Volume 1
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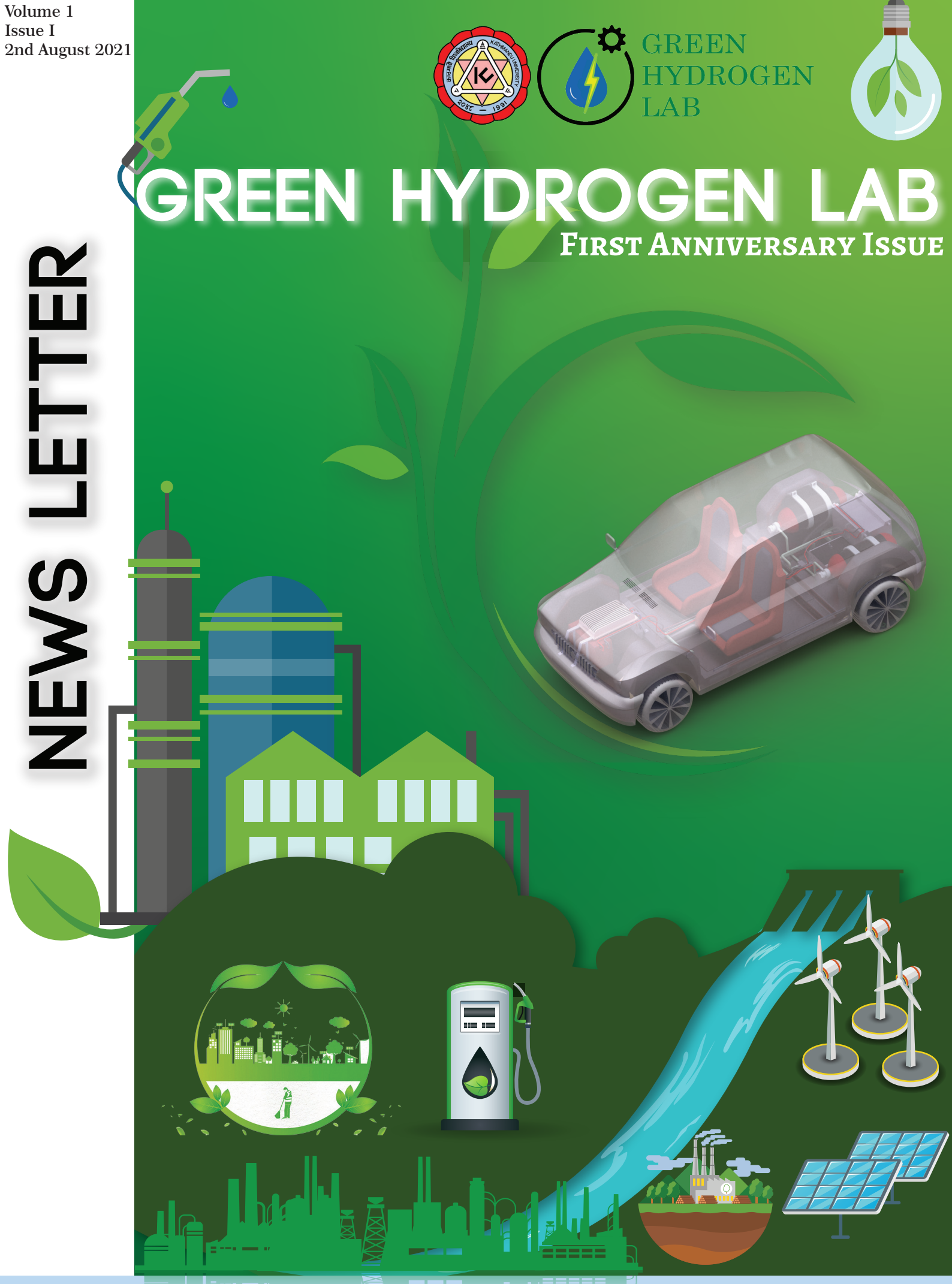
GREEN HYDROGEN LAB

GREEN HYDROGEN LAB

First Anniversary Issue

NEWS LETTER



Green Hydrogen Lab (GHLab)
Department of Mechanical Engineering, Kathmandu University

About GHLab

The Logo of Green Hydrogen Lab

The Vision of Green Hydrogen Lab (GHLab) is “Nepalese industries specialized to produce, store, transport, and use green hydrogen at a commercial level”. The logo of the Green Hydrogen Lab is a reflection of the vision it carries.

The core of the logo portrays the nucleus of Hydrogen with a water droplet representing Proton and Spark as its principal energy. The boundary of the core replicates the orbit of hydrogen with gear representing Electron.

The droplet at the center symbolizes renewable energy sources, which make hydrogen ‘Green’ or free from carbon footprints. The blue color of the water droplet represents the abundance of water on the planet earth. Water symbolizes the hydropower sector, which lays the foundation for the green hydrogen technologies in Nepal for socio-economic transformation.

