A Tunable Approach of Converting Low Grade High Ash Biomass to High Value Bio-Carbon for Commercial Applications

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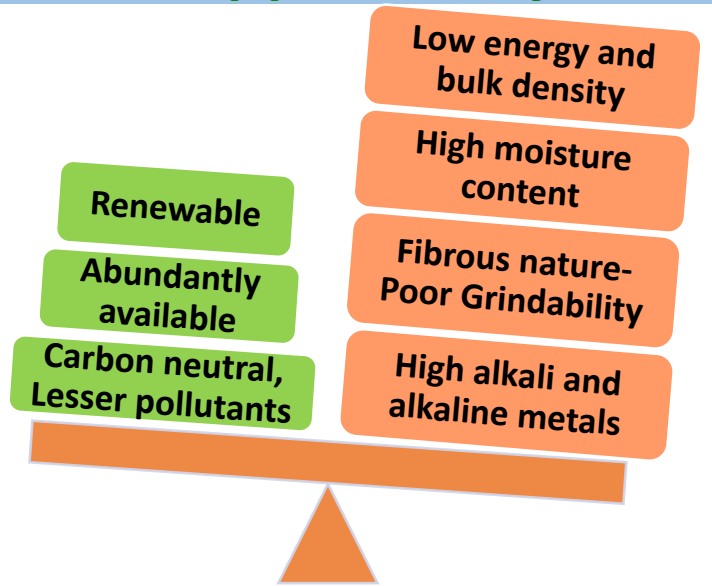
Theme of the research:

"Waste is a resource - waiting for an opportunity"

"Agri-food wastes is not regarded as an ideal replacement for fuel and materials application"



Research Questions:

- Can we produce industrial grade biocarbon from this low quality biomass (low alkali metals, higher HHV, and higher grindability)?

	Conventional pre-treatment: Drying, torrefaction, pyrolysis	**Alternative Pre-treatment:** HTC
❑ **Moisture**	✗	✓
❑ **Ash**	✗	✓
❑ **Processing time**	?	✓
❑ **Energy intensity**	✗	?
❑ **Operation**	✓	?

Hydrothermal Carbonization (HTC) processing where biomass is treated with hot compressed water instead of drying exhibits unique physicochemical properties

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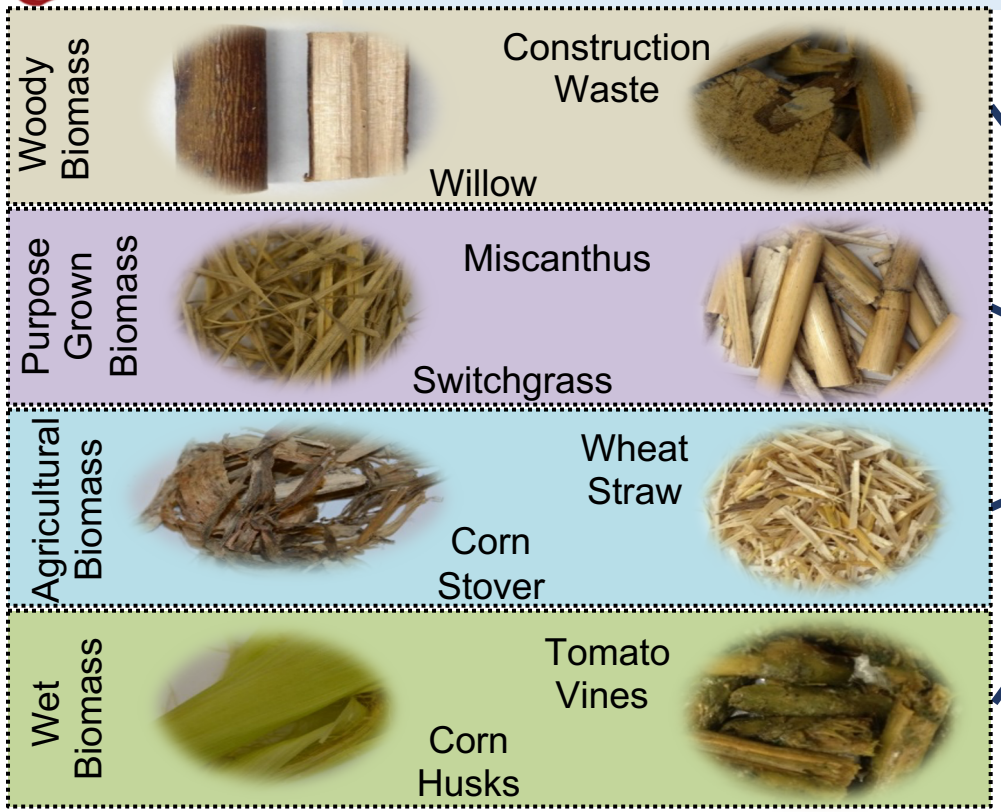
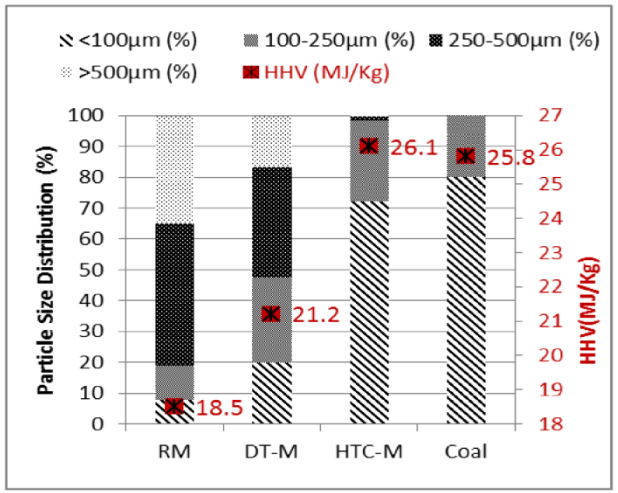
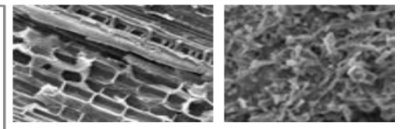
Biocarbon development research



