Experimental Study on development and demonstration of hydrogen production from food waste generated biogas

A Proposal for Funding under

Corporate Social Responsibility (CSR) / Alumni Donations

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Submitted to
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Contents

List of Figures

List of Tables

1. Project Title

Experimental Study on development and demonstration of hydrogen production from food waste generated biogas

2. Project Proponents

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3. Introduction

Increase in global population has led to continuous growth in demand of energy. Despite of huge efforts made into exploring and developing renewable sources of energy, fossil fuels stalks up to 80% of the total global energy consumption (Rusman & Dahari, 2016; Veziroğlu & Şahin, 2008). The extracting energy from non-renewable sources and combustion of carbon rich fuels for power generation and automotive applications is strictly associated with fossil fuel combustion. It is the root cause for carbon oxides emissions and accumulation of carbon oxides in the atmosphere results in global warming and climate change (Bian et al., 2020). It is also important to note that fossil fuels are diminishing rapidly, it is imperative to alternate fossil fuels with renewable and environment-friendly energy resource. The belief of hydrogen as next-generation energy carrier has widely spread in the last few years. This may be due to increase in concern related to increasing environmental pollution, particularly greenhouse gasses emission (Angeli et al., 2016; Bhat & Sadhukhan, 2009; Palma et al., 2020).

The hydrogen yield depends in a complex manner upon the design parameters such as physical dimensions, catalysts wall thermal conductivity, and on the process variables such as feed composition, fluid velocity, temperature, and pressure. To improve further hydrogen yield, there is necessary to investigate the effect of design parameters and process variables on the performance of thermally integrated Plug flow reactor managing the hydrogenation reaction from methane-steam and an exothermic catalytic oxidation reaction simultaneously. With increase in steam-to-carbon ratio, quantity of methane feed decreases. As a result, the maximum temperature of the reactant's dividing wall increases, leading to an increase in the conversion of methane in the methane reforming channel. Under high-pitched fluid velocity situations, a large sum of energy is released by the catalytic exothermic oxidation reaction to remove from the combustion chamber to make the temperature of the device very low. High reforming velocities in the reaction chamber serves a twin function of producing high flow rates of hydrogen for external application and reducing the temperature of a thermally integrated Plug flow reactor to assure the requirement of catalyst's stability and material prerequisites used by satisfying minimum and maximum critical fluid velocity. With increase in the wall thermal conductivity, the maximum temperature of the dividing wall decreases and a major factor in decreasing the severity of wall hotspots. A high velocity of the process fluid inlet flow will cause an increase in the amount of the heat transferred in the reactor from the combustion side to the reforming side and also decrease in the maximum temperature of the dividing wall and thus balancing thermally coupled exothermic and endothermic reactions during Steam Methane Reforming (Chen et al., 2019).

NIT Karnataka ranks one of the top colleges in India in providing technical education for under graduate, post graduate and doctoral students. In spite of all these advances in technical and educational fields, it faces severe environmental concerns which needs to be addressed immediately. The major waste generated in NITK campus are MSW from hostels, messes residences, food waste from messes, bicycle tyre waste from cycle shops, and other organic wastes.

4. Background and Motivation

Currently NITK is equipped with 500 kg daily feed capacity Biogas anaerobic digester. The technology adopted is approved model of Ministry of New & Renewable Energy, Government of India. The advantage of this model is its parameters are monitored remotely such as temperature of Digester, pressure in various components, gas storage level, electronic equipment of digester, performance, e.g., Electronic Valves etc. These specifications enable the plant to generate alerts and alarms for any irregular operations.

Table 1: Brief description of NITK 500 kg Bio-Waste Recycling Pilot Plant

S. No.	Parameter	Description
1	Feed	Food Waste
2	Plant Capacity	500 kg per day

3	Waste Details-approx.	Kitchen Waste / Food Waste
4	Area Required	Upto 36 sq. m.
5	Access Required	Access for Truck to site
6	Other requirements	Water @ 50-75 litres per day and 3-Φ power during installation
7	Electricity and Manpower for Operations	20 units/day & 1 person (part-time @ less than 4 Hours) for daily operations
8	Biogas Production	60 - 70 cu. m. of Biogas/day Approximately, 30 – 35 kg LPG equivalent fuel/day

The digester is bi-phasic and the two-stage digestion, stage one for Hydrolysis and Acidogenesis and Stage two for Acetogenesis and Methanogenesis results in better process stability and controls feed buffer rate, separation of robust from sensitive biochemical processes, higher gas yields, increases feed rate. These properties enable the plant to perform better and reduce fluctuations in stability, with higher plant throughputs and higher productivity.