The yellow color inside the electric spark depicts the fundamental nature of energy being omnipresent and omniscient. The green color in the spark represents the energy conversion process for producing clean hydrogen.

The black gear represents the industrial applications of green hydrogen for socio-economic developments.

The full name ‘Green Hydrogen Lab’ is colored green highlighting GHLab’s goal to develop knowledge and technology supporting the global paradigm shift in the energy usage patterns to restore the depleting environment.

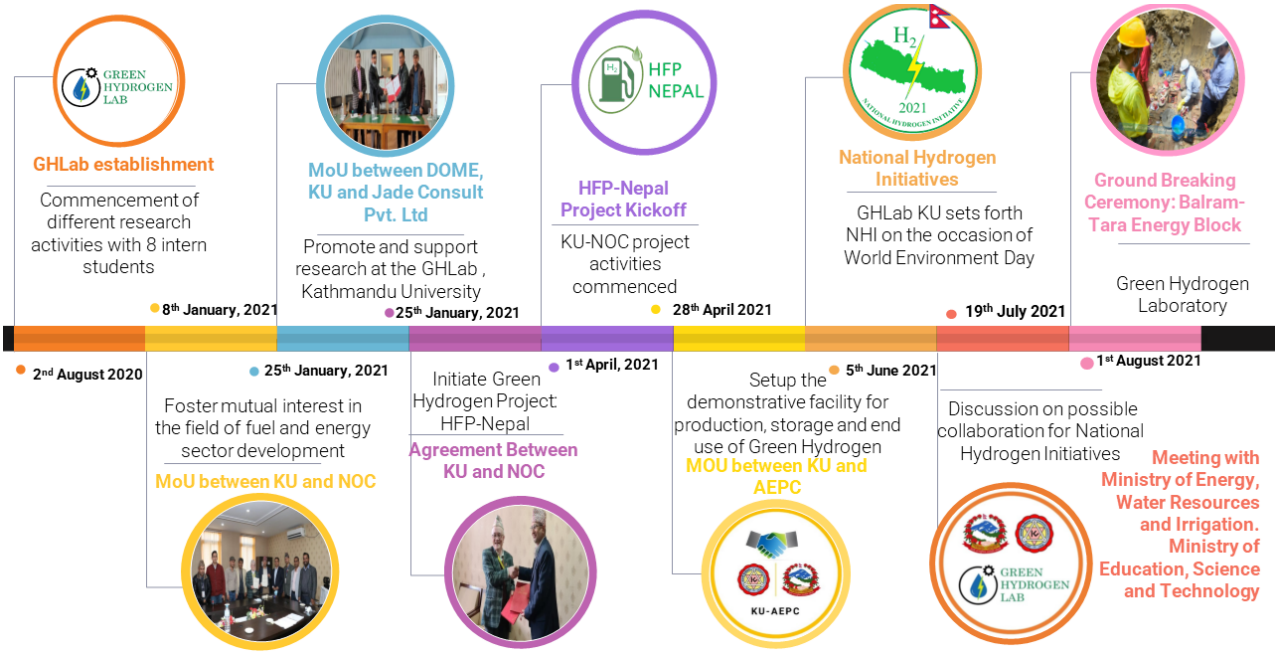
GHLab Vision:

Nepalese industries specialized to produce, store, transport, and use green hydrogen energy at a commercial level

GHLab Mission:

Technology transfer, innovations, and local adaptation of green hydrogen energy systems in Nepal through a continuous research and development activities

First Year of GHLab



MESSAGE FROM THE TEAM LEADER

Dr. Biraj Singh Thapa
Asst. Professor, DoME

The one-year journey of Green Hydrogen Lab at KU has established a strong foundation for the transition towards a low carbon economy in Nepal. This year marked the apex of global momentum towards net carbon zero goals with the USA and China joining the race along with the EU. The installed hydropower electricity in Nepal has surpassed the demand for the first time. The import of fossil fuels has reached 10% of the National GDP forcing the government of Nepal to announce the plan to substitute petrol-based vehicles with electric vehicles by 2030. The exponential growth of Diesel and LPG consumption, uncertainty over the natural gas-based chemical fertilizer plant in Nepal, and chances of loss of surplus electricity in the future has created a favorable situation for the adoption of green hydrogen technologies for commercial applications. Within one year of establishment, the Green Hydrogen Lab has been able to offer academic courses in the Department of Mechanical Engineering, developed infrastructure for basic research and laboratory works, and enter into dialogue and advocacy from the relevant ministries to the general public. At present, the conversion of IC engine vehicles to the hydrogen-fueled vehicle as a demonstration project, and laboratory test of Synthetic LPG fuel are the projects that impact the national level economy in the future

The National Hydrogen Initiative is being incubated as a consolidated program of the Nepal Government with the mandate to establish the policy foundations, develop an implementation action plan, and incubate a value chain for the business development with Green Hydrogen as the driving force to address the existing and upcoming challenges of the environment, fuel, energy, economy, and industrial development in Nepal. We look forward to receiving the generous support and guidance from everyone linked to this area directly or indirectly.