HTC Carbon

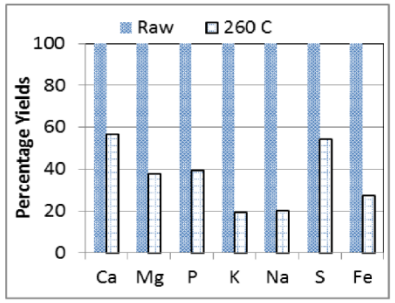
- **Bio-carbon** → Soil amendment
- **Bio-carbon** → Heat and power production
- **Charcoal** → Metallurgy applications
- **Activated Carbon** → Wastewater treatment; Energy storage





RM: difficult to grind

HTC-M: Easy to grind



- **HTC can be an ideal pre-treatment method to remove some of the barriers.**
- **Depending upon applications, it may require further processing**

Case Study 1: Bioenergy and biofertilizer from hydrothermal treated corn residue: a circular economy concept

Corn residue

M=1 kg_{dry}; E=18.13 MJ

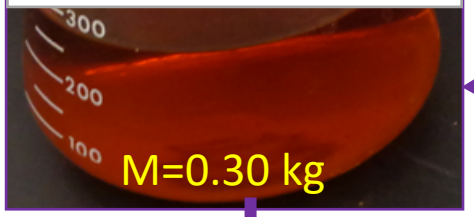
Hydrothermal process

M loss = 0.23 kg

Biocarbon for different application

M=0.47 kg; E=10.91 MJ

Liquid (HTPW)