The main gaseous by-products from the 500 kg capacity anaerobic digester installed at NITK campus is as shown in the table below:

Table 2: Composition of the Biogas

Sl. No.	Composition of Biogas	Values
1	Carbon dioxide (CO_2)	34-38 % vol
2	Methane (CH_4)	50-60 % vol
3	Hydrogen sulphide (H_2S)	100-900 mg/m^3
4	Hydrogen (H_2)	0-1 % vol
5	Nitrogen (N)	0-5 % vol
6	Oxygen (O_2)	0-1 % vol
7	Phosphorus (P)	104-144 mg/L
8	Undegraded organic matter	16.1 to 18.9 % vol
9	Lipids	3.4 to 4 % vol
10	Metallic composition	Traces (Minute)
11	Total Solids	18.5-18.9 % vol

Every year about 2.01 billion metric tons of Municipal Solid Waste (MSW) is generated worldwide. Environmental Protection Agency (EPA) approximates that 63.1 million tons of food waste is generated in the commercial, institutional, and residential sectors in 2018 (*Food: Material-Specific Data | Facts and Figures about Materials, Waste and Recycling | US EPA*, n.d.). The World Bank estimations tally conveys that waste generation will increase to 3.40 billion metric tons by 2050. An estimated 13.5% of a single day's waste is recycled, and 5.5% is composted. The report also approximates that between one-third and 40% of waste generated worldwide is not managed correctly and instead dumped or openly burned (*World Bank: Global Waste Generation Could Increase 70% by 2050 | Waste Dive*, n.d.).

Waste to energy has been a severe concern in present-day scenarios as fossil fuels are depleting and CO_2 levels are increasing at an alarming level. Despite the wide spread of COVID-19 pandemic in 2020 and lockdowns, global energy-related CO_2 emissions remained at 31.5 Gt, which contributed to CO_2 reaching its highest-ever average annual concentration in the atmosphere of 412.55 PPM, which is approximately around 50% higher than when the industrial revolution began (*CO2 Emissions – Global Energy Review 2021 – Analysis - IEA*, n.d.). The challenges of the increase in CO_2 emission cannot be tackled overnight as it needs decades of steady and constant effort.

Anaerobic digestion (AD) is an alternative and effective method to manage organic-rich waste as it concurrently removes the waste by producing clean, renewable energy (Jiang et al., 2018). The mesophilic condition unveiled advantages in biogas production and functioning stability during the long-term AD of organic waste with a stepwise increase in organic loading (Guo et al., 2018). Biogas has to be cleaned to convert CH_4 to H_2 to use it effectively as a fuel. Cleaning increases the heating value and lessens the threat of corrosion (López et al., 2012). A growing body of evidence suggests hydrogenation technologies form an attractive option for the deep decarbonization of global energy systems, and that recent improvements in their cost and performance point towards economic viability as well. The process not only produces low carbon footprint, but also improves H_2 and CO contents in the synthetic gas. Hence, generating pure hydrogen from biomass effectively and efficiently is currently the world is looking into. As per the statistics, 0.55 Mt/y of Hydrogen is consumed in 2020 and it will reach 8 – 10 Mt/y in 2021 (*Hydrogen - Fuels & Technologies - IEA*, n.d.) reflects the importance and growing global demand of hydrogen.

Calorific Value of raw Biogas is 20.2 MJ/kg and that of LPG is 46.1 MJ/kg. Without converting the heating value of raw biogas is almost half times lesser than that of the LPG. In order to increase the calorific value, efficient utilization and application of the product gas, it is most appreciating step to convert biogas to compressed H_2. The calorific value of Hydrogen is 120 – 140 MJ/kg. Thus, it is important to convert it into a higher fuel standard.

5. Project Abstract

The increase in the intake of students, constant change in consumption pattern and social behavior has increased the generation of food waste in National Institute of Technology Karnataka (NITK) Campus. A Steam Biogas Reformer (SBR) designed and developed in the present study will be used to convert the biogas generated from the food waste available in the NITK Campus into compressed Hydrogen gas. The research is intended to develop a bench scale setup for hydrogen production from methane rich biogas via Steam Methane Reforming (SMR) for primary analysis. Methane steam reforming is considered a widely available method to produce hydrogen at a large scale due to the well-developed methane infrastructures and the favorably high hydrogen to carbon ratio of methane [2]. Methane steam reforming is a strongly endothermic reaction as shown in Equation (1). It also includes the exothermic water gas shift reaction, Equation (2) which is more favorable at low-temperature conditions (200°C –550°C). The complete reforming process is described by Equation (3) as a combination of reactions Equations methane oxidation and water gas shift reactions.

