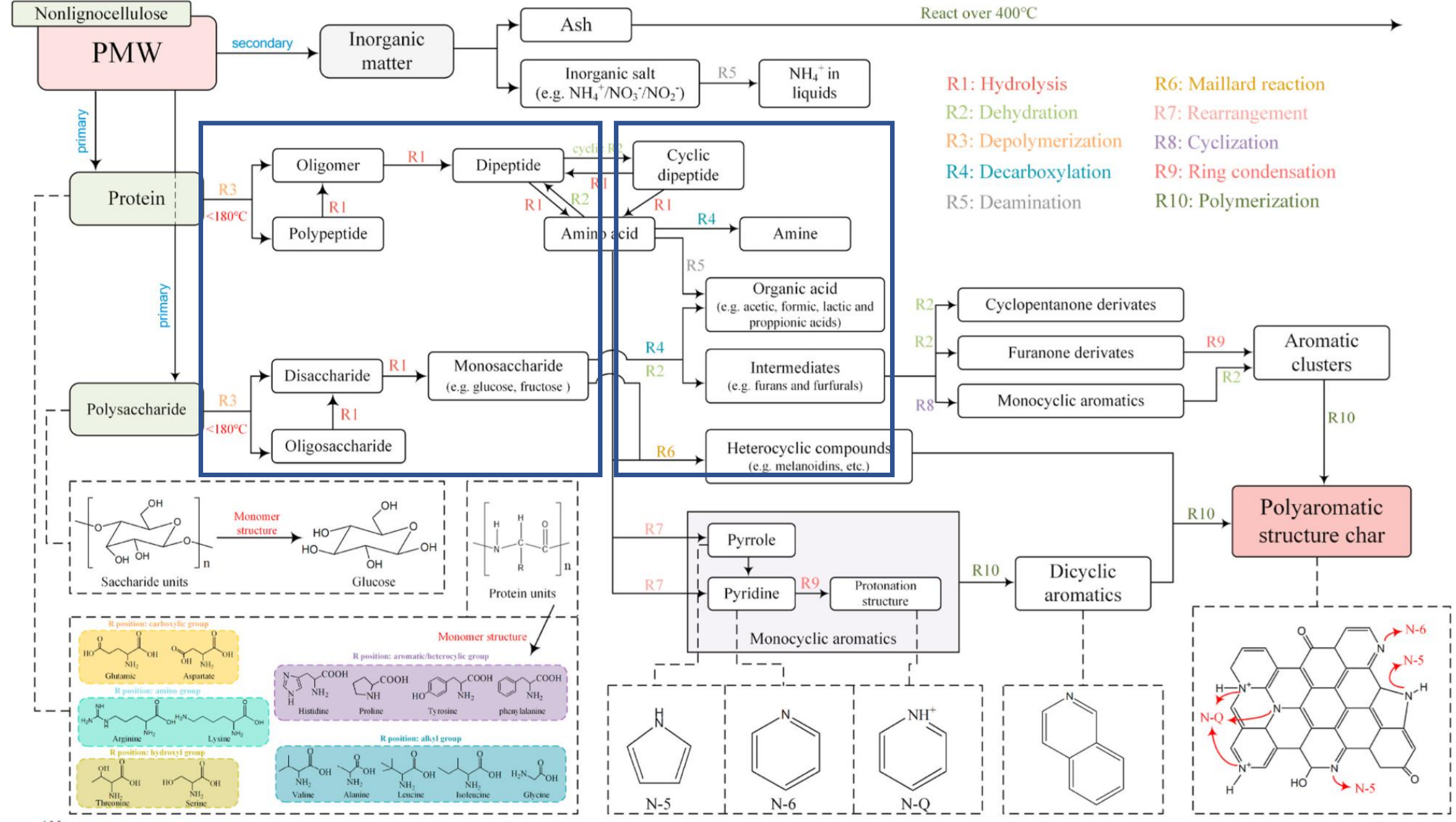
Bituminous Coal

Carbon content: 77 - 87%
Volatile matter: 42 - 29%
Average calorific value: 362500kj/kg.
Moisture content: 8% (in-situ).