AD process

Biogas

Biomethane

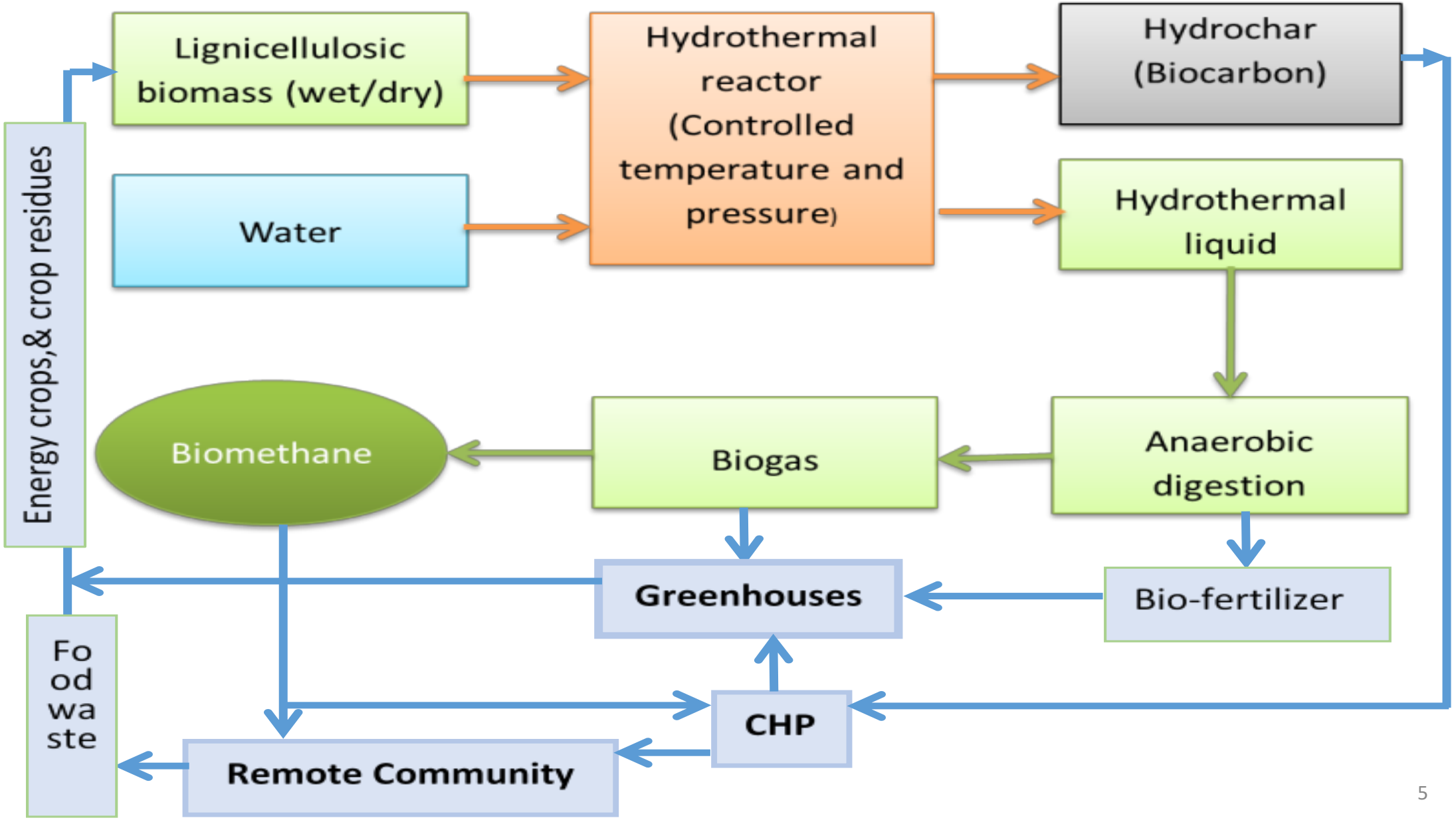
E = 3.35 MJ

Digestate (Biofertilizer)

