BIOBATTERY CONCEPT: DECENTRALIZED PRODUCTION OF FUEL FROM FOREST BIOMASS, AGRICULTURE RESIDUE, AND MUNICIPAL SOLID WASTE

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BACKGROUND

One of the key pathways of converting biomass/organic waste directly to a dense liquid, generally known as bio-oil, is through thermo-chemical conversion or conventional pyrolysis. The bio-oil produced from existing technologies has low pH and high viscosity and is typically unstable over time. These properties affect the overall feasibility and economics of the use of biomass-based feedstock for the conversion to fuels and chemicals. They need to be improved in order for bio-oil to be used in the production of fuels and chemicals.

Thermo-catalytic reforming (TCR) technology or intermediate pyrolysis, which is the core of the biobattery concept, is the key focus of this research project and will help address the challenges with the bio-oil produced from conventional pyrolysis. The fuels and chemicals can be used in the oil sands and power sectors. This bio-oil could further be co-refined with crude oil to produce biojet fuel, which could be used by the aviation industry.

This project will also help to commercialize the use of forest and agricultural residues and to diversify Alberta's economy while reducing GHG emissions.

AIMS AND OBJECTIVES

The major objective of the proposed project is the development of a decentralized technology at pilot scale through the biobattery concept, which includes intermediate pyrolysis of woodchips and straw biomass to produce biojet fuel and char for power generation. The short -term objectives are to:

i. Demonstrate the feasibility of TCR technologies at pre-commercial scale in Alberta
ii. Generate experimental results using various feedstock materials, e.g., forestry and agriculture wastes, in terms of bio-oil, gas, and char yields
iii. Explore the opportunity for biojet fuel production
iv. Establish operating procedures for running TCR technology at a 30 kg/h scale
v. Develop models that could help develop a commercial-scale unit
vi. Assess the risks by demonstrating TCR technology for Alberta-based feedstocks
vii. Test the results of converting TCR oil to biojet fuel
viii. Test the results of converting TCR-based char to power
ix. Develop joint IP with FhG-U for a 30 kg/h unit and associated technologies

PROJECT OVERVIEW

The TCR technology is an intermediate pyrolysis technology where conditioned biomass is heated in pyrolytic conditions to produce bio-oil, char, and gases. Biomass is fed through a hopper and pyrolysed in a reactor. The products are passed through a catalytic reformer; this is a key difference from other technologies. The outputs of the reformer are synthesis gas, bio-oil, and bio-coal/biochar. **Figure 1** shows TCR technology.