Hydrothermal Carbonization



Source: Sivaprasad, Manandhar and Shah, The Ohio State University (2021)

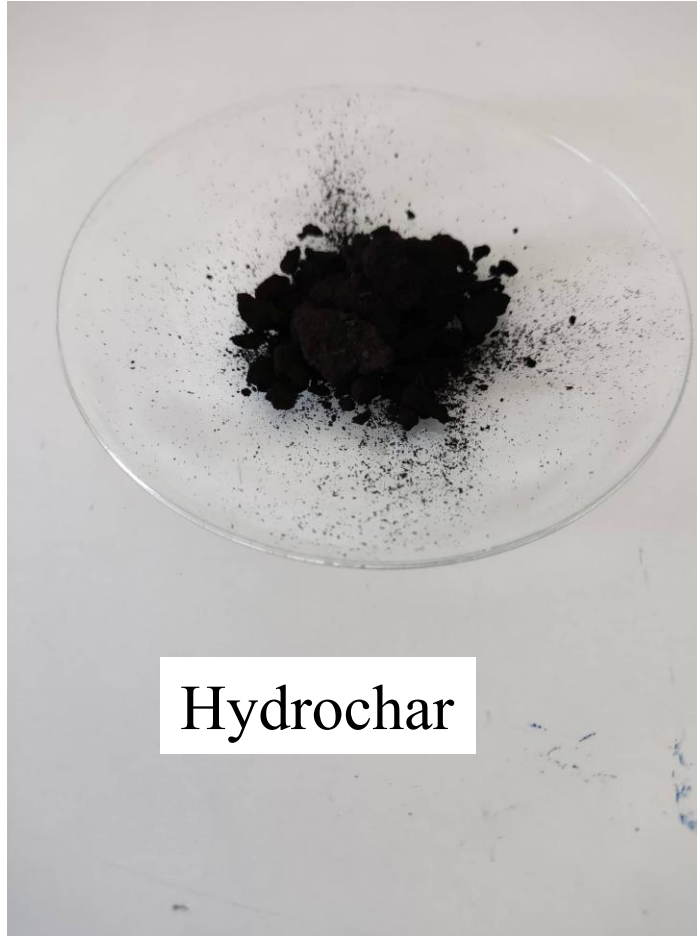


Materials and Methods 1



- **Parr hydrothermal reactor 4570A**
 - 1 L/ CSTR, max: 550 °C/ 350 bar
 - Modified for continuous operation
- **Parr hydrothermal reactor 4552**
 - 8 L/ CSTR, max: 350 °C/ 130 bar
- **Experiments at 180 – 300 °C*/ 40 - 68 bar**

HTC



Materials and Methods 2

- Anis (100g) mixed with water (500 ml) underwent hydrothermal carbonization between 200 – 250 °C for 2 h.
- The HT Liquor separation via centrifugation & filtration; total phenols (Folin-Ciocalteu method), COD content (potassium dichromate method), pH
- Measurement of HHV – Parr 6400
- Analysis via GC - BID

