

# Techno-economic analysis of a combined anaerobic digestion and hydrothermal carbonization system

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## INTRODUCTION

- Anaerobic digestion (AD) is a biochemical conversion method that treats wet biomass, such as sewage sludge, which is the solid fraction from wastewater treatment plants (WWTP). Anaerobic digestion effluent (ADE) is a microbe, nutrient, carbon, and water-rich byproduct from AD and is usually dewatered and sent to the landfill, incinerated, or applied to agricultural fields [1]. ADE dewatering is an energy intensive and expensive process.
- Hydrothermal carbonization (HTC) is a thermochemical conversion method that processes wet biomass, under subcritical conditions, into hydrochar and a liquor [2]; thus, it is ideal for ADE. Hydrochar is a carbonized material with potential uses including solid fuel and soil amendment [3]. Soil amendments can improve soil properties and therefore plant development. Different types of soil amendments include biochar and hydrochar [4].

## OBJECTIVE

- Evaluate the techno-economic feasibility of a combined anaerobic digestion and hydrothermal carbonization system for sewage sludge treatment and hydrochar production.

## METHODS

### HTC of ADE Experiments

- ADE of sewage sludge was collected from a WWTP in Ohio. HTC runs were carried out under different process conditions (temperatures and times) following a central composite design (CCD) (Fig. 1). HTC runs were carried out in a 1 L Parr reactor (Fig. 2). After HTC, the samples were recovered (Fig 2). The center point from the CCD was used as the base case for the techno-economic analysis, and hydrochar was produced at that condition to use as soil amendment.

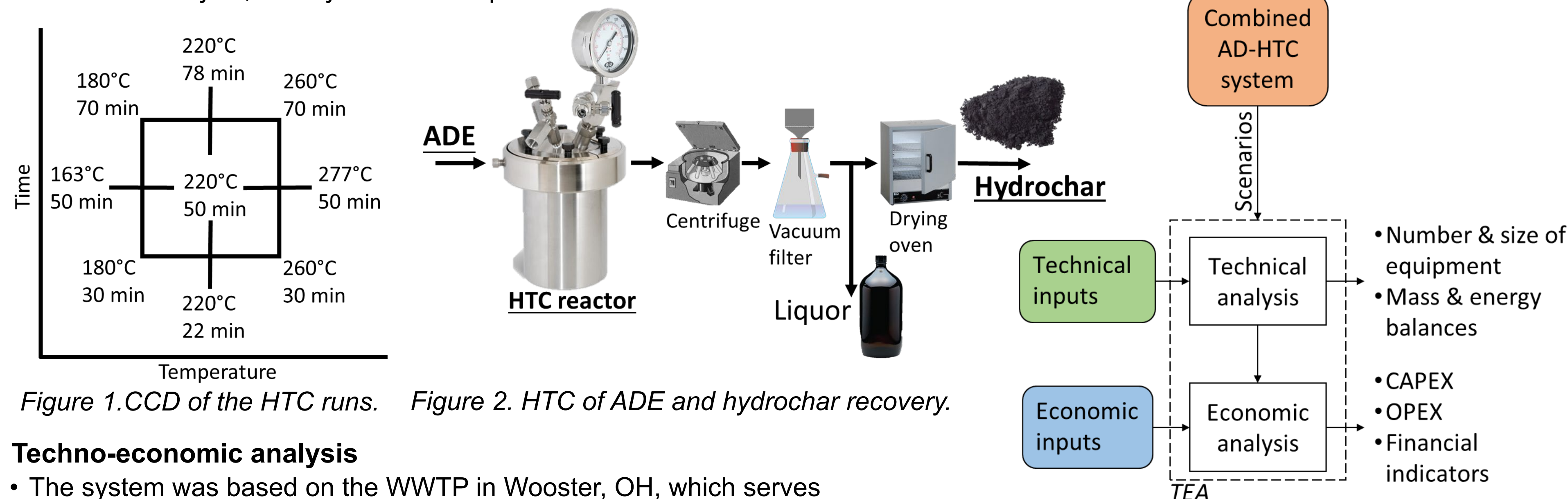


Figure 1. CCD of the HTC runs. Figure 2. HTC of ADE and hydrochar recovery.