MESSAGE FROM THE VICE-CHANCELLOR

Prof. Dr. Bhola Thapa

Kathmandu University has been leading to initiate and institutionalize new academic programs and research avenues to address the future need for Nepal. Since its establishment, KU has carried the vision to establish itself as a research-based university. Research-based industrial development is one of the initial programs of Kathmandu University. This program is oriented to enable Nepal to utilize its natural resources to develop a renewable energy supply system. With a similar purpose, Green Hydrogen Lab at KU has been established to employ hydropower energy to develop a sustainable energy supply system for social and economic development in an environmentally sustainable manner. We have always emphasized water as a valuable resource in the country.

While we were designing courses or planning for research, we kept water in the center and we revolved around. We had a slogan, water is our white gold. We need to mine it and make the country prosperous through hydropower and harness it most effectively through hydrogen. School of Engineering achieved something which we can be proud to develop hydropower of the country and now it is time to move towards the next phase of development that is to utilize this power most effectively. One of the suitable ways to save the loss is by using hydrogen as a storage medium.

The environmental and health challenges induced by emissions are forcing the effects of Nature to liftoff the carbon footprints from the energy and economy ecosystem. The COVID-19 has already enlightened the need for the elimination of carbon footprints from the energy our society uses at present. While rest of the world is making the transition towards the hydrogen-based economy, the developing countries in the Himalayan region cannot alone remain behind.

There is a need to initiate scientific exploration and research on this technology in the local universities. Since technology has achieved a much higher development stage at a global level, the start for us would be knowledge transfer and local adaptation. If the initiation is taken earlier, the transition period of the technology transfer will be much shorter.

The Green Hydrogen based economy is the future of the sustainable solution to balance the economy and environment. The initiation of Green Hydrogen lab is a step to prepare the academic part of Nepal to develop knowledge and resources in the field of Green Hydrogen studies. To start the production, transmission, and utilization of Green Hydrogen from hydropower projects, GHLab has been established as a 'Centre for Green Hydrogen (CGH)' as an exemplary multidisciplinary research unit with state-of-art research facilities. It has been working for a year to identify the prospects of Hydropower to Hydrogen(H2H) in the Nepalese context and transfer the relevant knowledge in the region. These engagements in academic and research degrees will produce capable and competent human resources necessary for project development in the future.

GHLAB:TEAM

Dr. Biraj Singh Thapa
Team Leader

Prof. Dr. Bhola Thapa
Advisor

Dr. Daniel Tuladhar
Head of Department

Nashla Shakya
MS by Research Candidate

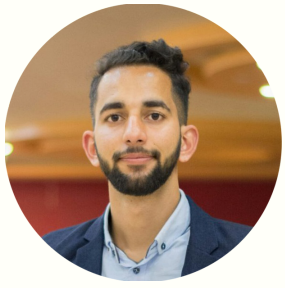
Green Hydrogen as a Fuel for Transportation

Abhishek Subedi
Research Assistant

Parametric Modeling of re-electrification from green hydrogen.

Bishwash Neupane
Research Assistant

Production, Storage, Distribution and Commercialization of Green Hydrogen as Transportation fuel in Nepal



Ramesh Pokhrel
Research Assistant

Green hydrogen laboratory setup and instrumentation

Nishan Dhakal
Visiting Researcher

Coal Exit, Power to Heat, Hydrogen economy and sustainable energy transition (regulatory and policy framework)

Chandan Chaudhary
Intern RA

Electrical System Analysis in Green Hydrogen production

ACTIVITIES OF 365 DAYS

Paper: Green Hydrogen as a future Multi-disciplinary Research at Kathmandu University
31/03/2020

A paper was published in the International Journal of Physics authored by Dr. Biraj Singh Thapa and Prof Bhola Thapa on the topic of Green Hydrogen as a future Multi-disciplinary Research at Kathmandu University. The paper discusses the importance of research at university, the necessity of research of green hydrogen technology in Nepal, and proposed a multi-disciplinary research center at Kathmandu University.

Green Hydrogen: Future Multi-disciplinary Research at KU, keynote Speech, CRHT-X
28/04/2020

A keynote speech for the 10th series of the annual event of the Turbine Testing Lab at KU, "Current Research in Hydropower Technologies, CRHT-X", was presented by the team leader of Green Hydrogen Lab, Asst. Prof Biraj Singh Thapa. In the keynote speech, Dr. Thapa presented the paper: Green Hydrogen as a future Multi-Disciplinary Research at Kathmandu University.