$$\mathrm{CH4} + \mathrm{H2O} \leftrightharpoons \mathrm{CO} + 3\mathrm{H2} \qquad \Delta\mathrm{H298} = +206\,\mathrm{kJ/mol} \tag{1}$$

$$\mathrm{CO} + \mathrm{H2} \leftrightharpoons \mathrm{CO2} + \mathrm{H2} \qquad \Delta\mathrm{H298} = -41\,\frac{\mathrm{kJ}}{\mathrm{mol}} \tag{2}$$

$$\mathrm{CH4} + 2\mathrm{H2} \leftrightharpoons \mathrm{CO2} + 4\mathrm{H2} \qquad \Delta\mathrm{H298} = +165\,\mathrm{kJ/mol} \tag{3}$$

The present work is compared with the results of the conventional micro reactors, advanced reaction systems and conventional fixed bed reactors and difference in the results is to be discussed for optimization of the technique. Based on the experimental and theoretical results, the bench scale is rescaled to pilot scale for commercialization purpose. Further produced hydrogen will be used in house power generation by developing hydrogen fueled generator.

6. Contact Details:

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7. Why this Project?

Steam methane reformer is widely used for hydrogenation process. Catalyst supported reforming reaction has overall hydrogen production efficiency of about 65 – 75% with operating temperature differing from 700 - 1000°C and pressure varying from 1 to 20 bar (Meloni et al., 2020; Wang et al., 2017). Fabricating a reformer capable of sustaining thermal shock for maximum number of operating cycles is tedious and challenging task (Pourali et al., 2021). Thus, there is instant requirement of fabricating a reactor and investigating a best catalyst combination to increase the efficiency of hydrogen production, decreasing the hydrogenation temperature with process intensification.

The foremost setback of methane steam reforming reactions at low temperatures, is the development of an active catalyst which can achieve conversion up to equilibrium values i.e isothermal reaction temperature (Angeli et al., 2014a). Steam reforming of natural gas or biogas containing impurities such as higher hydrocarbons or sulfur compounds still remains a challenge. Further research over these catalytic systems in terms of deactivation mechanisms and rate, sintering effect caused by coke formation on the surface of the catalyst, thermal shock and heat management in the reactor, effectively modelling of the industrial grade reactor are wide areas to carryout research in this technology (Angeli et al., 2014b). However, the interest on low temperature methane steam reforming catalysts has been recently investigated by considering the importance of using bimetallic catalysts and promoters for the low temperature reaction and there is wide gap in developing and investigating bimetallic catalyst (Abbas et al., 2017; Chen et al., 2019).

In natural gas or Biogas reforming, CO_2 conversions will always be higher than CH_4 conversions due to possible reversible WGS (rWGS) reaction as shown in Equation (1). This may be due to the available of the required energy from the reactor heater or the catalyst behavior due to the exposed time on the catalyst is more or ineffective thermal management. However, the required energy consumption and carbon formation at high temperature on the catalyst surface still remains as the major disadvantages of the process (Izquierdo et al., 2012). Periodic Oxidative Reforming of Biogas to activate the catalyst and to prevent the carbon deposition on the catalyst surface, presence of oxygen at higher temperature, but oxygen present in the reformer may lead to the partial oxidation of the methane generating CO as the main product as shown in Equation (2) and may form solid carbon as shown in equation 6. Thus, there is a necessity to develop new catalytic systems, partial oxidation condition and reactor chamber in order to avoid the carbon deposition in the biogas reforming process.

$$CO_2 + H_2 \leftrightharpoons CO + H_2O \; (\Delta H298 = 41 \text{ kJ/mol}) \tag{1}$$

$$CH_4 + 0.5O_2 \leftrightharpoons CO + H_2 \; (\Delta H298 = -36 \text{ kJ/mol}) \tag{2}$$

Reactions that lead to carbon formation are the Bouduard equilibrium reaction.

$$2CO \leftrightharpoons CO_2 + C \;\; (\Delta H298 = -172.5 \text{ kJ/mol}) \tag{6}$$

8. Objectives

To accomplish the above discussions, the following objectives are to be defined.

1. Detailed characterization and investigation of the influence of Ni-Co-Fe based catalyst in the oxides of the aluminum environment to generate hydrogen effectively with multicycle durability and low deactivation rate.
2. Development of the plug and flow Steam Biogas Reforming reactor capable of hydrogen generation by maintaining a conventional reactor efficiency.
3. Modelling and experimental studies of the reactor configuration, reactant flow conditions of low-temperature drop reactor chamber that can ultimately be used at large scales for commercialization of hydrogen production.
4. Life cycle assessment (LCA), after implementing the simulation results to reduce the energy consumption, costs, volume, and possible wastes.