### Techno-economic analysis

- The system was based on the WWTP in Wooster, OH, which serves a population of ~26,600 people and receive 14.4 ton/h of sewage sludge.
- The process was modelled using SuperPro Designer 9.5.
- The techno-economic analysis was performed using data from the WWTP, equipment and process conditions; properties of feedstock, intermediates, and final products; and cost of feedstock, materials, equipment, and utilities (Fig. 3).

### Use of hydrochar as soil amendment

- Soil was amended with different char types (pyrochar, hydrochar from sewage sludge, and hydrochar from manure) at varying rates (0, 1, 3, 5, 10, & 15 g char/kg soil).
- Lettuce seeds were sown, and germination rates were recorded and analyzed.

## RESULTS

- Reaction temperature during HTC had a significant effect on hydrochar yield, which decreased with higher temperatures (Fig. 4).
- The capital investment for the combined AD-HTC system was calculated to be ~\$32 M, a payback time of < 6 years, NPV of ~\$10 M, and IRR of ~12%.
- Germination rates of char amended soils at 3 g/kg were higher than no-char (Fig. 5).

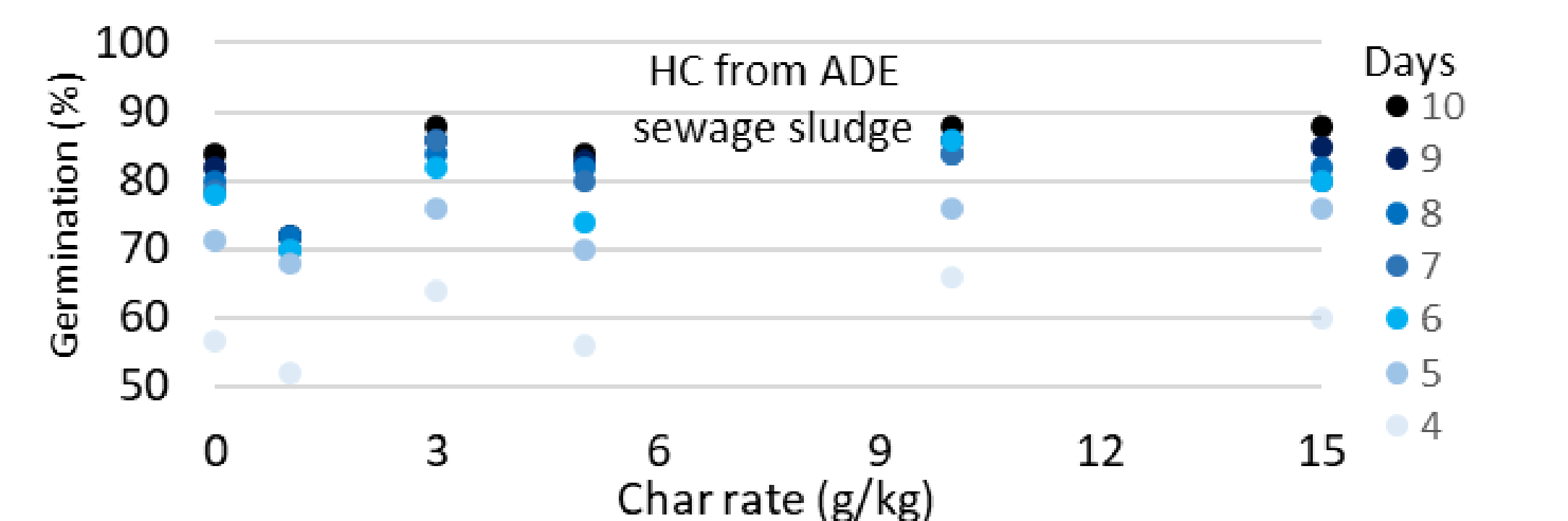


Figure 5. Effect of char rate on lettuce germination from day 4 to day 10.