Green Hydrogen Technology: Why and How in Nepal? KU, SOE-SOM Webinar
07/06/2020

A KU Intra-school webinar was held on 7th June 2020, with the presence of professors and delegates present from the School of Engineering and School of Management. The main agenda of the webinar was to discuss the hydropower development in Nepal and the possibilities of production of green hydrogen from hydropower, storage, and end-use in the context of Nepal.

Commencement of Internship for 8 different Research Activities
02/08/2020

On 2nd August 2020, with the official establishment of Green Hydrogen Lab at Kathmandu University, an internship for 8 undergraduates and graduates was commenced for different research topics. The research topics included the development of lab facilities, production of hydrogen from different sources, end-use of green hydrogen, and feasibility scenarios of green hydrogen in Nepal.

Webinar: Hydrogen to Hydropower in Nepal: Opportunities, Challenges, and Way Forward
11/09/2020

The Webinar, "Hydropower to Hydrogen in Nepal: Opportunities, Challenges, and Way Forward", was organized on 11 September 2020. NTNU Alumni Nepal and Green Hydrogen Lab, Kathmandu University have jointly hosted the event with the expectation to initiate discussions towards the transition of energy and economy of Nepal towards green hydrogen.

Panel Discussion on "Towards the National Policy for Sustainable Green Hydrogen Economy in Nepal"

08/10/2020

A panel discussion on the occasion of the hydrogen and fuel cell day was held on 8th October 2020 on the topic "National Policy for the Sustainable Green Hydrogen Economy in Nepal". Speakers mainly working in the field of Energy Sector and policy level presented their view on the topic and discussed how Nepal can move towards the green hydrogen economy.

2nd NRN Global Knowledge Convention: Hydrogen Ecosystem for Sustainable Development in Nepal

11/10/2020

Asst. Prof. Biraj Singh Thapa for pushing forward the agenda set by KU on Green Hydrogen Technology for Nepal put forward a very prominent presence at 2nd NRN Global Knowledge Convection Diaspora for Innovation and Prosperity in Nepal: Post COVID-19 Scenario.

Lecture Series on Hydrogen Technologies

22/09/2020-15/10/2020

A series of Lectures were held on the Green Hydrogen Technologies targeting engineering and science research students from a multi-disciplinary field of study. The major target of this lecture series was to train the intern research students at GHLab providing a fundamental understanding of green hydrogen technology. Mr. Pralhad Gupta was the lecturer of the series and along with him, other guest lecturers presented on the relevant topics. The lecture series lasted for three weeks and by the end of the lecture series, students and researchers were asked for simple mini projects based on the understandings. Each researcher worked on the home projects and presented their findings

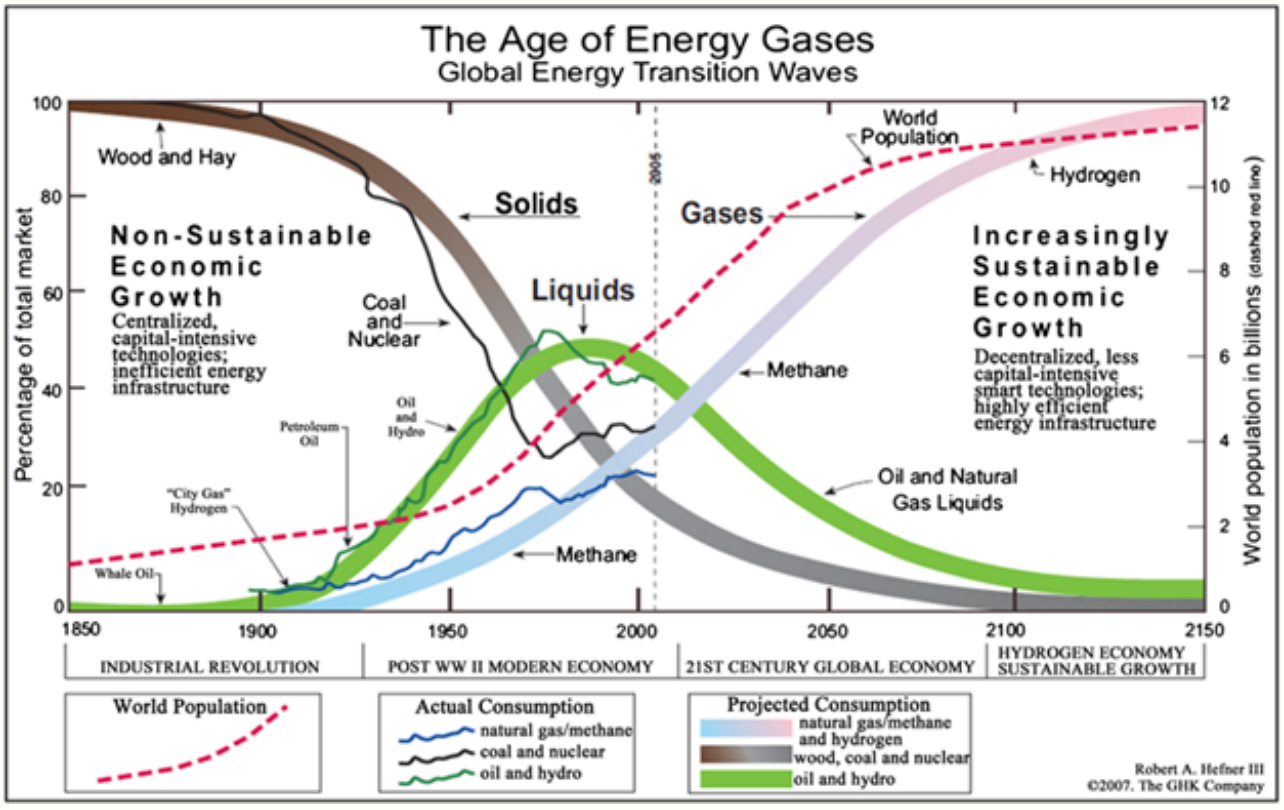
Collaboration with Nepal Oil Corporation (NOC)