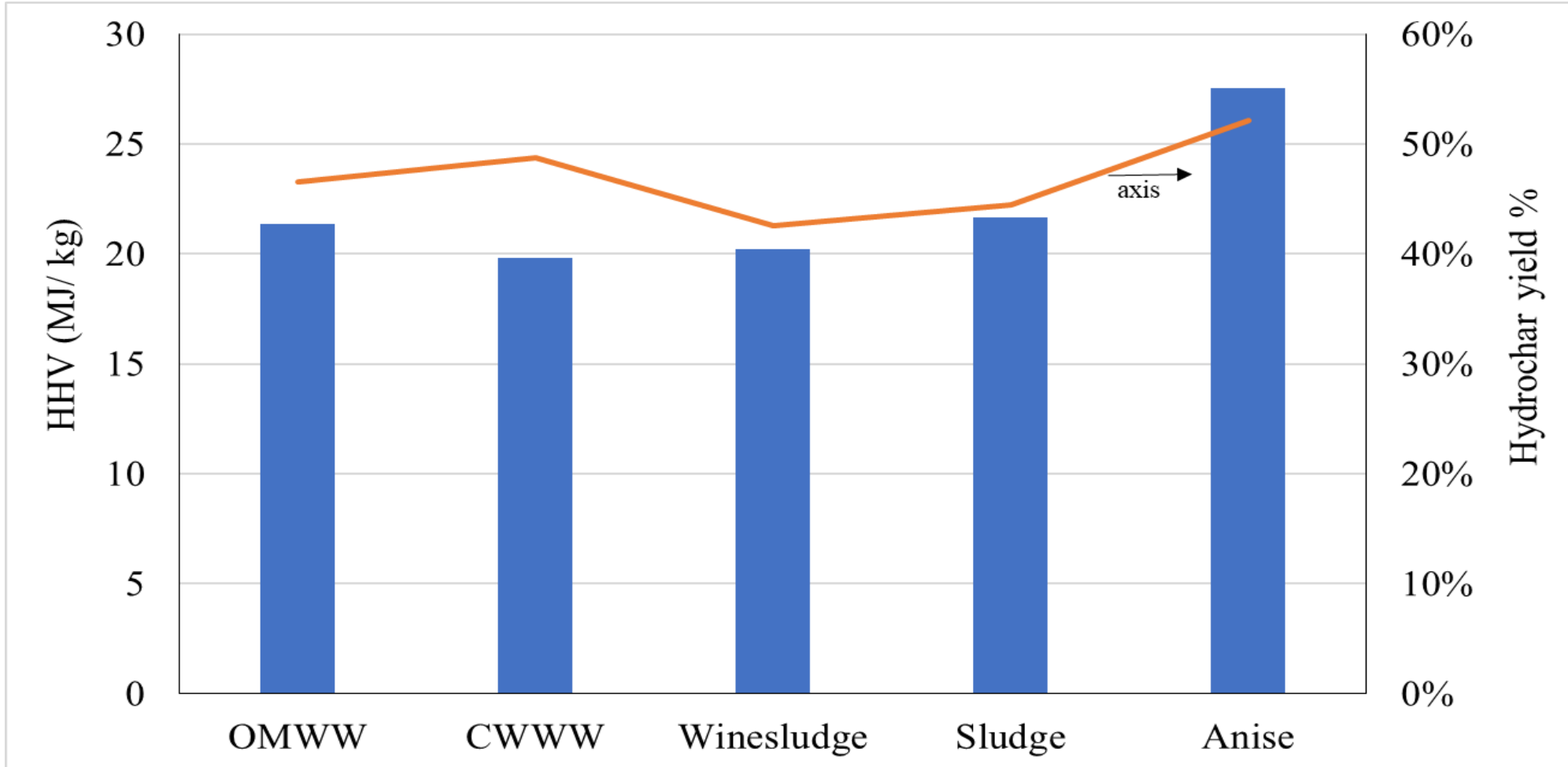


Materials and Methods 3



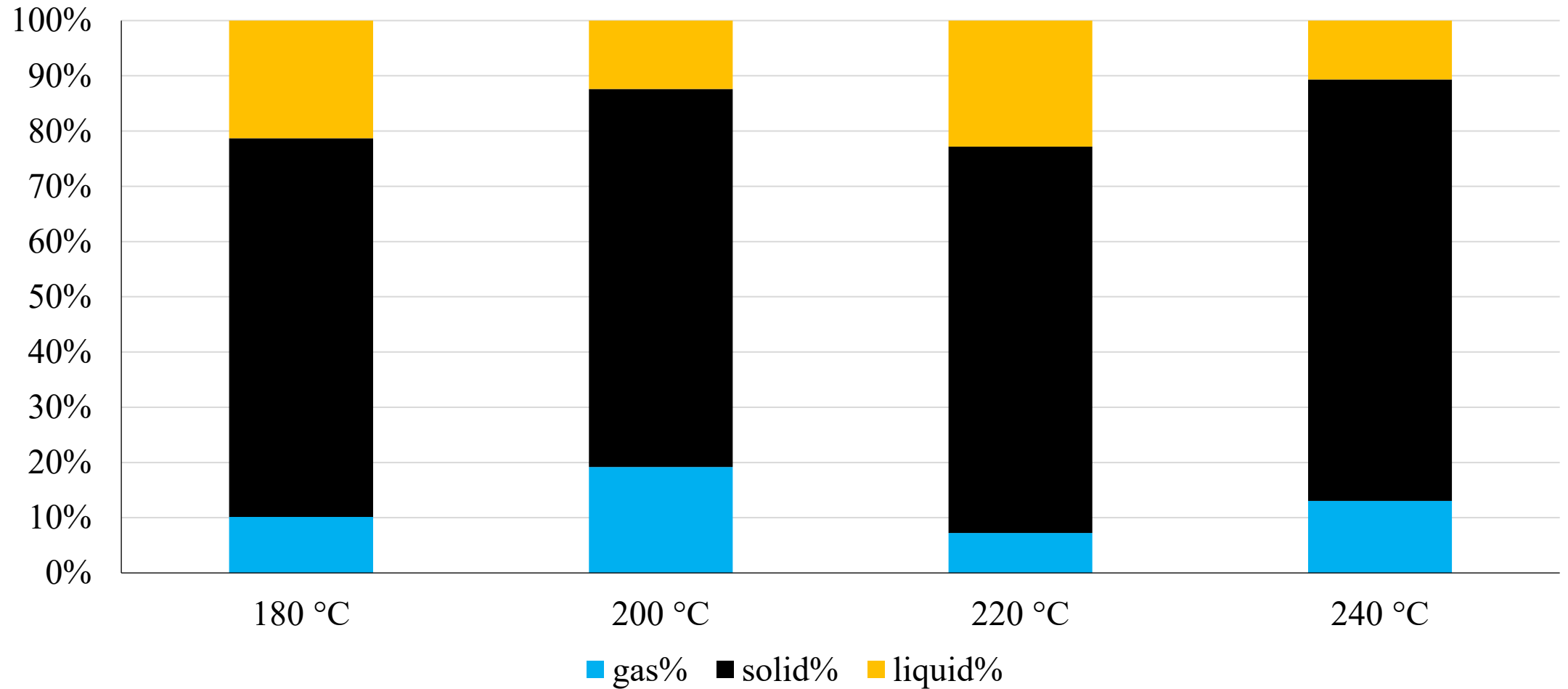
- Shimadzu Nexis GC-2030
- GC – BID (plasma) detector
- Gas column:
 - Restec ShinCarbon 80/100
- Liquid columns
 - **J & W Agilent HP – FFAP**
 - **MEGA - 10**