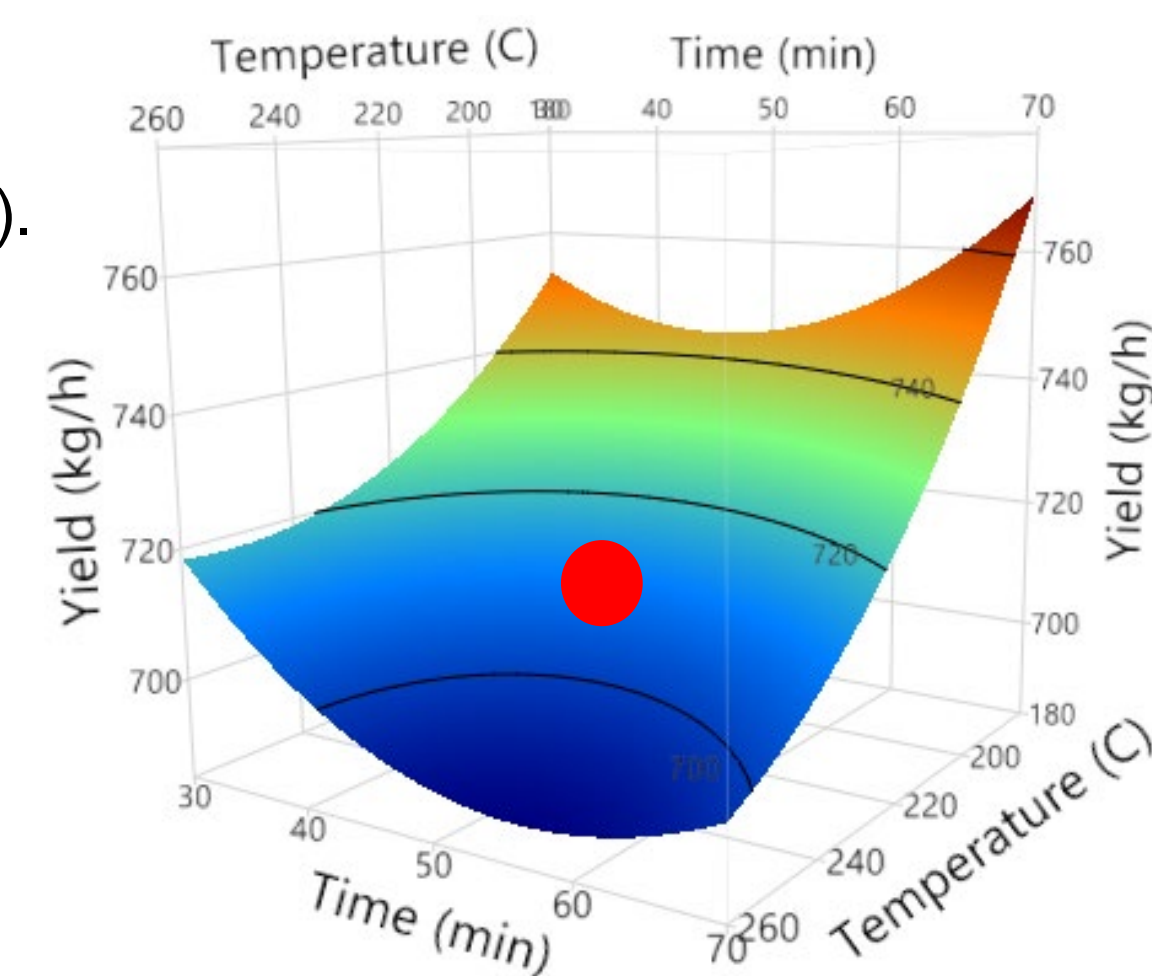


Figure 4. Hydrochar yield response surface. Effect of temperature and time.

## CONCLUSIONS

- Hydrochar yield is mostly influenced by reaction temperature.
- Hydrochar has the potential to be used as soil amendment when applied at low rates.
- Hydrochar production and sewage sludge treatment have the potential to be technically and economically feasible through the combined AD-HTC system.