08/01/2021

On 8th January 2021 Kathmandu University (KU) and Nepal Oil Corporation (NOC) signed an MOU to foster mutual interest in the field of fuel and energy sector development and contribution to increased cooperation between academic institutions and government corporations. The MOU has been signed by Dr. Bahadur Nepali, Dean of School of Engineering, KU, and Er. Deepak Baral, Director, NOC. The MoU between NOC and KU is important in the development of technology that can produce green hydrogen from electricity. There have been discussions of electricity going to be surplus soon in the future and the investment in the hydropower sector will be badly affected if the plans and preparations for its alternative use are not done timely. After the agreement, KU will also provide the necessary engineering consultancy for relevant project activities currently being operated by the corporation.

Following the MOU, Kathmandu University and Nepal Oil Corporation signed an agreement on 25 February 2021 to initiate the project "Technology Transfer and Local Adaptation for developing NOC as a hydrogen fuel producing and distributing company". NOC approved the project proposal on 7th February 2021. As a part of academic-institution and government corporations' collaboration, both institutions have consented to cooperate in the field of green fuel and energy sector development. The major objectives of this project are:

- Recommendations for Policy guideline for Green Hydrogen for Government of Nepal emphasizing production, storage, end-use of Green Hydrogen as future fuel for Nepal.
- Establish a 'Center for Green Hydrogen' at Kathmandu University for academic and research engagement within a broader interest of business development possibilities.
- Develop a demonstrative pilot project for the production of green hydrogen fuel and conduct tests for its commercial use in the transportation sector.



Collaboration with Hydropower Industries

25/02/2021

On 25th February 2021, the Department of Mechanical Engineering, Kathmandu University, and Jade Consult Pvt. Ltd signed an MoU to establish a foundation for the cooperation with Mechanical Engineering aspects of alternative energy including hydropower and green hydrogen. The MOU also includes an activity of grant from Jade Consult to promote and support research at the newly established Green Hydrogen Lab under DOME, KU.

The MoU has been signed by Dr. Daniel Tuladhar, Head of Department, DoME, KU, and Mr. Binod Ghimire, General Manager, Jade Consult Pvt. Ltd.

As per the MOU Jade Consult will support the development of infrastructure and facilities in the Green Hydrogen lab to the worth of Ten lakh Nepali Rupees (NRs 10,00,000/-). Relevant equipment as suggested by Green Hydrogen Lab will be procured by Jade Consult. The property after then will be hand over to the Department of Mechanical Engineering, Kathmandu University. The facility and equipment produced under this cooperation will be used for academic and research activities at the Green Hydrogen Lab. The purchasing activities need to be completed within the fiscal year of 2078/79 BS. The Memorandum will remain in force for a period of 2 years.

Collaboration with Government Industries

Ministry of Industry, Commerce and Supplies

On 12 December 2020, a meeting was held between Kathmandu University and the Ministry of Industry, Commerce and Supplies to discuss cooperation for Engineering services and hydrogen fuel.

From KU, Prof. Bhola Thapa and Assist. Prof. Biraj Singh Thapa was present. From the Ministry, secretaries and board members of Nepal Oil Corporation were present.