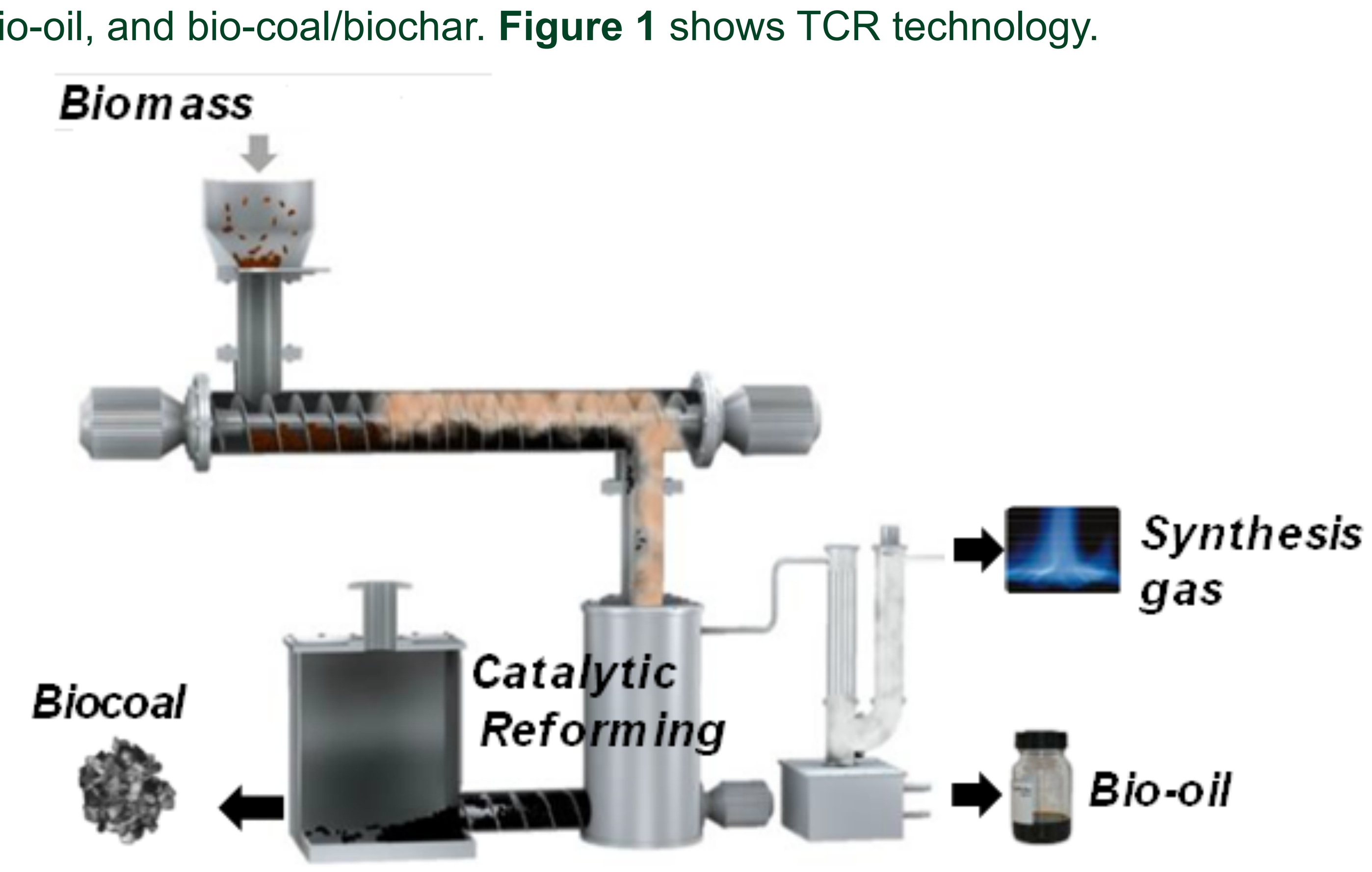

Figure 1: Thermo-catalytic reforming (TCR) technology

Figure 2 shows the energy balance of the TCR process. The sample feedstock in the figure is digestate. A significant portion of the input energy comes out as char. Most of the energy, which comes out in gas, can be recycled back to provide the process energy requirement. It is expected that the energy balance of the process would be similar for other feedstocks. The laboratory scale 2 kg/h TCR (TCR-2) unit, which will be at the chemical engineering laboratory at the University of Alberta, will be used to test the performance of the TCR at a lower scale, while the pilot plant (TCR-30) will be located in the Advanced Energy Research Facility (AERF) at the Edmonton Waste Management Centre in close collaboration with the City of Edmonton.