## REFERENCES

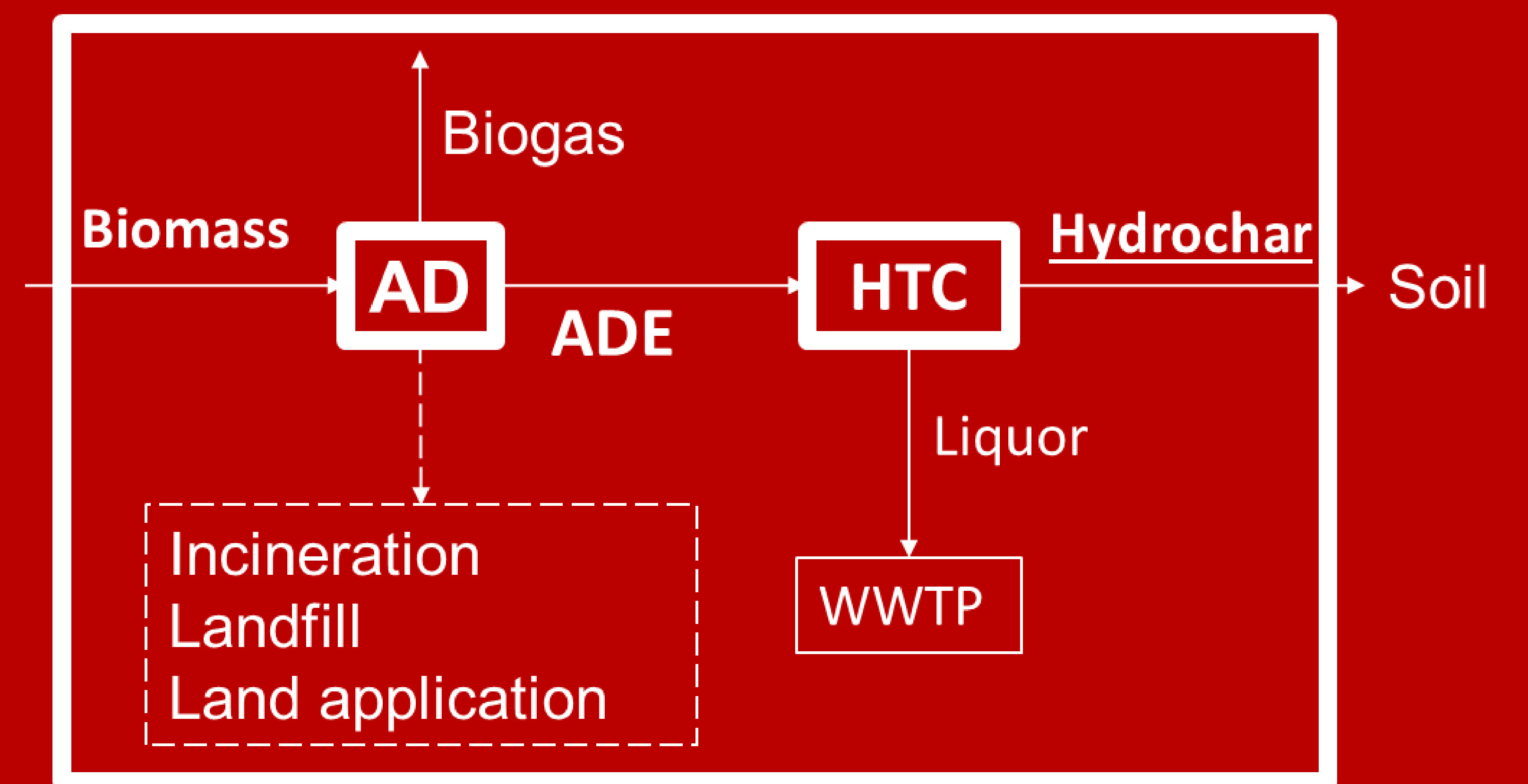
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## ACKNOWLEDGEMENTS

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Combined AD-HTC system