Dr. Biraj Singh Thapa, Team Leader of GHLab presented the cooperation possibilities of engineering services and the concept of Green Hydrogen technologies. Secretaries highlighted the need for alternative renewable energy and requested Kathmandu University to work together in this need. Based on the discussion, a Memorandum of Understanding was signed on 8th January 2021 between Kathmandu University (KU) and Nepal Oil Corporation (NOC) to foster mutual interest in the field of fuel and energy sector development and contribution to increased cooperation between academic institutions and government corporations. Later on, 25th February, an agreement was signed between KU and NOC to initiate the project "Technology Transfer and Local Adaptation for developing NOC as a hydrogen fuel producing and distributing company".

Ministry of Energy

On 19th July 2021, a Virtual meeting was held between Kathmandu University and the Ministry of Energy, Water Resources, and Irrigation (MOEWRI) to discuss KU-MOEWRI cooperation for Green Hydrogen Initiatives. From KU, Vice-Chancellor, Dean and Associate Dean of School of Engineering, Team Leader and Researcher of Green Hydrogen Lab were present. From the Ministry, Secretaries and Directors of Alternative Energy Promotion Centre and Nepal Electricity Authority were present.

Dr. Biraj Singh Thapa, Team Leader of GHLab presented the concept of Green Hydrogen Technologies and the need for National Hydrogen Initiatives. Mr. Devendra Karki, Secretary of Energy highlighted the need for a policy framework for the establishment of hydrogen technologies in Nepal and requested Kathmandu University for the recommendations. The discussion has established the grounds for bigger-scale demonstration projects to be carried out under the collaboration between the Ministry and KU. Vice-Chancellor Prof. Bhola Thapa gave the welcome speech and Secretary Devendra Karki gave the closing remarks.

Ministry of Education, Science and Technology

On 27 August 2021, a meeting was held between Kathmandu University and Ministry of Education, Science and Technology to discuss cooperation for Green Hydrogen Initiatives. From KU, Associate Dean Brijesh Adhikary and Assist. Prof. Biraj Singh Thapa were present. From the Ministry, secretaries and concerned stakeholders were present. Dr. Biraj Singh Thapa, Team Leader of GHLab presented the concept of Green Hydrogen Technologies and the need for National Hydrogen Initiatives. The discussion has opened up the possibilities of future collaboration in hydrogen research jointly with the Ministry and KU.

GHLAB: SEED FUNDING

Project ID: **KU-KMOU Green Hydrogen Project**

External Partner: **Korea Maritime Ocean University (KMOU)**

Total Fund: **USD $10,000**

The KU-KMOU project is the first externally funded project of the Green Hydrogen Lab. With the financial support of Professor Young Ho-Lee, Division of Mechanical Engineering, Korea Maritime Ocean University (KMOU), the research activities were initiated with 8 intern students on different hydropower to hydrogen-related topics as:

1. Setting up facilities for Green Hydrogen Lab. (Abhishek Subedi)
2. Feasibility scenarios for production of Green Hydrogen from large biogas plant in Nepal (Anmol Parajuli)
3. Possible End Use of Green Hydrogen in Context of Nepal. (Bishwash Neupane)
4. Development of specifications for the production of Green Hydrogen from spill energy of Chauri Khola-II micro-hydro project. (Manjur Raj Basnet)
5. Hydrogen Trucks for Nepal: Why and How? (Prabin Ngakusi)
6. Green hydrogen from Mini hydropower plants in Nepal. (Pranabh Regmi)
7. Green Hydrogen from other Renewable Energy Sources. (Roshan Parajuli)
8. Feasibility scenarios of Green Hydrogen energy in Nepal. (Sushobhan Bhattarai)

This project proved to be the key milestone of the lab as based on the foundation set up by this project, the lab was officially established and successfully secured research grants from other partners like NOC, AEPC, Jade consultancy, and NORHED.

KU-AEPC PROJECT FOR LAB DEVELOPMENT

The project aims to build basic foundations and facilities at the Green Hydrogen Lab, KU to demonstrate the commercial value chain of green hydrogen technology. With the research facilities, the project intends to develop a platform for the relevant energy sector of Nepal to study, understand, and adapt hydrogen business locally. The project was commenced on the 28th of April with six months project period. The funding is mutually done from the Alternative Energy Promotion Centre and Kathmandu University. The main activity of the project is to create a foundation for high-end collaborative research space for technology transfer and local adaptation of hydrogen technology. It will initiate a new interdisciplinary research team in Nepal in the field of hydrogen technology which is an emerging business at the international level. The project will help establish a strong partnership between academia and industry resulting in innovations.

Project Objectives:

1. Build basic foundations and facilities at the Green Hydrogen Lab, KU to demonstrate the commercial value chain of green hydrogen technology.
2. Develop a platform for the relevant energy sector of Nepal to study, understand, and adapt hydrogen business locally.
3. Conduct institutional activities and build networks to promote green hydrogen technology in Nepal.

The project has set up the 1 kW Laboratory Value chain model in Green Hydrogen Lab, Kathmandu University.