9. Expected Outcomes and benefits from Project

1. A Steam Biogas Reformer setup which can be applied for patent.

2. Development of the new catalyst which can work efficiently under different Biogas compositions.
3. Outsourcing Hydrogen produced.
4. Waste management inside NITK campus.
5. Keeping our entire campus clean and tidy.
6. Utilizing Hydrogen for power generation.
7. Reduction in greenhouse gas (GHG) emissions.
8. Revenue can be generated by conducting workshops/seminars

10. Resource requirements

SI. No.	Consumables	Bench Scale	Pilot Scale
1	Fuels (CBG)	02 cylinder/year	500 cylinders/year
2	Catalysts	1 kg/year	100 kg/year
3	Chemicals and Calibration	3 litre/year	300 litres/year
4	Pipes, Pipe fittings	Site dependent	
5	Mass flow controllers	04 Units	04 Units/year
6	Athena AT-1000P Palladium membrane assembly maintenance	--	(5 m^2 * 2)/year
7	Methyldiethanolamine (25 liters)		
8	Electricity expenses	Site dependent	
9	Hollow fibre membrane	--	(5 m2 * 2)/year
10	Expenses at the Testing Sites	3 samples/year	3 samples/year
11	Zeolites pellets	5 kg	500
	Permanent Equipment		
1	50 m^3/hr capacity Biogas to Hydrogen reformer (Material and fabrication cost)	--	1 Unit
2	Lab scale Biogas to Hydrogen Reformer		
3	100 m^3/hr capacity steam boiler (Material and fabrication cost)	--	1 Unit
4	Athena AT-1000P Palladium membrane assembly	--	1 Unit
5	Compressor (5 Bar)		2 Units
6	Compressor (Lab scale, 2 No.)	2 Units	
7	3 Zone Split Tube Furnace	1 Unit	
8	Methane preheater	1 Unit	1 Unit
9	Pump	1 Unit	1 Unit
10	Reformer cooler	1 Unit	1 Unit
11	Vacuum Pump for lab-scale		1 Unit
12	Electrochemical Hydrogen Compressor		1 Unit

13	Post shift condenser	1 Unit	1 Unit
14	Chiller	1 Unit	
15	Pressure regulators	2 Units	4 Units
16	Gate valves	10 Units	10 Units
17	HPLC Pump	1 Unit	
18	Methane leak sensor with alarm	1 Unit	1 Unit
19	Hydrogen leak sensor with alarm	1 Unit	1 Unit
20	CO2 Fire extinguisher	1 Unit	1 Unit
21	Pressure Swing Absorber	1 Unit	1 Unit
22	Simulation Software SIMApro	1 unit	