HHV and mass yield % of hydrochar



**experiments at 220 °C/ 35 bar/ 4 h duration/ severity factor: 5.91

Mass balances of Anise HTC



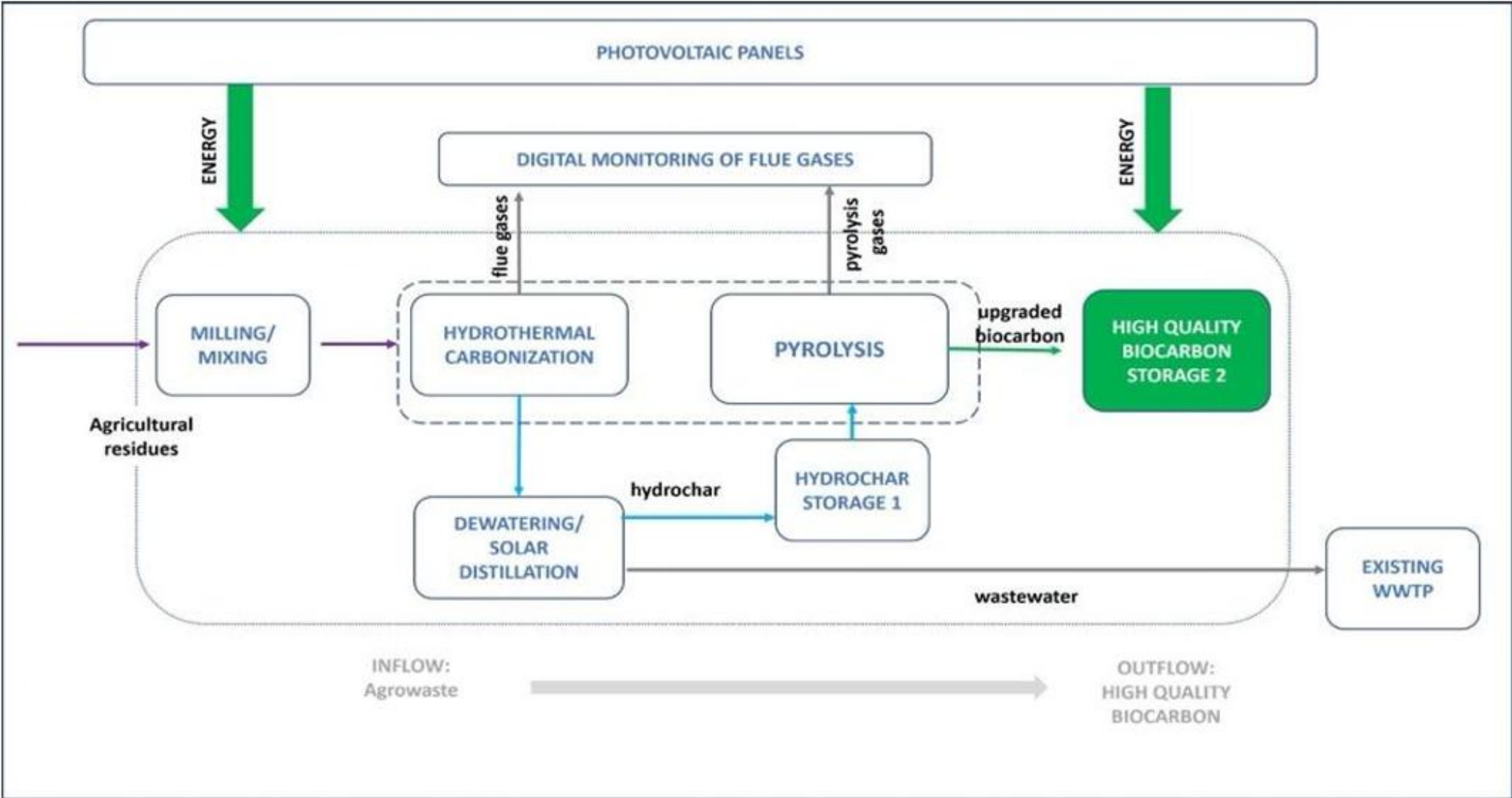
The Pilot Site @ Lesvos WWTP



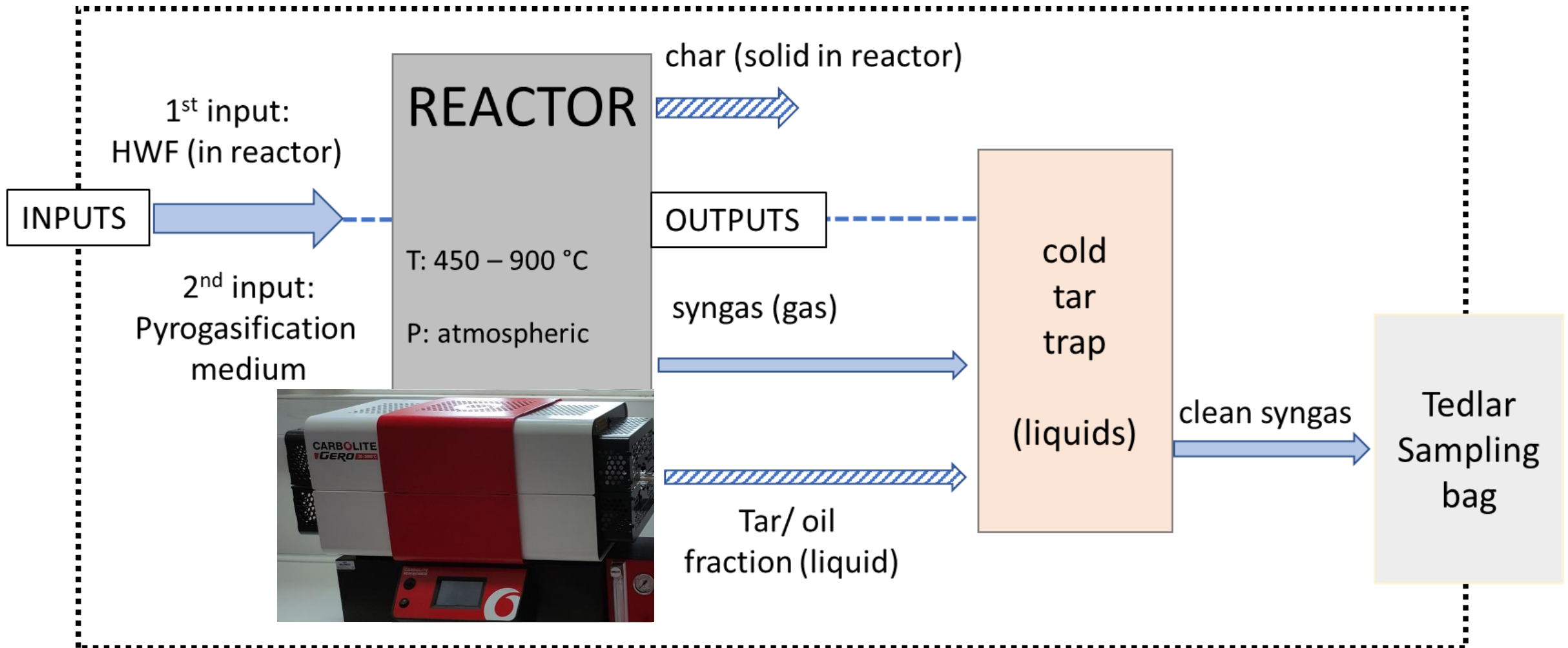
The HYDROPYR concept - description

- The system is being upgraded in this project by adding a pyrolyzer and PV panels. Thus, the novel process of PV-assisted hydrolysis in a value chain that is from now on named HYDROPYR.
- The pilot facility will operate for a two-year span and for at least eight cycles that would account for seasonality and feedstock fluctuation.
- The novel pilot hydrolysis plant will be monitored for its performance and energy requirements.
- **The produced gases from HYDROPYR will be monitored continuously.**

