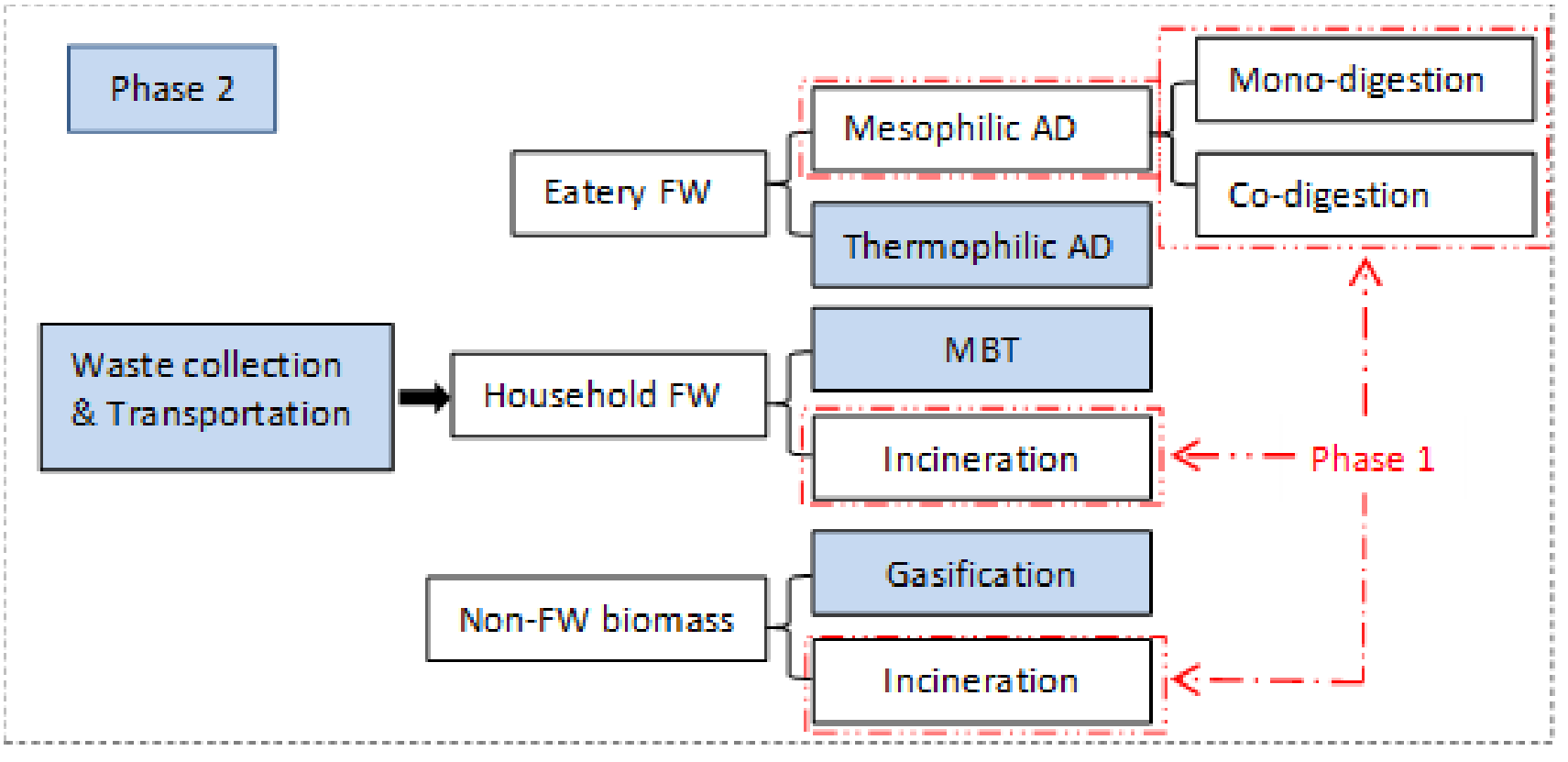
Life Cycle Assessment

at Energy and Environmental Sustainability for Megacities (E2S2) Program



Associate Professor
Dr. Tong Yen Wah

Assistant Professor
Dr. Wang Xiaonan

Research Fellow
Dr. Tian Hailin

Life Cycle Assessment

Background

Increasing amounts of municipal solid waste are posing environmental problems in megacities, such as Shanghai and Singapore. Different technologies are proposed to dispose the solid waste to recover energy and material. However, the environmental impacts of each technology or the combination of these technologies needs to be understood to reach a high level of sustainability in the future. Therefore, the main objective of this subproject is to assess the environmental impact of different technologies from the life cycle perspective and help the decision makers to determine which strategy to use from sustainable development point of view.