Recovery N=31%, P=23%, K=26%, S=19%

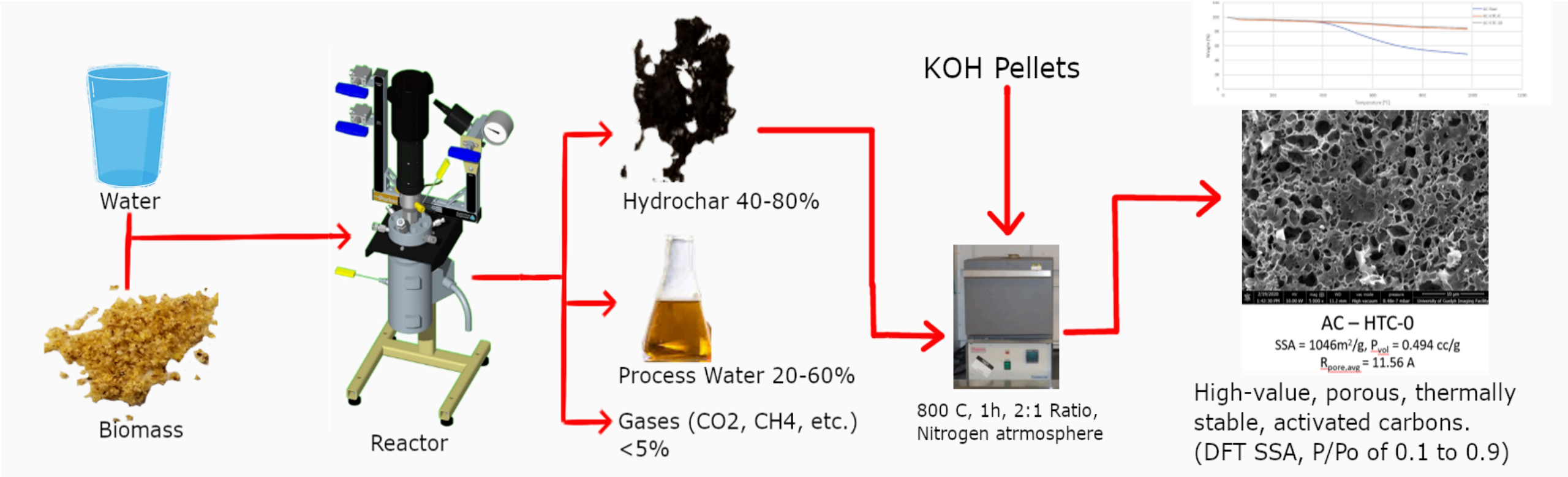
Overall energy recovery efficiency=79%

Case Study 1: Waste to Wealth: A Circular Economy Based Approach



Case Study 2: A Tunable Approach for Activated Carbon Production from Low Value Biomass

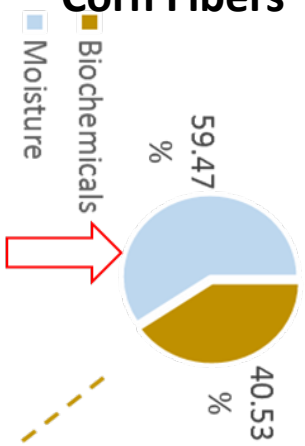
- Valuable, high quality activated carbons can be produced through a 2-step HTC and chemical activation procedure.
- Applications in heavy metal removal, water filtration, gas storage, super capacitors, and many more.



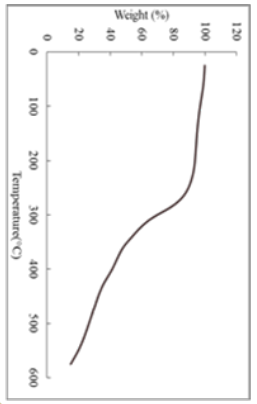
Bio resource – Industrial Co-Products Applications

