NANYANG TECHNOLOGICAL UNIVERSITY SINGAPORE

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BIOMASS WASTE TO BIOMETHANE ENHANCED BY SELF-SUFFICIENT GREEN HYDROGEN

Abstract:

The overarching goal is to identify viable biomass wastes in Singapore and in the southeast Asia (SEA) region and then develop a process to convert the biomass waste to biomethane enhanced by self-sufficient green hydrogen. To be added to gas grid, the methane purity should be higher than 95%, which is much higher than that in normal biogas (50-75%). Thus, biogas upgrading with minimum carbon intensity, which needs green hydrogen, is crucial. We have patented and licensed 'hybrid electrolysis' that generates carbon-negative green hydrogen from biomass waste. Additionally, we also patented and licensed biogas upgrading in a two-phase fermentation with efficient hydrogen dissolution using a novel ceramic membrane contactor module.

Herein, we hypothesize to integrate hybrid electrolysis and biogas upgrading to produce high-purity biomethane with the lowest carbon intensity to date. Specifically, we aim to achieve the following targets: (1) to convert biomass waste (paper/cardboard waste, palm oil waste, sugarcane bagasse, etc) to sugar (glucose and xylose) and it is derivatives, (2) to Type of Grant: External - No Evaluation produce green hydrogen from biomass waste to support biogas upgrading, (3) to convert the byproduct to green H_2 powered by PV, and (4) to upgrade biogas to high-purity biomethane (> 95%). The proposed research covers the key technology interests of the latest R&D initiatives (RIE2025) namely Sustainability & Advanced Engineering.

Driven by national goal of decarbonization, bio-LNG will contribute significantly to the science and engineering community in Singapore.

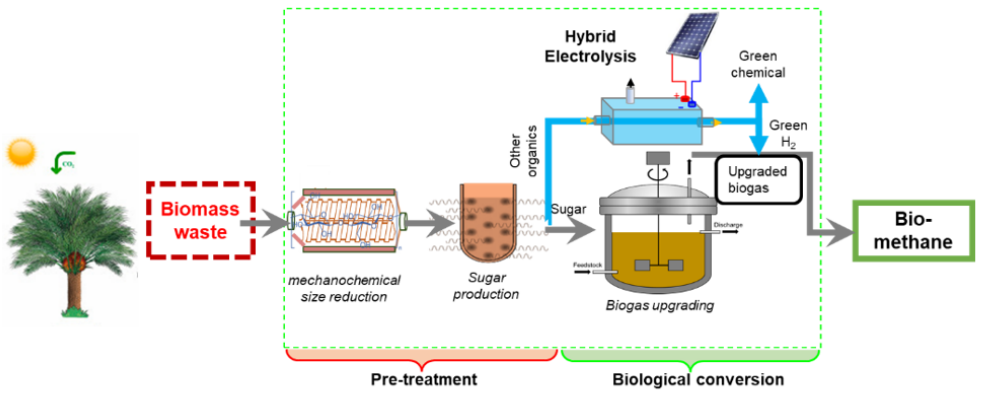

Figure 1: The new process consists of pretreatment and biological conversion steps.

Properties	Heavy Fuel Oil	Biodiesel	Liquefied Natural Gas	Ammonia	Liquefied Hydrogen	Bioethanol
Heating value(MJ/kg)	39	38	48	19	120	27
Sulphur (% m/m)	<3.5	0	0	0	0	0
Life-cycle GHG equivalent (g/MJ)	77-87	75-111	63	137	70~125	24-34
Major issues	air pollution	low scalability	carbon emission	slow burning	energy-consuming liquefication	not compatible

Table 1: Marine fuel property comparison.

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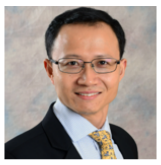

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BENEFITS

Though the cost of biofuels is higher than that of fossil fuels, specific mandates on biofuels or ever-increasing carbon taxes (3 times increase to $80 by 2030 in Singapore) will make biofuels more competitive and viable economically. Importantly, biofuels can well address the emission issue of CO_2, SO_x and NO_x. Among the popular biofuels, biodiesel has poor scalability while bioethanol is incompatible with ship engines. In contrast, biomethane is clean and compatible with maritime industry. Energy-efficient liquification of biomethane to bio-LNG is a mature industrial process and widely adopted in Singapore. Therefore, our research aiming to make high-purity and green biomethane from lignocellulosic waste is significant and could make a breakthrough in sustainable biofuel.