A CYCLIC CARBON ECONOMY IN THE PRODUCTION OF BIOCHAR AND FAST-GROWING, PROTEIN-RICH DULSE SEAWEED

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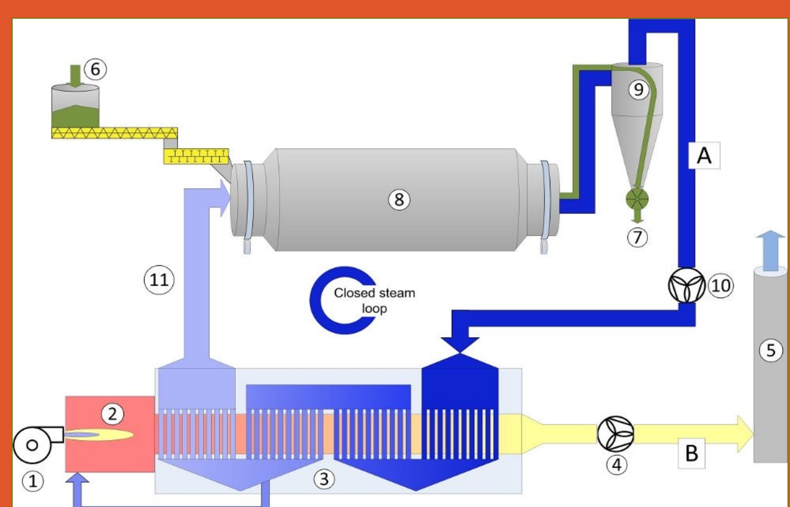
PRE-PYROLYSIS

- Valuable proteins RuBisCo and phycobilin are extracted from the raw seaweed, leaving behind wet biomass waste
- Waste can be converted into valuable byproducts
- A superheated steam dryer is employed to reduce the moisture content before the biomass is pyrolyzed
- Offers high energy recovery over simpler heating methods and short residence time



1. Burner
2. Combustion Chamber
3. Gas/Gas Heat Exchanger
4. Exhaust Gas Fan
5. Exhaust Stack
6. Wet Product
7. Dry Product
8. Rotary Drum
9. Cyclone
10. Main Fan
11. Superheated Steam

A: Possible heat recovery process gas
B: Possible heat recovery flue gas

GASIFICATION

- Converts organic forest scraps into carbonaceous material in the absence of oxygen
- Reduces moisture content in woody biomass, need for efficient pyrolysis
- Produces syngas to heat pyrolysis unit

PYROLYSIS

- Primarily produces biochar with some bio-oil and bio-gas
- Bio-gas is burned to create heat to power other parts of process
- Fully automated unit to reduce labor costs and increase reaction control
- Self-sustaining by utilizing the hot flue gas generated by the gasification unit