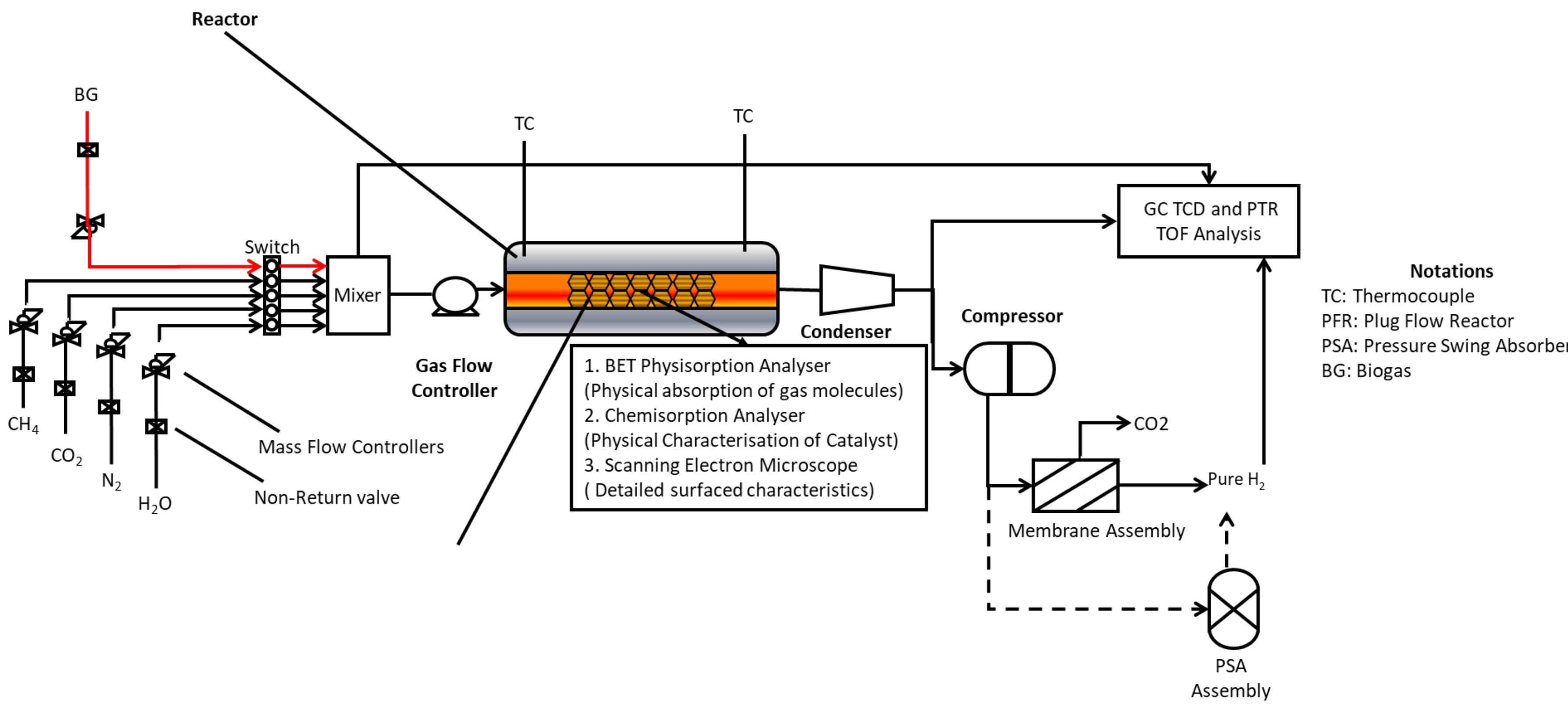

Figure 1: Bench scale Requirement

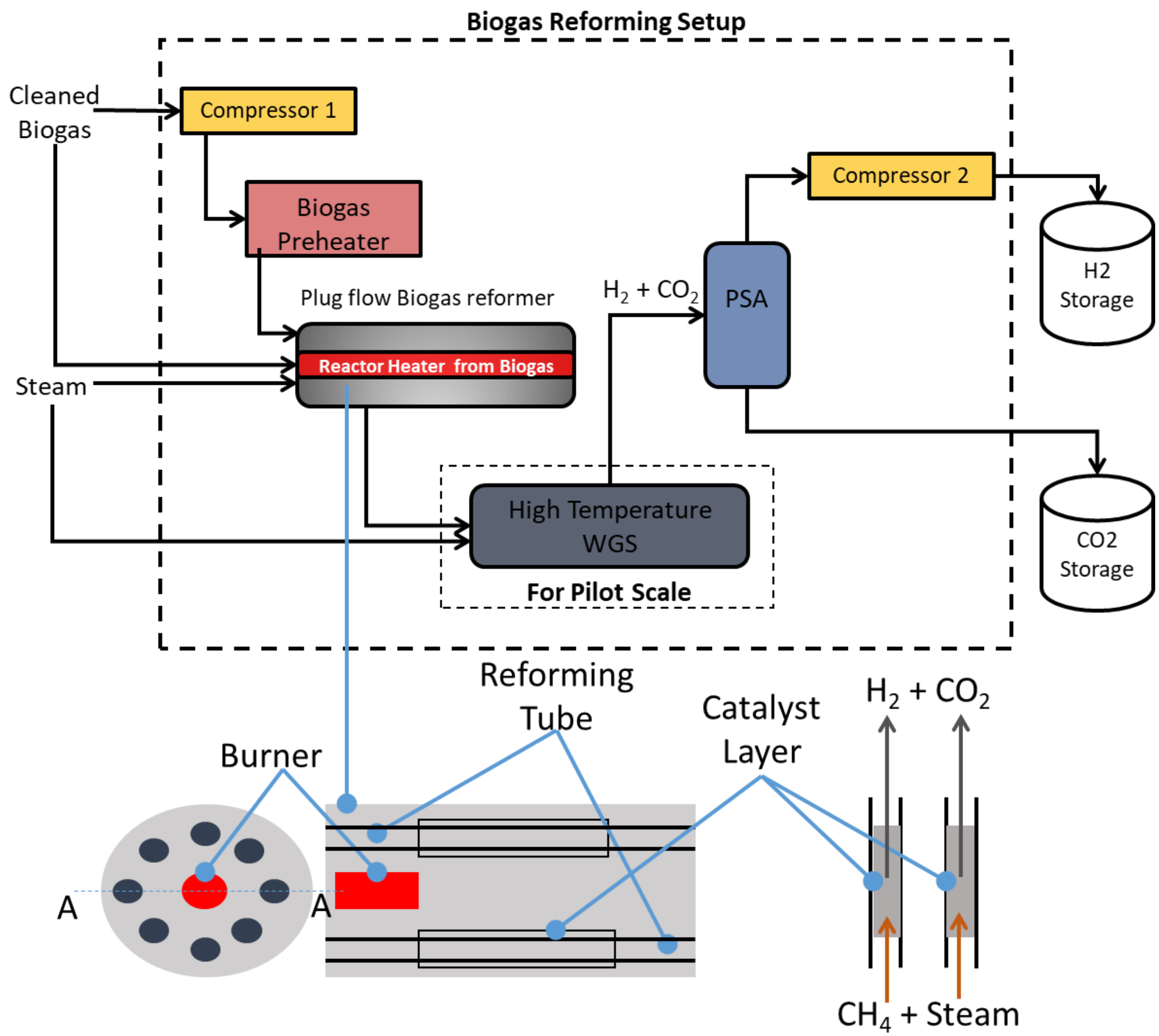

Figure 2: Steam Biogas Reforming Setup

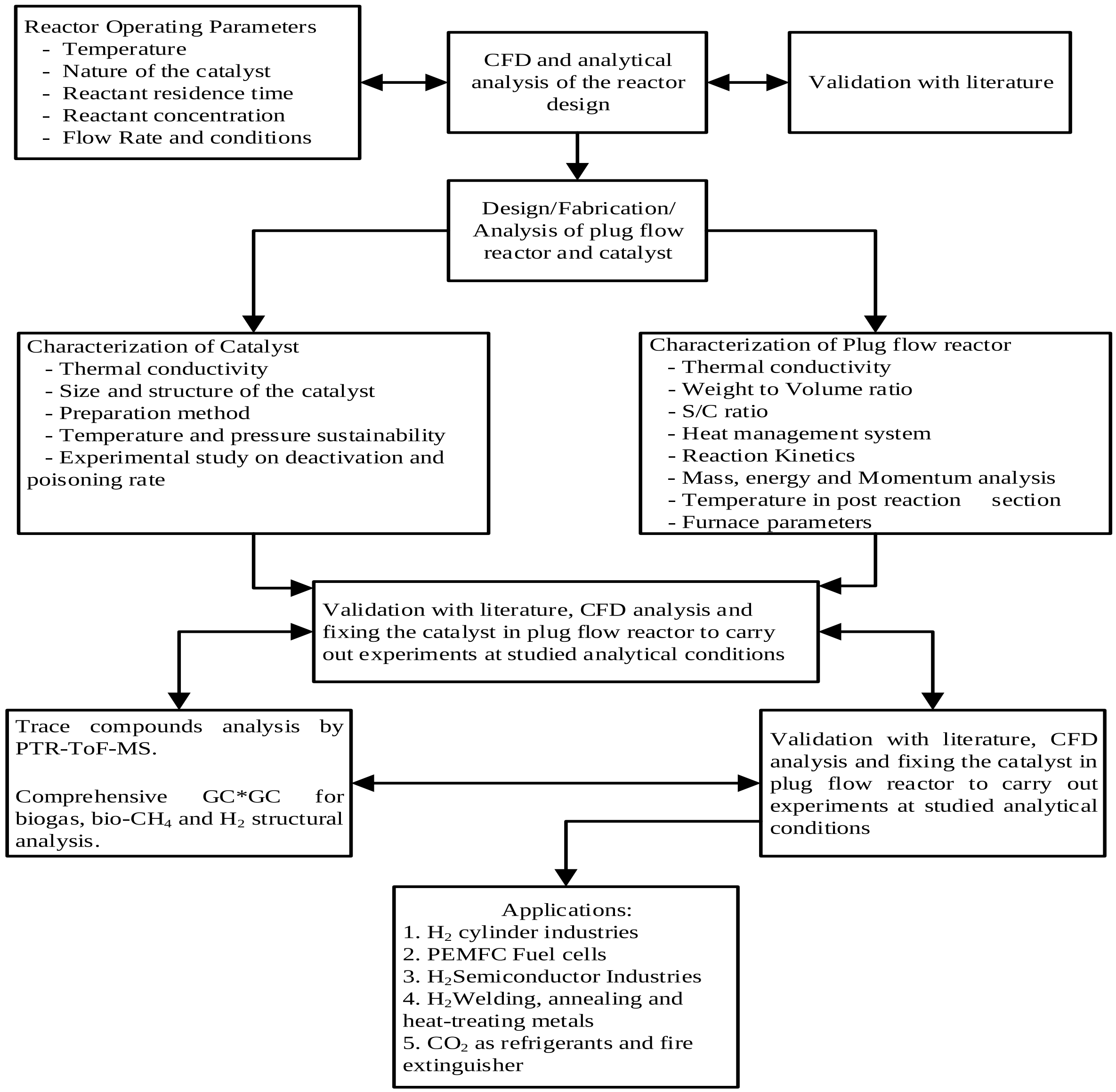

Figure 3: Flowchart of the overall experiment procedure

11. TOTAL BUDGET ESTIMATES

S. No.	Item	Budget			
		1 Year	2 year	3 Year	Total
1	Equipment	1,14,45,000.00			1,14,45,000.00
2	Fellowship/Scholarship	19,72,800.00	19,72,800.00	19,72,800.00	59,18,400.00
3	Consumables	9,75,000.00	3,40,000.00	3,48,750.00	16,63,750.00
4	Travel	60,000.00	60,000.00	60,000.00	1,80,000.00
5	Contingencies	75,000.00	75,000.00	75,000.00	2,25,000.00
6	Workshop/ International Conference (Future Expenses)	1,30,000.00			1,30,000.00
7	Others	1,10,000.00	1,10,000.00	1,10,000.00	3,30,000.00
Total		**1,98,92,150.00**			