FIBER

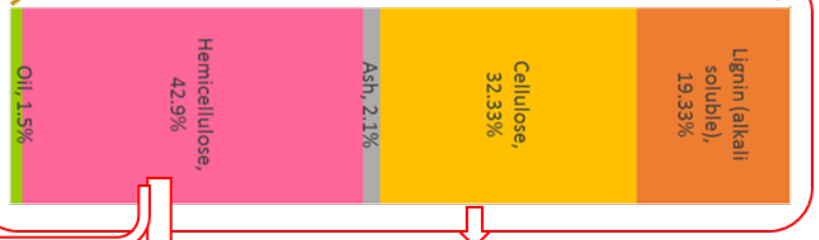
Corn Fibers

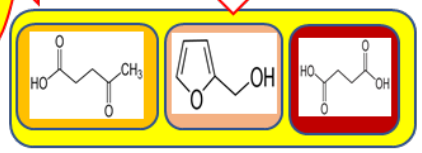


Fiber

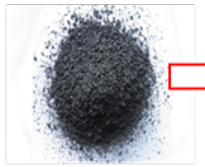


Xylitol / Ethanol





Platform Molecules

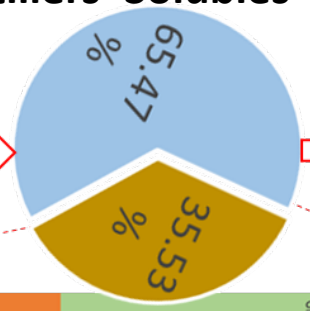


Bio carbon

Adsorbent

CDS

Corn Distillers' Solubles



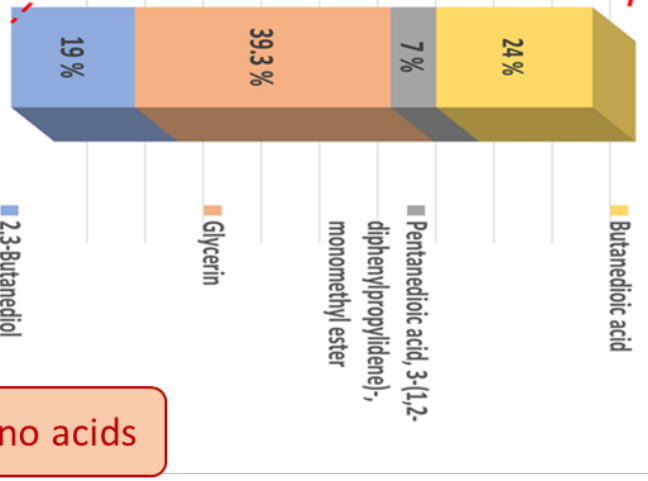
Toxic residue / organic extracts

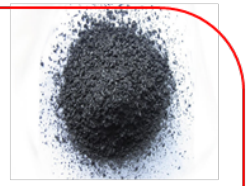
Hydrothermal Carbonization

Proteins

Functional Peptides for Feed

Amino acids

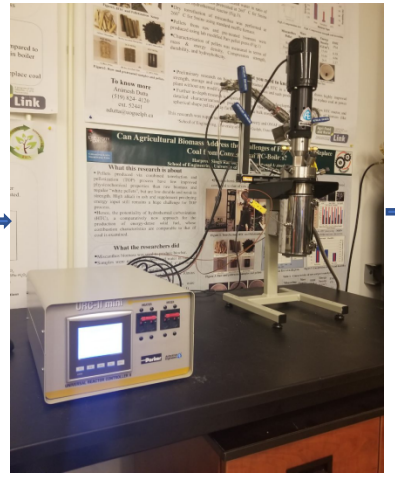


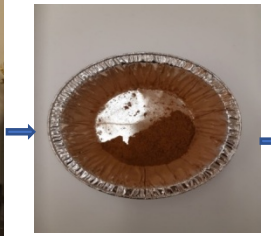


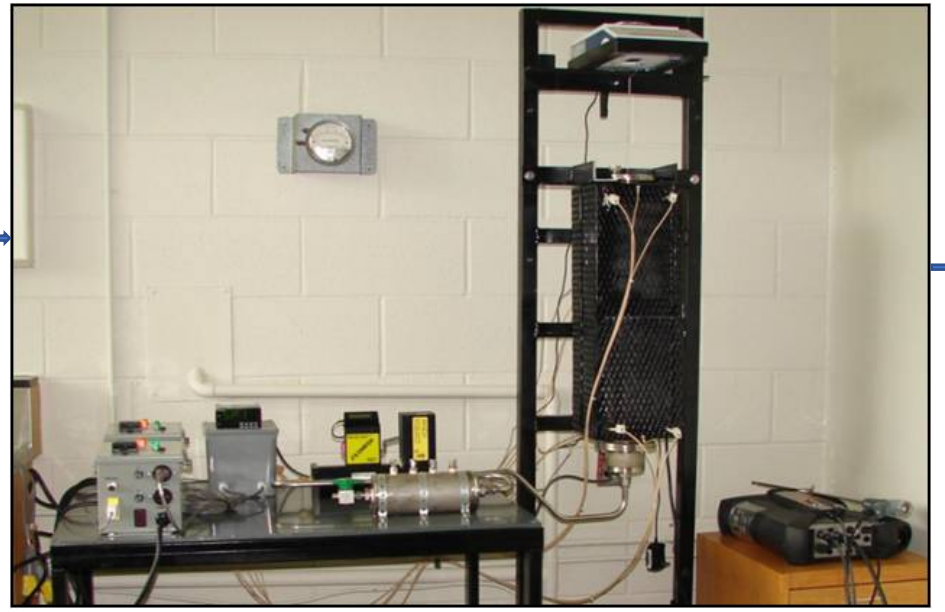
Bio carbon

Adsorbent / Fertilizer

Case Study 3: Miscunthus/Switchgrass to Biocabon for Iron and Steel Industries: A Tunable Approach