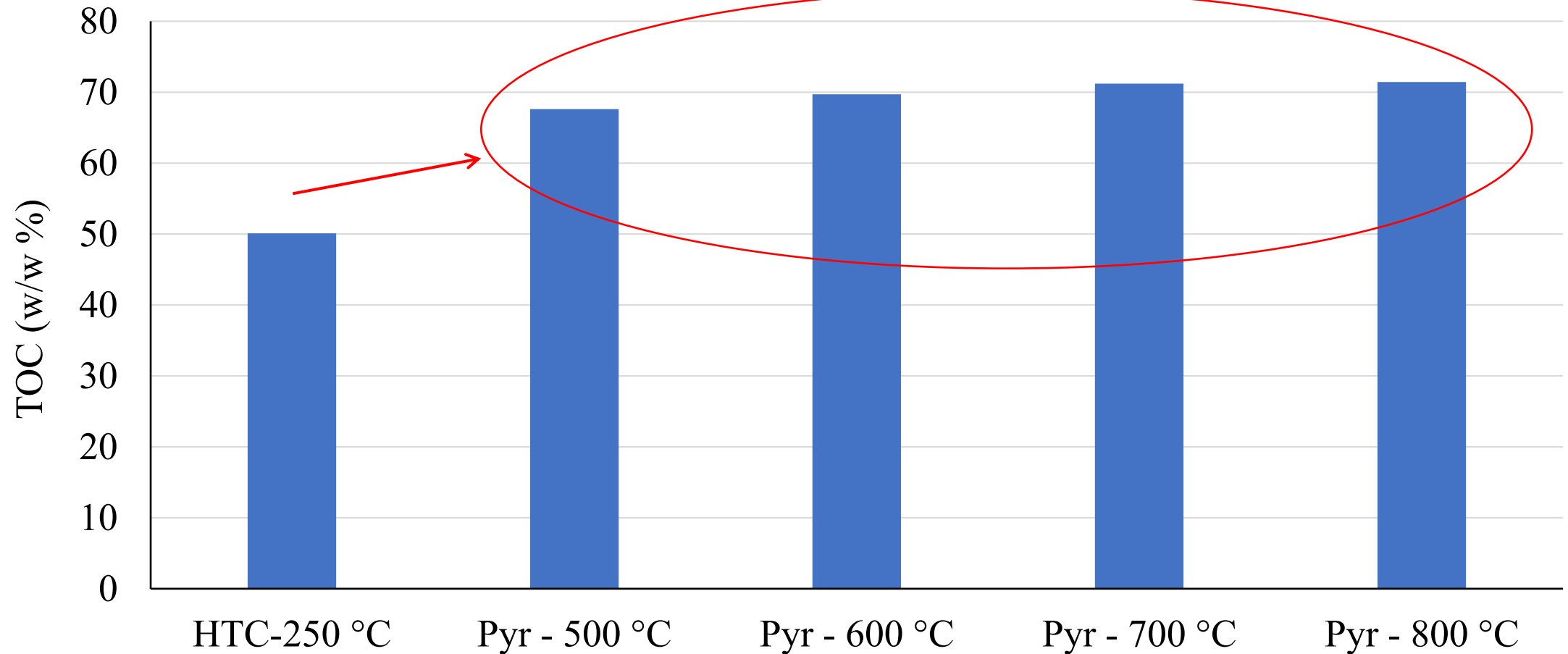
The HYDROPYR concept - BioFairNet Pilot Site



Preliminary pyrolysis of hydrochar



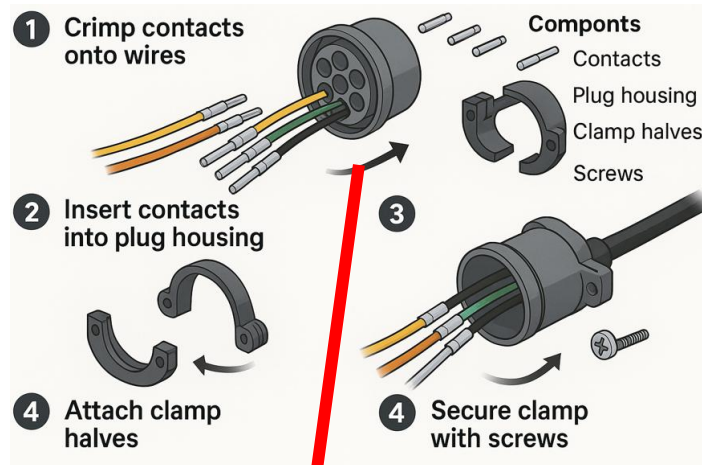
HYDROPYR - From Hydrochar to Biochar



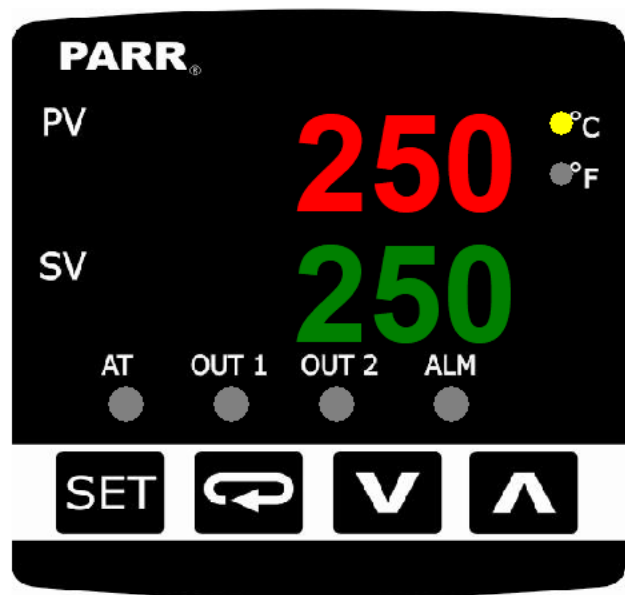
Green energy transition of HTC/ pyrolysis