Budget Split details:

Detailed Budget for Salaries and Wages for Project Personnel

S. No	Designation(s)	Number of Persons	Monthly Emoluments	First Year (INR)	Second Year (INR)	Third Year (INR)
	A. Full Time					
1	Post-Doctoral Fellowship (PDF)	1	55,000.00	6,60,000.00	6,60,000.00	6,60,000.00
2	Ph.D. Fellowship	1	35,000.00	4,20,000.00	4,20,000.00	4,20,000.00
3	Project Associate (M.Tech/MSc/B.Tech)	2	50,000.00	6,00,000.00	6,00,000.00	6,00,000.00
	Including HRA @16% (only for PDF)		8,800.00	1,05,600.00	1,05,600.00	1,05,600.00
	B. Temporary					
4	Daily wage workers to be hired for short durations during testing @ Rs 600/day	2	15,600.00	1,87,200.00	1,87,200.00	1,87,200.00
TOTAL (INR)				19,72,800.00	19,72,800.00	19,72,800.00
GRAND TOTAL (INR)			**59,18,400.00**			

<u>Justification for manpower required</u>

The proposed Salary will be provided in terms of Fellowships for the Post-Doctoral, Doctoral and Masters Students to work on the research activities

- One Post-Doctoral position is required to develop professional skills under the mentorship of an experienced researcher.
- A PhD scholar is required to interpret the technical results and add value to the research conducted and further to explore the possibilities of up-gradation of the project and publish the results (PhD fellowship will be given to the candidate who is who is already joined the PhD program under Non-Scholarship Category)
- The candidates with M.Tech/B.Tech/M.Sc. degree will help in designing and they will pursue Research at NITK
- Fellowship for the candidates is fixed as per the NITK norms and all the selected candidates will work under the supervision of the PI.

BUDGET FOR EQUIPMENT:

Permanent Equipment		
		INR
1	50 m^3/hr capacity Biogas to Hydrogen reformer (Material and fabrication cost)	7,00,000.00
	Lab scale Biogas to Hydrogen Reformer	1,00,000.00
2	100 m^3/hr capacity steam boiler (Material and fabrication cost)	4,10,000.00
4	Compressor (5 Bar)	2,00,000.00
5	3 Zone Split Tube Furnace	8,30,000.00
6	Methane preheater	30,000.00
7	Palladium Membrane Assembly for Labscale	80,000.00
8	Vacuum Pump for labscale	20,000.00
9	Electrochemical Hydrogen Compressor	3,50,000.00
10	Reformer cooler	25,000.00
11	Post shift condenser	30,000.00
13	Non return valves	30,000.00
14	Chiller	1,00,000.00
15	Pressure regulators	30,000.00
16	Gate valves	15,000.00
17	HPLC Pump	7,50,000.00
18	Methane leak sensor with alarm	50,000.00
19	Hydrogen leak sensor with alarm	50,000.00
20	CO2 Fire extinguisher	10,000.00

21	Pressure Swing Adsorber	5,40,000.00
22	SIMApro Software	6,15,000.00
23	Thermal Desorption System for GCGCTOFMS	26,50,000.00
24	GC with TCD and FIDs	24,00,000.00
25	Gas custom calibration for PTR TOF MS	3,90,000.00
26	PTR TOF MS 1000 Multiport valve	10,40,000.00
GRAND TOTAL (INR)		**1,14,45,000.00**

Justification for equipment proposed

S. No.	Equipment	Justification
1	50 m^3/hr capacity Biogas to Hydrogen reformer (Material and fabrication cost)	The reactor is used to carry out a chemical reaction process and proceed towards the conversion of reactant to the product with and producing the highest yield
2	Lab scale Biogas to Hydrogen Reformer	To carry out the Biogas reforming research in the bench scale
3	100 m3/hr capacity steam boiler (Material and fabrication cost)	Reforming of the Biogas is carried out in the presence of Steam. Every mole CH_4 in Biogas requires two moles of steam to carry out the reaction
4	Athena AT-1000P Palladium membrane assembly maintenance	The product of reforming is a Syngas with a mixture of H_2 and CO_2. To separate H_2 from CO_2, a Palladium membrane is required
5	3 Zone Split Tube Furnace	To maintain the temperature of the reformer tube
6	Chiller	To transfer the heat to the post-shift condenser
7	Compressor (5 Bar)	The Biogas reforming is carried out at elevated pressure to obtain maximum conversion.
8	Biogas preheater	To attain the equal temperature distribution during the reaction phase, preheater is necessary.
9	Pump	To maintain the flow of the reactants uniform.
10	Reformer cooler	To cool the product gas from the reactor.