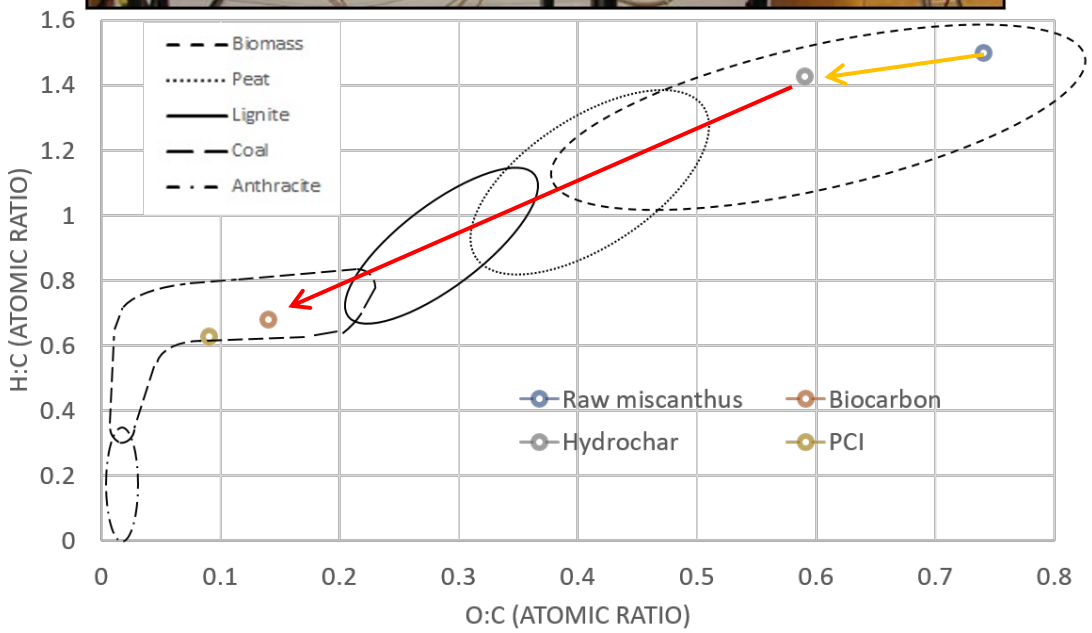






Properties	Raw Switchgrass	Torrefied-290
%C	**44.76 ± 2.04**	**64.28 ± 2.42**
%H	6.04 ± 0.62	4.34 ± 0.69
%N	0.66 ± 0. 08	0.68 ± 0.13
%S	0	0
%O	**44.09 ± 1.87**	**23.58 ± 1.87**
HHV (MJ/Kg)	**17.13 ± 1.49**	**26.04 ± 1.91**
%VM	84.3 ± 3.18	50.35 ± 2.72
%Ash	**4.45 ± 0.23**	**7.12 ± 0.38**
%FC	11.25 ± 0.8	42.53 ± 1.83

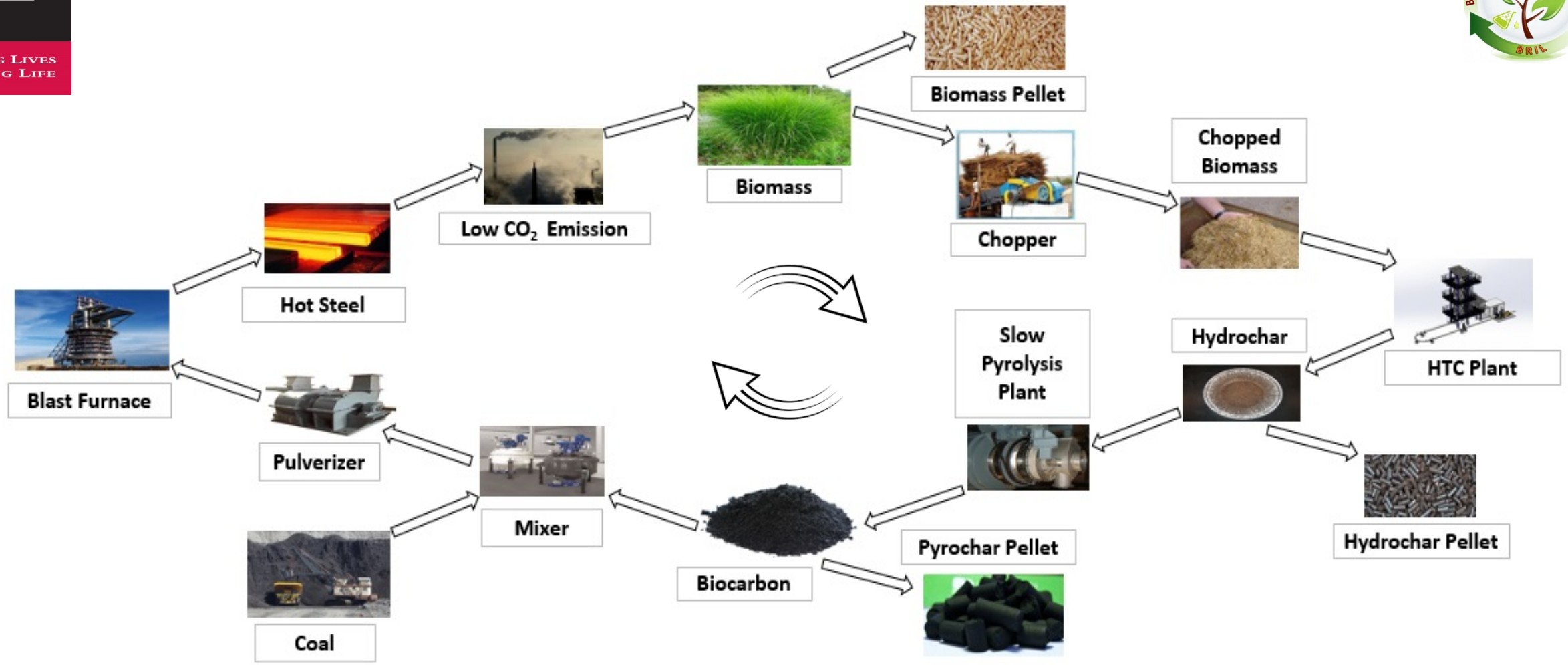
Hydrochar	
C(%)	**52.2**
H(%)	6.2
N(%)	0.05
S(%)	0
O(%)	**41.31**
Ash(%)	**0.24**
FC(%)	15.1
VM(%)	84.66
HHV (MJ/Kg)	**20.37**



