IITB-Monash Research Academy

Indian Institute of Technology Bombay | MONASH University

An Indian-Australian research partnership

Project Title:	Investigating the transition and bottlenecks for sustainable H2 adoption from global and regional perspective	
Project Number	**IMURA1044**	
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Research Clusters:

Highlight which of the Academy's CLUSTERS this project will address?
*(Please nominate JUST **one.** For more information, see www.iitbmonash.org)*

1. *Material Science/Engineering (including Nano, Metallurgy)*
2. *Energy, Green Chem, Chemistry, Catalysis, Reaction Eng*
3. *Math, CFD, Modelling, Manufacturing*
4. *CSE, IT, Optimisation, Data, Sensors, Systems, Signal Processing, Control*
5. *Earth Sciences and Civil Engineering (Geo, Water, Climate)*
6. *Bio, Stem Cells, Bio Chem, Pharma, Food*
7. *Semi-Conductors, Optics, Photonics, Networks, Telecomm, Power Eng*
8. *HSS, Design, Management*

Research Themes:

Highlight which of the Academy's Theme(s) this project will address?
(Feel free to nominate more than one. For more information, see www.iitbmonash.org)

1. *Artificial Intelligence and Advanced Computational Modelling*
2. *Circular Economy*
3. *Clean Energy*
4. *Health Sciences*
5. *Smart Materials*
6. *Sustainable Societies*
7. *Infrastructure*

The research problem

Decarbonization of national and global economy as well as specific carbon intensive sectors is considered as a necessity to achieve climate change mitigation targets. Decarbonization aims to reduce the carbon intensity or total carbon emissions of the economy or specific sectors. One of the promising alternatives for decarbonization is use of sustainable hydrogen since hydrogen is an important input to several carbon intensive sectors such as refinery and steel. The transition to a hydrogen economy though will be challenging. There are a number of different pathways to produce hydrogen. These range from water electrolysis, biomass gasification, methane pyrolysis to coal gasification. Adoption of novel hydrogen production methods is easier is some sectors that other due to scale issues. Moreover, the net benefit of using sustainable hydrogen can be different in different industries. The cost of production as well as the technology readiness levels will also matter. Given these complexities, it is difficult to understand the possible transition from the current scenario to a future scenario with sustainable hydrogen. Better understanding of this transition can help prioritize technology development and identify appropriate policy interventions.

Project aims

The goal of the project is to develop a model-based framework to understand the adoption of sustainable hydrogen in the future. The key research questions that we would answer are:

1. Which novel hydrogen production technology is likely to be adapted?
2. What is the likely timeframe for the adoption of novel hydrogen technologies?
3. Which sectors of the economy are expected to lead the transition to sustainable hydrogen?
4. What the impacts of this transition on economic and environmental metrics?
5. How can the transition be optimized through technology and policy interventions?

In order to answer these questions, the work will involve developing a system dynamics model considering important sectors of the economy. The model will capture the specific attributes of the sectors such as total size, hydrogen demands, purity constraints and so on. The regional peculiarities will be incorporated by considering a specific region such as India and/or Australia for study. This will bring in issues related to availability of raw material for the various production routes. The model simulations and scenario studies will provide answers to the research questions mentioned above.

What is expected of the student when at IITB and when at Monash?

The proposed work will involve development of the basic model that will be generic. However, we will explore the application of the model to two different regions, namely India and Australia. We anticipate that the student will need to connect with relevant stakeholders. We feel that it is important for the student to be based on the country for which the model is being used. This will allow the student to interact directly with various stakeholders and experts.

Expected outcomes

The expected outcome of the work are as follows:

- Simulation model as a decision support tool capturing the transition of hydrogen sector
- Quantitative and realistic estimates of adoption of novel hydrogen technologies in specific sectors and the economy
- Quantitative assessment of the economic and environmental implications of adoption of novel hydrogen technologies
- Specific recommendations regarding technology development and policy intervention to ensure a more sustainable system

How will the project address the Goals of the above Themes?

Hydrogen is considered as one of the clean energy solutions globally. Since combustion of hydrogen does not lead to carbon di oxide emissions, it is being considered as a potential fuel option for the transport and other sectors. Moreover, hydrogen is an important input to various energy sectors. For example, about 50% of the total hydrogen consumed in the chemical and manufacturing sector is used in the petroleum/petrochemical refineries. Thus, indirectly, hydrogen plays a pivotal role in promoting green energy solutions. Green energy of course has a direct implication on sustainable societies. The issues related to sustainability though go beyond energy production. Here, factors such as product life cycle, local and regional resource availability, energy access and affordability, and social acceptance also

come in. The proposed work will consider some of these factors.
Therefore, we believe that this work address several goal of the “Clean energy” and “Sustainable societies” themes.

Potential RPCs from IITB and Monash

IIT Bombay:

- Prof. Sanjay Mahajani: He has expertise in energy technologies, including biomass gasification and related processes. He is also actively involved in the refinery decarbonization work which is related to this project.
- Prof. Srinivas Seethamraju: He has expertise in waste to energy processes and has expertise in process modelling and simulation.
- Prof. Santanu Bandyopadhay: Expertise in energy systems modelling and optimization, renewable energy systems.

Monash University:

- Prof. Damon Honnery – Initiated the Woodside Project on Energy Leadership. IPCC Lead author, 2007 Report on Energy Systems.
- Prof. Sankar Bhattacharya – extensive experience in gasification of coal, biomass and waste materials, including process development, catalyst development etc.

Capabilities and Degrees Required

- Undergraduate degree in engineering, preferably Chemical Engineering.
- Prior experience in computational modelling (desired but not necessary)
- Experience in working with energy systems (desired but not necessary)
- Strong analytical capability and programming skills
- Willingness to work on an interdisciplinary problem

Necessary Courses

CL665: Sustainable engineering principles
CL701: Computational methods in chemical engineering
EN618: Energy systems modelling and analysis

Potential Collaborators

IIT Bombay:

- Prof. Sanjay Mahajani (Chemical Engineering)
- Prof. Prakash Ghosh (Energy Science and Engineering)

Select up to **(4)** keywords from the Academy’s approved keyword list **(available at http://www.iitbmonash.org/becoming-a-research-supervisor/)** relating to this project to make it easier for the students to apply.

Modelling and Simulation
Energy, Energy Storage, Energy Materials
Computer Simulation
Green Chemistry and Renewable Energy