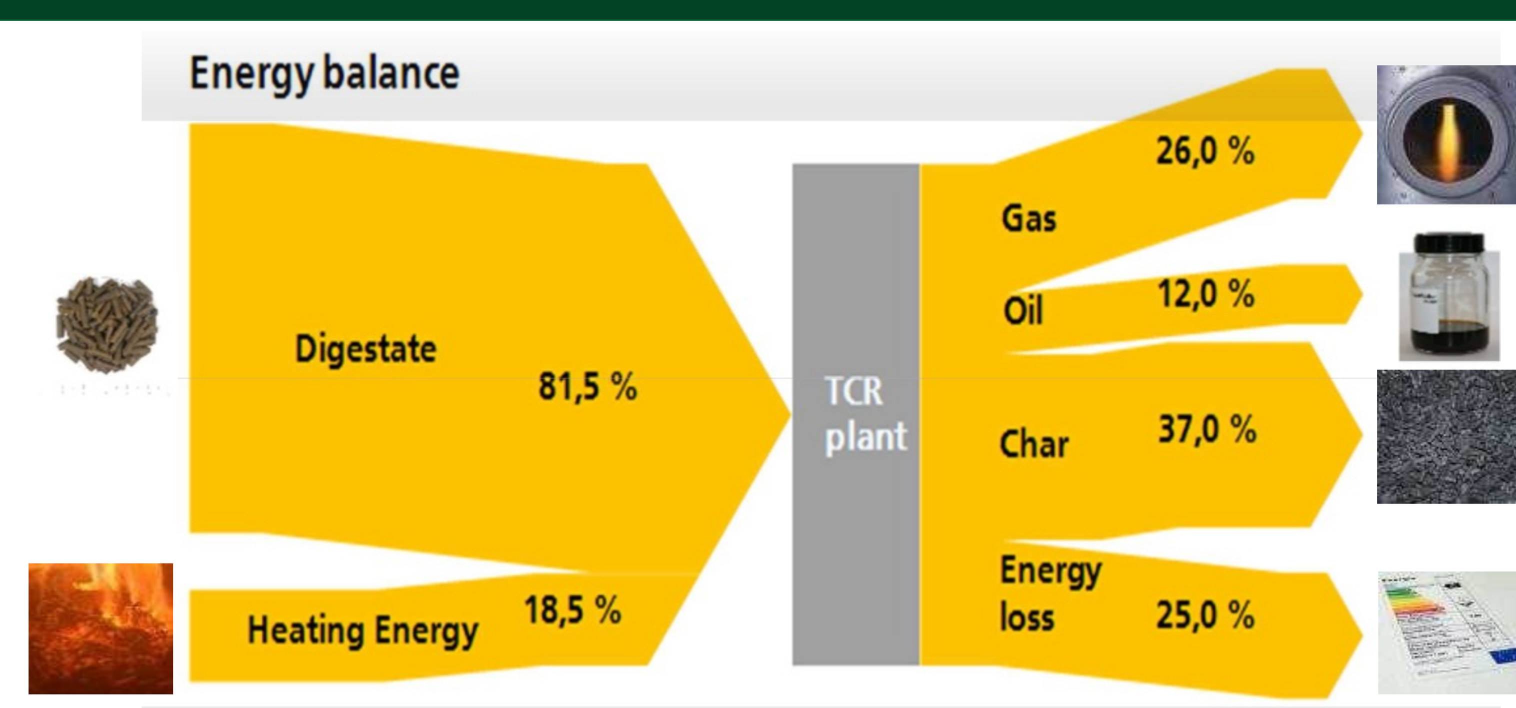

Figure 2: The energy balance of the TCR process

For a 30 kg/h pilot plant (TCR-30), the objective is to test the optimum operating conditions for maximum yield and best product quality yet to be defined. Two feedstocks are considered currently: forest and agricultural biomass. The main operating variables influencing the pyrolysis products are: i) pyrolysis temperature, ii) residence time or soak time at pyrolysis temperature, and iii) heating rate (ramp rate). IPs are shown in **Figure 3**.