- Pecchi et al. (2022) applied HP-DSC experiments and showed that HTC is exothermic.
 - Contrary to other thermal processes (i.e. pyrolysis), the exothermicity of HTC is attributed to decarboxylation reactions.
- **Nonetheless, in pilot sites the utilization of auxiliary systems and the propagation of transport phenomena create the necessity for high-intensity electricity.**
- **Also, there is an assumption that the electrical grid will be “greenified” and will support electrified PI operations. This is not the case for several reasons: capacity of the grid to support industrial operations, the need for frequency control, the variability of RES.**

PLC in HTC



- The need for advanced controls has been widely communicated.
- State-of-the-art HTC reactors can support such needs.
- An example of using a 4848B Parr controller is presented (left).
- The connection of the reactor controllers with electric valves and mass flow controllers allows advanced operational capabilities.



Out1	0%
Out2	8%

Address 1

PV 250 C Alarm 1
 Alarm 2

SV 250

Out1

Out2

Address 2

PV 1 EU Alarm 1
 Alarm 2
 Alarm 3

SV 50

Out1

Address 3

PV 40.0 EU Alarm 1
 Alarm 2
 Alarm 3

SV 275.7

Out1

Address 1

PV 0 C

SV 0

Control

Ctrl. Method

Run/Stop

Heat/Cool

Com. Write

Lock Status

Input

Input Type

Unit

SV

Range Hi

Range Lo

PID Parameter

Pb

Ti

Td

Ctrl. Period1

I Offset

Alarm

Alarm 1 Mode

Absolute Up Limit Down

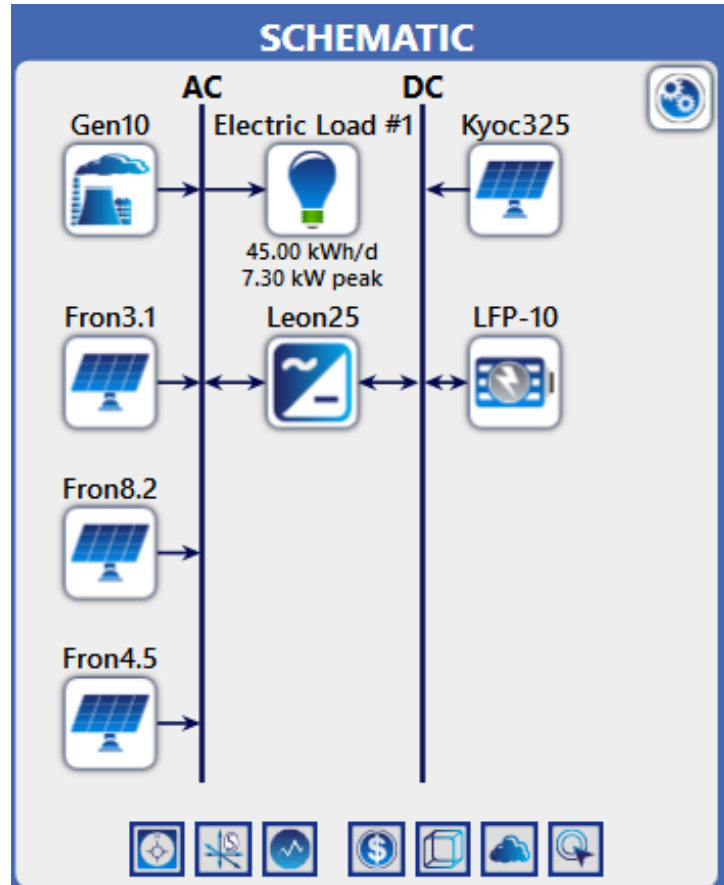
Alarm 2 Mode