NORHED II PROJECT

Summary:

Project Duration: **Q1 2021- Q4 2026**

Total Budget: **20 million NOK (Approx.)**

Partner Institutions: **Norwegian University of Science and Technology (NTNU), Wuhan University (WHU), University of South-Eastern Norway (USN) and Himalayan University Consortium (HUC)**

NORAD has funded the project, "Research Based Education for Development of Hydropower Professionals for the Himalayan Region (Hydro-Himalaya)" at Kathmandu University. The project will produce 32 academic degrees (2 Post Doc, 10 Ph.D., 20 Masters by Research) under three thematic areas: Effective Production, Effective Transmission and Effective End-use of Hydro Energy and Green Hydrogen is the specific research area that is envisioned under effective end-use of hydroelectricity.

Acknowledging the need to prepare the academic institutions at Nepal to develop knowledge and resources in the field of Green Hydrogen studies, NORHED-II Project will provide research scholarships for 4 Masters, 1 PhD, 1 Joint PhD and 1 Post-Doctoral students at KU willing to further their academic career in Hydrogen Technology. The project will produce first PhD and first post-doctorate in the field of Hydrogen Technology in Nepal. Norway having the largest hydrogen R&D cluster in Scandinavia, the graduate students enrolled under the 'Green Hydrogen' research area of the project will collaborate with Norwegian University of Science and Technology (NTNU) and are eligible for mobility with NTNU for up to 18 months as a part of their respective degrees. In addition, investments will be made in laboratory equipment and facilities to directly contribute to the associated research activities for research in Hydropower to Hydrogen. Overall, the project aims to develop the knowledge and technology in the field of Hydrogen from the university research activities and transfer for the industrial adaptation so that Himalayan region has access to sustainable and resilient energy infrastructure.

Objectives:

1. Strengthen the research-based education within hydropower engineering at Kathmandu University by producing a better-qualified workforce in the Himalayan region.
2. Transfer of academic and research competence from Kathmandu University to the Nepalese and Himalayan region universities in the field of hydropower engineering.
3. Bridging academia and industry for sustainable solutions and practices.

Expected Outcome:

1. Overarching goal – The Himalaya region has increased access to sustainable and resilient energy infrastructure, educated nationals able to maintain and further develop the energy sector and industry utilizing and promoting sustainable solutions.
2. Education – The Himalaya region has increased access to local personnel with relevant education and skills to maintain and further develop the energy infrastructure in a sustainable matter.
3. Technology Development – The Himalaya region has increased access to sustainable and resilient technology specifically developed or adapted for the technical challenges in the region.
4. Industry development – Domestic and regional industry are matured and ready to implement new innovations.

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Kathmandu University Sets Forth
NATIONAL HYDROGEN INITIATIVE
On the occasion of World Environment Day

5th June, World Environment Day is a global platform for public outreach towards environment preservation. The theme for 2021 is "Ecosystem Restoration". With this promising theme, Kathmandu University proposes 'National Hydrogen Initiative (NHI) 2021-2030'. This is conceived as a consolidated program to be initiated and owned by the Government of Nepal, managed by Kathmandu University, funded by the government, industries, donors to establish and execute the green hydrogen economy for Nepal. The NHI incorporates world practice towards energy management and a roadmap for establishing policies, develop pilot projects of commercial nature, and create a conducive environment for the investments in business development in the field of Hydrogen Technology in Nepal.

"There is a need for a consolidated program initiated and owned by the Government to establish and incubate the green hydrogen economy for Nepal, and prepare the business sector to take over the commercial applications in a competitive manner at local, regional, and international markets."

Prof. Bhola Thapa
Advisor, Green Hydrogen Lab
Vice-Chancellor, Kathmandu University

"The National Hydrogen Initiatives is an activity under 'University's role in the state transformation' from the new leadership at KU. Academic exercises are open knowledge thus we invite all the relevant stakeholders to contribute and take away whatever is possible."

Asst. Prof. Biraj Singh Thapa
Team Leader, Green Hydrogen Lab

Nepal is among the countries that are most vulnerable to climate change and its effects, including more severe water-induced disasters and extreme hydro-meteorological events, such as drought, storms, flooding, landslides, debris flows, soil erosion, and avalanches. The energy-related CO2 emissions account for two-thirds of global greenhouse gas emissions. For a reasonable likelihood to stay below 1.5°C of warming, global net anthropogenic CO2 emissions should decline by around 45% by 2030, from 2010 levels, reaching net-zero by around 2050.

The groundbreaking research and innovation and the policy-based interventions to promote renewables as the primary supply of energy is pushing green hydrogen to overtake fossil fuel both technically and economically. Most of the developed countries have already released their policies and strategies to promote and adopt the green hydrogen as the future energy vector. It is expected that the demand for hydrogen to rise by 10 times by the year 2050 compared to that of 2015 with the major consumption in the commercial sector not existing today.