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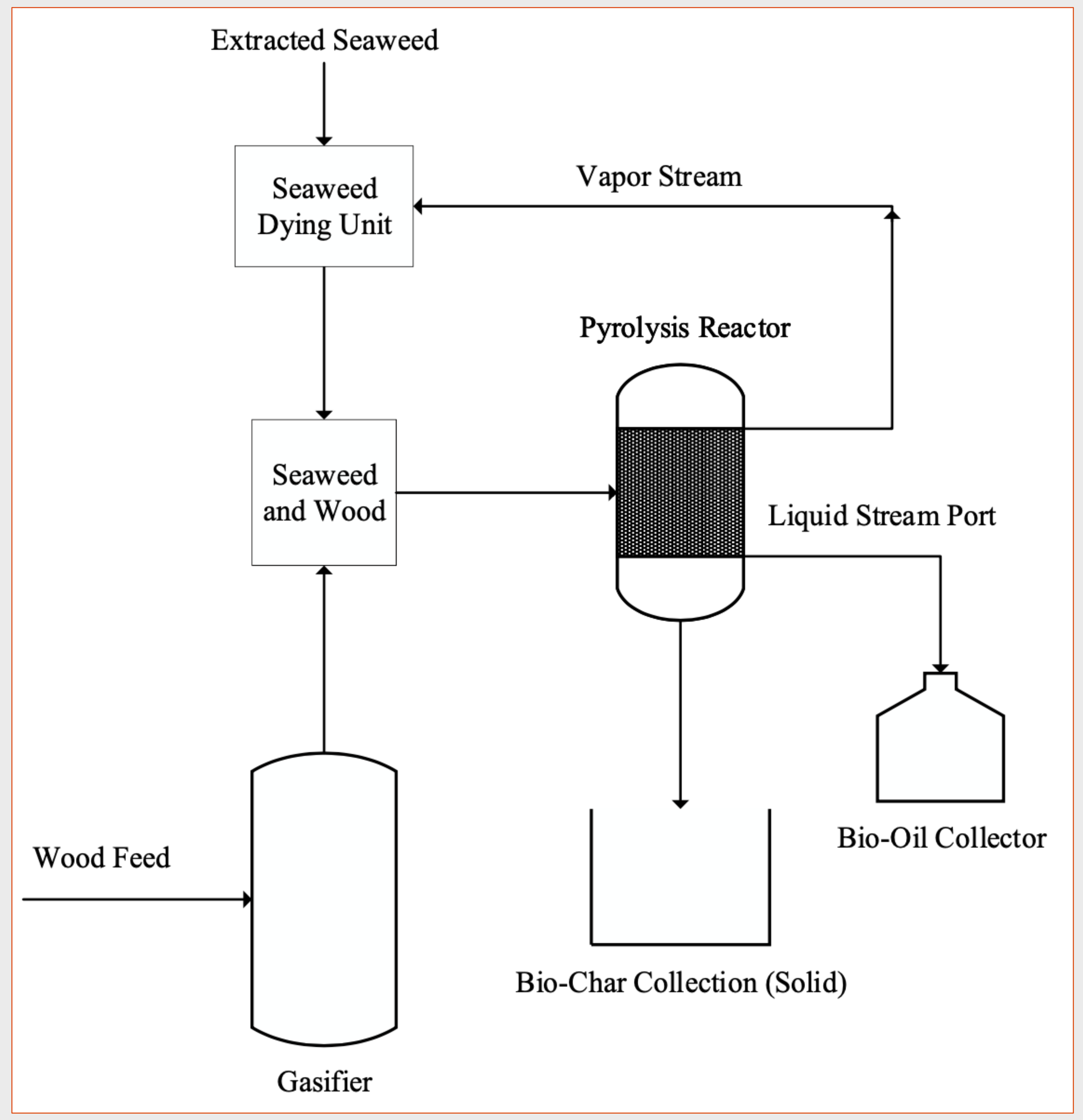
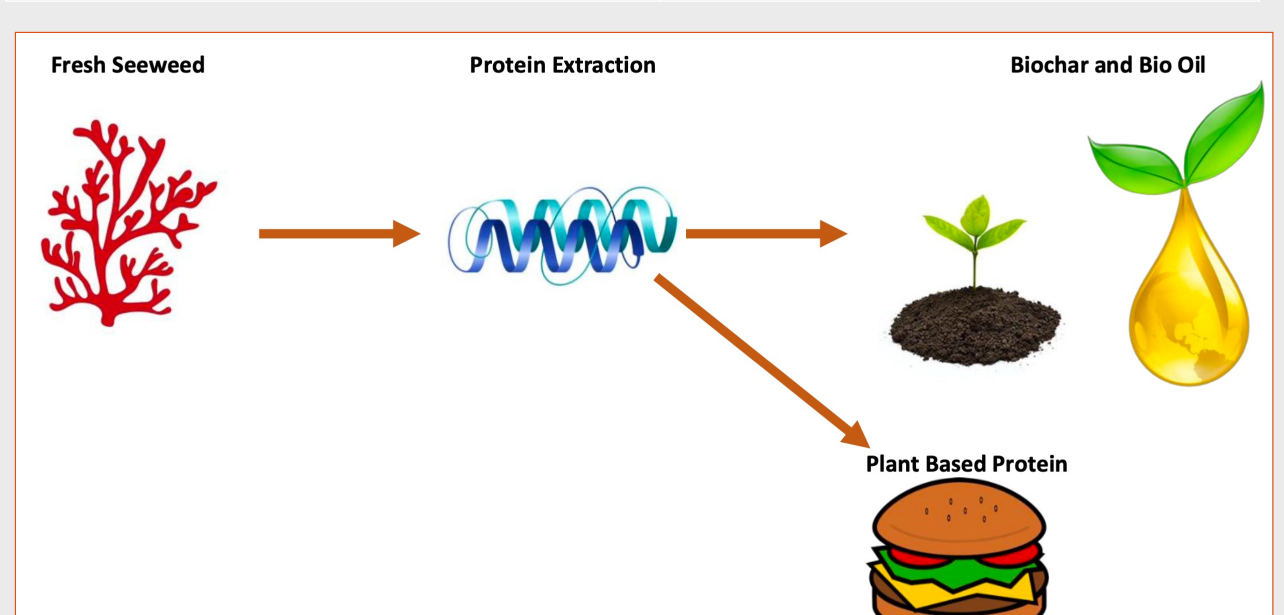