Biocarbon	
C(%)	**79.67**
H(%)	4.5
N(%)	0.35
S(%)	0
O(%)	**14.69**
Ash(%)	**0.79**
FC(%)	63.71
VM(%)	35.5
HHV (MJ/Kg)	**32.59**

PCI coal	
C(%)	**77.66**
H(%)	4.1
N(%)	1.76
S(%)	0.3
O(%)	**9.53**
Ash(%)	**6.65**
FC(%)	56.94
VM(%)	36.41
HHV (MJ/Kg)	**32.07**

Case Study 3: Overall Approach

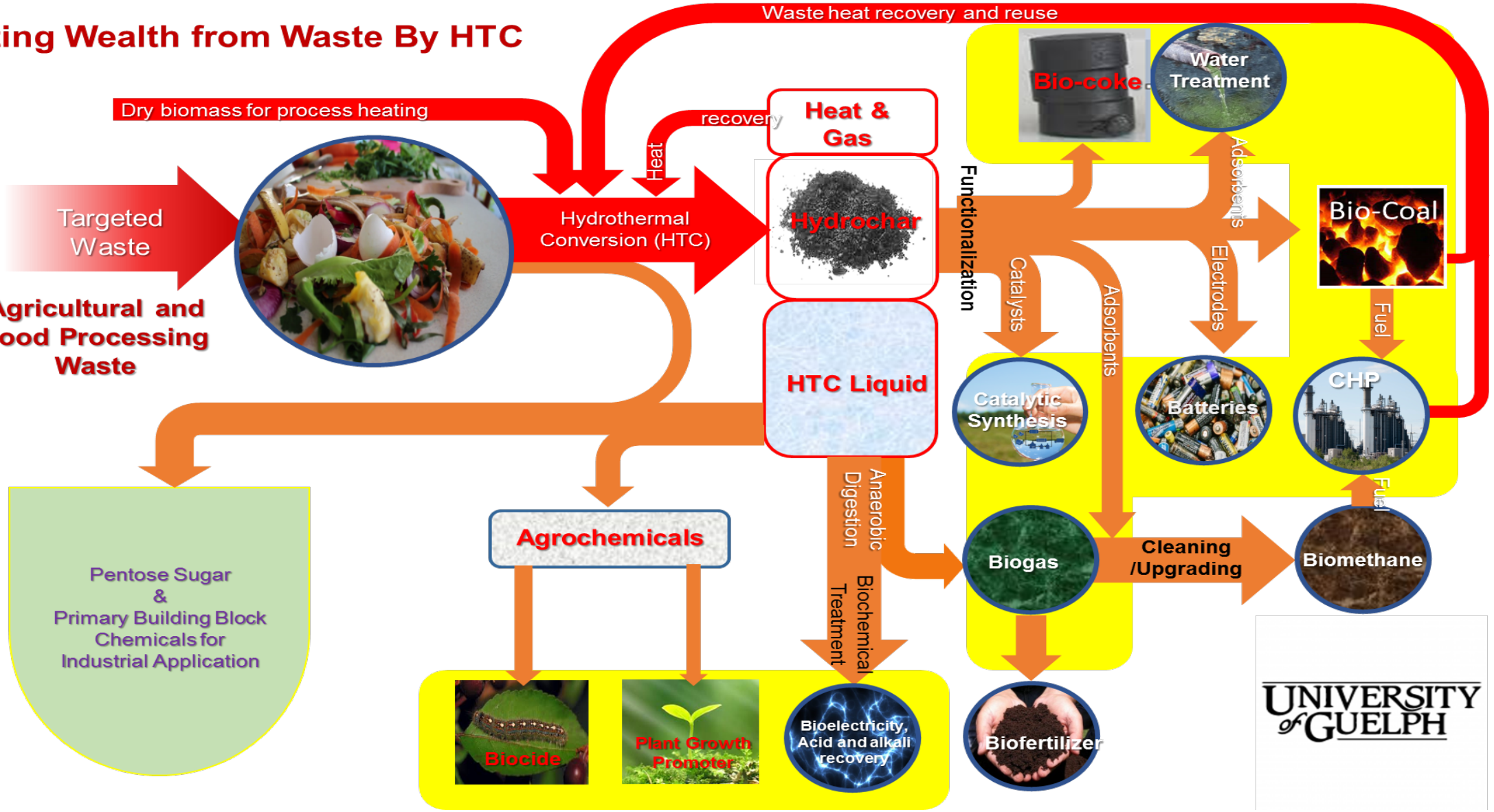


- Integrated HTC and slow pyrolysis of high ash low grade biomass
- Biocarbon with less ash content and good combustion behavior
- Partial replacement of fossil carbon in blast furnace ironmaking process
- Reduction of GHGs emission

Conclusion: Preprocess greenhouse residues, energy crops, crop residues, municipal green bin fruit processing wastes through HTC processing.

Approach Under Evaluation

Creating Wealth from Waste By HTC



Leading to zero-waste solutions