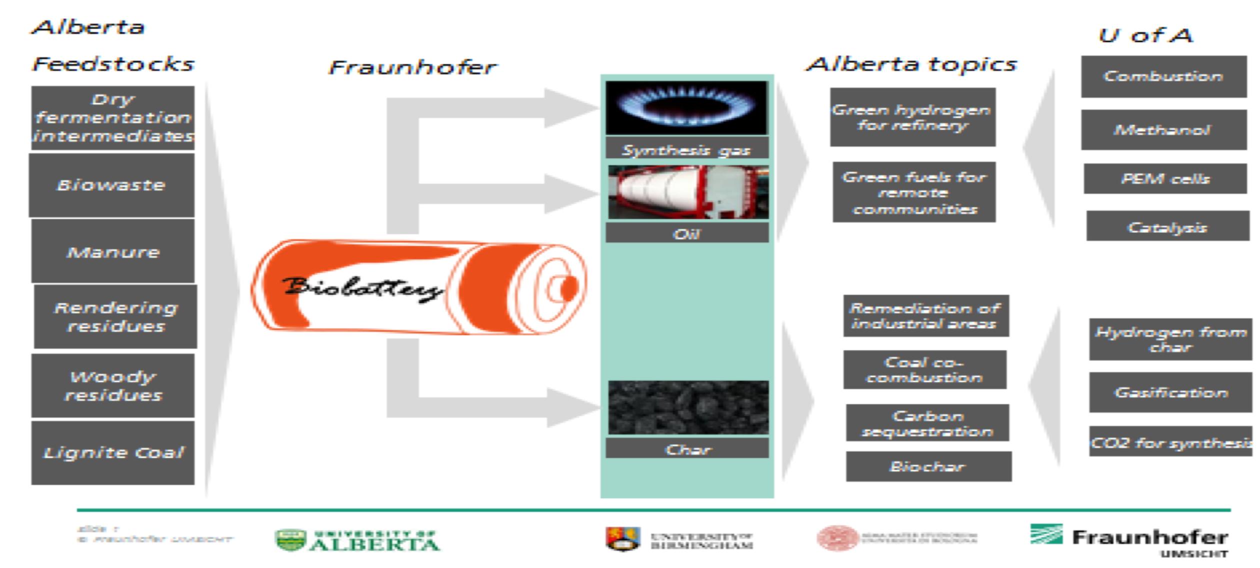

Figure 3: The biobattery concept for Alberta

EXPECTED OUTCOMES

• ***Aviation Industry*** – The biojet fuel produced from refining the bio-oil produced through TCR technology can be used in the aviation industry. The conditioned bio-oil could be co-refined in a conventional refinery to produce bio-jet fuel.

• ***Power Industry*** – One of the key applications of the char produced from the project is in the power industry. The char could be directly used to replace coal or could be co-fired with coal. The char will also be directly in line with the aim of Alberta's Climate Leadership Plan to generate 30% renewable power by 2030. More than 50% of the power generated in Alberta is from coal. There is a potential to use the produced char in these power plants.

• ***Oil Sands and Chemical Industries*** – The biochar produced from the biobattery project could be used as a remediation agent. This project has a very large potential for the oil sands industry. The gases produced from TCR include hydrogen, and the refined hydrogen can be used in the chemical industry to upgrade bitumen. Currently, more than 95% of the hydrogen used is produced from natural gas, and natural gas production emits high GHGs.

• ***Agricultural Industry*** – The biochar produced from the biobattery project could be used as a soil conditioner. This use has great potential in Alberta's agricultural sector.

• ***Municipalities*** – The biobattery technology concept is to use many feedstocks and to produce useful products. The agricultural and forestry wastes feedstocks available in various municipalities can be used in the biobattery technology. This technology can be used at a decentralized scale, and that is a key benefit of this technology.

FUTURE DIRECTIONS

1. Testing the TCR-2 and TCR-30 units.
2. Production of bio-oil from various feedstocks.
3. Upgrading bio-oil to biojet fuel.

PARTNERS

The funding partners for this project include:
• Alberta Economic Development and Trade (EDT)
• Alberta Innovates (Bio Division)
• Fraunhofer Institute – Germany
• Westjet
• Future Energy Systems, University of Alberta

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UNIVERSITY OF ALBERTA
FUTURE ENERGY SYSTEMS

CANADA FIRST
RESEARCH EXCELLENCE FUND

This research has been undertaken thanks in part to funding from the Canada First Research Excellence Fund.