Alarm Disable Down

PV tuning

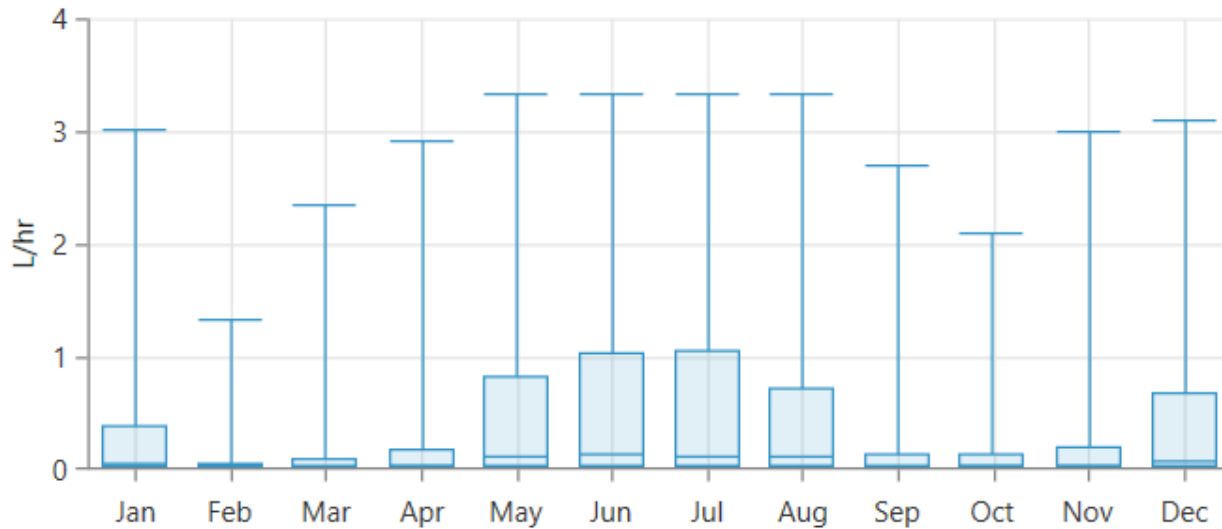
PV Offset

Energy modeling of RES integration

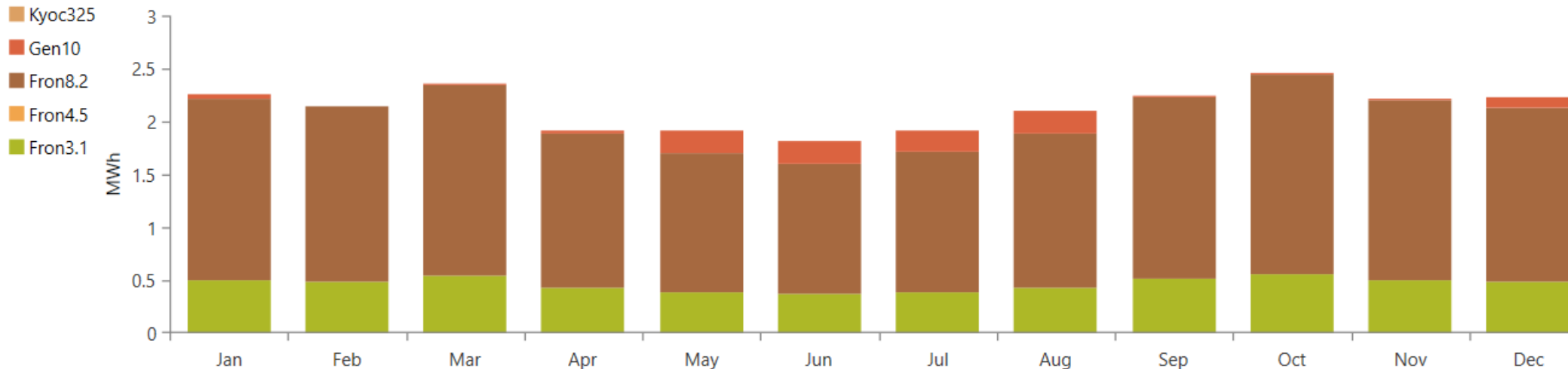


- Microgrid energy modelling can be a pathway to model the green transition of industrial PI systems. (software HomerPro)
- The conventional generators are supported by RES and storage systems
- In the case of the HTC reactor, we have modelled the system by accounting multiple configurations and we produced an optimal solution after 10.240 simulations.

Electrical production of optimal architecture



Monthly Electric Production



- The LCOE is reduced from 1.13 €/kWh to 0.465 €/kWh
- The operation of the diesel generator is reduced but is still necessary
- **Storage technologies are paramount!**

A few points for discussion

- HTC can be an excellent technology for treating mixed waste, and converts ~ 50% of the TS in hydrochar
- The novel concept of HYDROPYR couples HTC with pyrolysis for the upgrading of hydrochar into biochar
- State-of-the-art controllers can advance the capabilities of the existing reactors
- The integration of onsite RES systems with PI reactors/ systems is critical for the true “greenification” of PI. Batteries are critical for the higher RES penetration and a conversation should be made about the role of pump hydro on a national level.



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Thank You For Your Attention!

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