Research achievement from phase 1

Environmental impact associated with various waste treatment technologies, including incineration, anaerobic digestion (AD) followed by compost, AD followed by incineration and AD followed by gasification, were analyzed in phase 1. An extensive review of the current technologies disposing waste in Singapore were also compared in phase 1. Moreover, the environmental influence and economic feasibility about decentralized biomass gasification technology for electricity were also investigated.

Publications from phase 1:

1. Tong, H., Shen, Y., Zhang, J., Wang, C.-H., Ge, T.S., Tong, Y.W. 2018a. A comparative life cycle assessment on four waste-to-energy scenarios for food waste generated in eateries. Applied Energy, 225, 1143-1157.
2. Tong, H., Yao, Z., Lim, J.W., Mao, L., Zhang, J., Ge, T.S., Peng, Y.H., Wang, C.-H., Tong, Y.W. 2018b. Harvest green energy through energy recovery from waste: A technology review and an assessment of Singapore. Renewable and Sustainable Energy Reviews, 98, 163-178.
3. You, S., Tong, H., Armin-Hoiland, J., Tong, Y.W., Wang, C.-H. 2017. Techno-economic and greenhouse gas savings assessment of decentralized biomass gasification for electrifying the rural areas of Indonesia. Applied Energy, 208, 495-510.

Specific research questions in phase 2

1. Which waste collection method is with the least negative environmental impacts among the available options?
2. How about the balance between gains and losses for thermophilic AD from a holistic view? How about the comparison between mesophilic and thermophilic AD systems?
3. What is the sustainable practice of source separation from household solid waste? Is mechanical biological treatment environmentally friendly?
4. Besides food waste, how about the environmental impact of the current technologies treating the all the waste streams of the complex municipal solid waste.
5. Regarding the non-food waste treatment, which one is more sustainable, incineration or gasification?

Methodologies

Life cycle assessment (LCA) is an international accepted scientific tool to holistically evaluate the waste to energy and resources technologies by quantifying their potential environmental impacts. Generic LCA databases, such as Gabi and Ecoinvent, will support the basic analysis. Moreover, in order to have the results matching the local reality, onsite analysis of part of the data will be also performed.

LCA will be conducted to find the waste collection method which has least negative environmental impacts by comparing the available waste collection methods, such as 1) installation of processor in kitchen sink to macerate organic waste and utilization of water as a transport medium; 2) emplacement of separate rubbish chute in the high-rise public apartments as a direct route to the treatment facility; and 3) employment of special designed collection containers and trucks for food waste collection and transportation.

Thermophilic AD is proposed to enhance the biogas production yield. However, extra heat is required to maintain the temperature of the digester compared to mesophilic one. Moreover, other technical parameters will also influence the overall performance, such as the biological enhancement additives and pre-treatment process to shorten the start-up phase of a thermophilic reactor. Therefore, LCA will be used to have a holistic environmental evaluation of the two AD systems.

Apart from eatery food waste (FW), the technologies treating other urban biomass, such as household FW and non-FW biomass (paper, wood and sludge etc.), can also be investigated using separate LCA studies for each waste category respectively.

For more information, please visit: https://www.create.edu.sg/about-create/research-centres/e2s2

CREATE
Campus for Research Excellence And Technological Enterprise

NATIONAL RESEARCH FOUNDATION
PRIME MINISTER'S OFFICE
SINGAPORE

1 CREATE Way, #15-02
CREATE Tower
Singapore 138602
Tel: (+65) 6684 2900
Fax: (+65) 6684 0384
Website: www.nrf.gov.sg
Email: communications@nrf.gov.sg