Process flow diagram for production of biochar and bio-oil from protein extraction residuals of Oregon Dulse seaweed and added forestry residuals (i.e. wood chips). A slow pyrolysis unit will be used to produce biochar while a gasifier burning wood chips will supply energy for the pyrolysis, as well as for the superheated steam dryer.

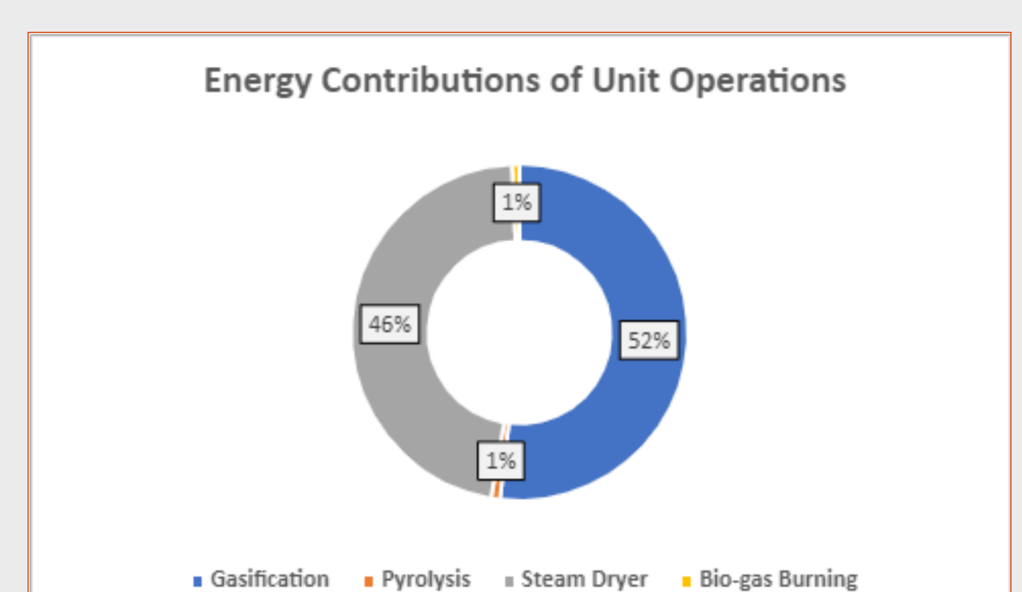
PRODUCTS

Biochar	Bio Oil
• **Carbon Sequestration:** used to capture and store carbon from the atmosphere • **Agriculture:** improves crop yield due to its high mineral content	• **Usable Fuel Source:** requires little to none post processing • **Clean Energy:** heat source, transportation, cooking, replacement for fossil fuels



IMPACT

- Shown are the magnitudes of each unit operation in the process; drying and pyrolysis require energy, while gasification and burning bio-gas produce usable energy
- Steam drying allows for ~80% energy recovery and can be improved upon with an additional pre-drying step (such as centrifugation)
- We expect to be sequestering ~ 2 million tons CO_2e- per year from producing biochar alone



OVERVIEW

- Pacific dulse seaweed, taxonomically known as *Develeara Mollis*, is the fastest-growing and most protein-rich vegetable available on the market
- Grown on non-arable land, affording lower land use and higher protein content than soy and other popular plant-based sources
- Oregon Dulse views this as an opportunity to simultaneously be carbon negative, while tackling the world's increasing protein demands
- Goal: to create an operation capable of producing 4 million pounds of protein a year

DYNAMIC MODEL

- Utilizing Julia, a programming language, and a popular notebook package, Pluto, variables within the model can be assigned to interactive sliders
- This affords real-time exploration to changes in variables such as the desired yearly production rate of protein, number of growing tanks on-site, the seaweed's expected growth rate, and more