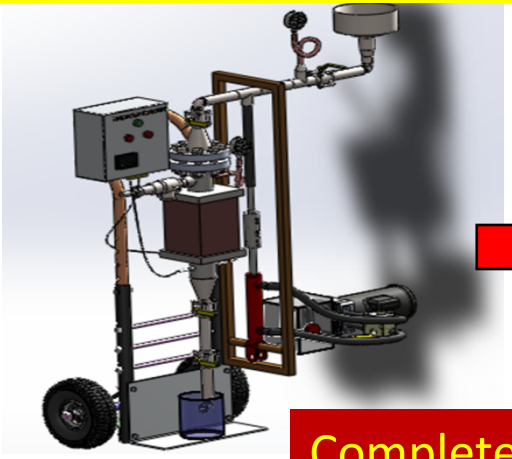
HTC products from low quality agri-food residue can be a potential newer value chain

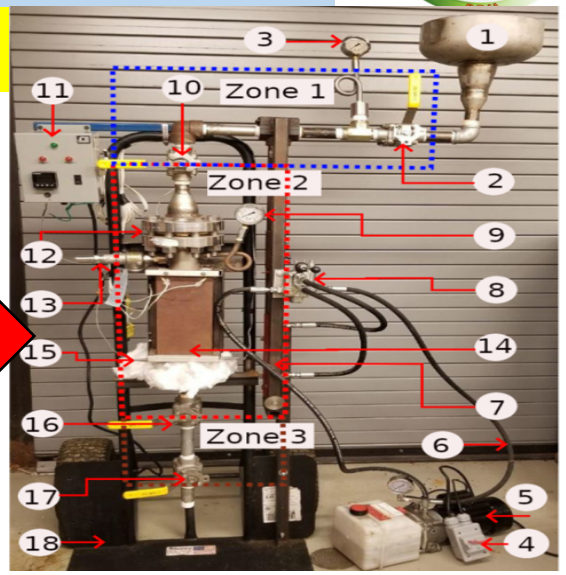
Technical Progress

Lab scale continuous hydrothermal carbonization (HTC) reactor

A lab-scale continuous hydrothermal carbonization (HTC) reactor is developed and validated.

Conceptual Design



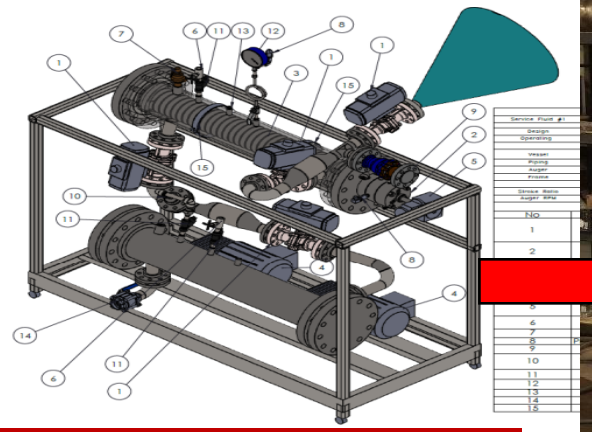


Complete

Pilot scale continuous hydrothermal carbonization (HTC) reactor

A continuous pilot scale HTC reactor being developed. The process was validated with laboratory scale trials.

Conceptual Design



Under Commissioning

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BRIL TEAM

Thank You for Your Time

Acknowledgement

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