11	Post shift condenser	To reduce the pressure of the outlet gas.
12	Pressure regulators (12)	To maintain the pressure of the reactants uniform.
13	Gate values (12)	To regulate the direction of reactant flow.
14	Pressure Swing Absorber	To separate the H_2 from other product gases
15	Methane leak sensor with alarm	For monitoring and detecting levels of methane in the immediate surrounding within % Lower Explosive Limit levels
16	Hydrogen leak sensor with alarm	Hydrogen is a highly flammable gas. For the safety of entire system, Hydrogen leak sensor is required.
17	Thermal Desorption System for GCGCTOFMS	Thermal desorption used for the analysis of gases, which utilizes heat to increase the volatility of contaminants such that they can be removed from the adsorbents and inject it in to GCGCTOFMS
18	GC with TCD and FIDs	Used for the analysis of Gases
19	PTR TOF MS 1000 Multiport valve	To switch between different inlets for the different primary inlets.
20	CO_2 Fire extinguisher	A preventive requirement to reduce the spread and accidental damage caused due to fire.
21	Simulation Software SIMApro	To simulate the LCA process.
22	Gas custom calibration for PTR TOF MS	To calibrate the PTR TOF MS according to the user-defined output.
23	Zeolite 5A, 13X	To store the separated H2 gas in the pressure swing absorber.
24	Palladium Membrane Assembly for Lab scale	To purify the Hydrogen from other constituents in the product section.
25	Vacuum Pump for lab scale	To extract the hydrogen molecules from the Palladium membrane assembly

26	Electrochemical Hydrogen Compressor	To pressurize the purified Hydrogen gas for storage.

BUDGET FOR CONSUMABLES MATERALS:

Detailed Expenditure for Expendable Equipment Stores and Supplies-Consumables					
S.No.	Item	First Year	Second Year	Third Year	Total
1	Fuels	30,000.00	30,000.00	30,000.00	90,000.00
2	Catalysts	50,000.00	50,000.00	50,000.00	1,50,000.00
3	Chemicals and Calibration	25,000.00	25,000.00	31,250.00	81,250.00
4	Pipes, Pipe fittings	30,000.00	10,000.00	12,500.00	52,500.00
5	Mass flow controllers	6,00,000.00	0.00	0.00	6,00,000.00
6	Methyldiethanolamine (25 litres)	40,000.00	40,000.00	40,000.00	1,20,000.00
7	Electricity expenses	40,000.00	40,000.00	40,000.00	1,20,000.00
8	Hollow fibre membrane	20,000.00	10,000.00	10,000.00	40,000.00
9	Expenses at the Testing Sites	20,000.00	20,000.00	20,000.00	60,000.00
10	Zeolites pellets	70,000.00	70,000.00	70,000.00	2,10,000.00
11	Other consumable expenses	50,000.00	45,000.00	45,000.00	1,40,000.00
	Total	9,75,000.00	3,40,000.00	3,48,750.00	16,63,750.00
Grand Total		**16,63,750.00**			

Justification for consumable materials giving estimated requirement of consumable for each prototype.

The requirement for consumables like fuels, catalyst, membrane and other experiment related items are essential and basic requirement of the steam biogas reformer.

BUDGET FOR TRAVEL:

Travel Expenses				
S.No.	Item	First Year	Second Year	Third Year
1	Inland Tavel	30,000.00	30,000.00	30,000.00
2	Visit to Industry partner	30,000.00	30,000.00	30,000.00
Total (INR)		60,000.00	60,000.00	60,000.00
Grand Total (INR)		**1,80,000.00**		

DETAILS OF THE CONTINGENCY:

S.No.	Item	First Year	Second Year	Third Year
1	Contingencies (Article processing charges Stationary and Contingent postal expenses etc.)	50,000.00	50,000.00	50,000.00

2	Books, Publications, Documentation, Report Preparation	25,000.00	25,000.00	25,000.00
	Total	75,000.00	75,000.00	75,000.00
Grand Total		**2,25,000.00**		

OTHER POSSIBLE EXPENSES:

Organizing Workshops/ International Conferences:

S.No.	Item	First Year	Second Year	Third Year
1	International Conference	1,00,000.00		
2	TA/DA	30,000.00		
Grand Total		**1,30,000.00**		

Technical services and sample analysis charges

		First Year	Second Year	Third Year
1	Charges for Personnel engaged in Technical Services (CPTS) (For Permanent Employees of the Institute)	50,000.00	50,000.00	50,000.00
2	Sample Analysis charges (20 Samples at INR 3000/-)	60,000.00	60,000.00	60,000.00
Total in Rupees		**3,30,000.00**		

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