At present more than NPR 20 billion is used to import fossil-based fuels for Nepal, which is about 10% of the National GDP. It is expected that the demand for fossil fuel in Nepal could rise to 6 times by the year 2050 than that of 2010. It is projected that the total supply of primary energy from diesel in Nepal for the year 2050 will rise to 18% from about 5% at present. While the rest of

the world is gearing up to cut the dependency on fossil fuels, such exponential growth in demand for petroleum products in Nepal is very alarming.

Government of Nepal in 2016 planned to formulate the Low Carbon Economic Development Strategy that envisions the country's plan to promote economic development through low carbon emissions in different sectors. Petrol cars hold the largest share of vehicles in the transportation sector of Nepal. However, the import of diesel is almost three times that of petrol. Due to the lightweight and short travel distance, battery-based EVs could be the alternative to petrol-based vehicles. The Government of Nepal has announced an ambitious plan to replace the light vehicles running on petrol with electric vehicles by 2031. Several countries are considering Hydrogen as an option for diesel replacement in the transportation sector. Nepal can consider this as a future plan.

The LPG gas has been consistently on top of fossil fuel energy consumption in Nepal. The demand for LPG for cooking is more than double that of electricity and tends to remain the same until 2035. Unless an alternative to LPG is sought, Nepal cannot limit its CO2 emissions and dependency on cooking fuels from other countries. Synthetic/Green Natural Gas is coming as the alternative to methane for commercial application. The technology to generate hydrogen from renewable electricity and combine it with bi-product CO2 or captured CO2 from the air to get the methane is getting commercially feasible. Urea production, metal mining and processing, agrochemical industry are other areas where green hydrogen is replacing fossil fuels.

The Himalayas range forms the greatest band of mountains on the planet bringing huge prospects of hydropower development opportunities. This is especially true to Nepal, where more than 20000 MW of hydropower projects are under some stage of development. However, the forecasted domestic demand for electricity falls much lower than its production within this year. By the end of 2028, Nepal could have an excess of 3500 MW of electricity that might go to waste if proper energy management and policies are not defined at present. Export of excess hydroelectricity by cross-border grid connection among the South Asian Countries is one of the major discussions in Nepal. However, geopolitical complexities and high energy prices in Nepal may limit this possibility.

The surplus hydroelectric power and abundant solar energy in Nepal can profitability be converted as green hydrogen for local utilization, and export to the international market. The production and supply of green hydrogen energy could be one of the innovative businesses for Nepal. This will have a significant impact on the energy mix scenarios in the country and the energy export alternatives. This can also be one of the major sources of revenue from carbon trading. However, it needs very strong political and social commitments, high-level knowledge transfers from university to the industry and business sector, and willingness from the commercial and business sectors to diversify their business towards Green Hydrogen.

The Green Hydrogen Lab at KU has been established with the vision “Nepalese industries specialized to produce, store, transport, and use green hydrogen energy at a commercial level”. Nepal Oil Corporation, Alternative Energy Promotion Centre, Jade Consult Pvt. Ltd and the Norwegian Government’s NORHEDII project have been contributing to the research activities in the lab. It is extremely important to push forward ongoing activities in the green hydrogen for the national level impact with industrial and commercial activities. Intervention and support from the Government play the pivoting role for successful outcomes.

Progressive activities at Green Hydrogen Lab, KU:
·KU-Govt. of Nepal Program "National Hydrogen Initiative"
·KU: SOE-SOA Project "Green Society Initiatives"
·KU: SOE-SOL Project "Energy Law for Green Economy in Nepal"
·KU-HUC/ICIMOD "Energy ecosystem for the transition towards a low carbon society in HKH region"
·KU-World Bank Studies on "Green hydrogen as business opportunities in Nepal"
·KU-Asian Development Bank Partnership on "Deep Dive workshop on Hydrogen Technology on Nepal Case"

The National Hydrogen Initiative (NHI) is conceived as a consolidated program of the Nepal Government with the mandate to establish the policy foundations, develop an implementation action plan, and incubate a value chain for the business development with Green Hydrogen as the driving force to address the existing and upcoming challenges of the environment, fuel, energy, economy, and industrial development in Nepal.

Vision of NHI: Transformation of Nepalese Economy and Society by enabling the sustainable and affordable Green Hydrogen Technologies from the available renewable energy resources.

Mission of NHI: Reduction in fossil-based fuel consumption and greenhouse gas emissions, and contribute to more secure and efficient industrial processes by enabling the commercialization of green hydrogen technologies in Nepal.

Targets of NHI:
Policy Interventions:
·Educational and research programs for human resources.
·Nepal's National Green Hydrogen Policy and Road Map.
·100 million USD Nepal Hydrogen Initiative funds.
·Green Hydrogen Task Force with Government, Industries, and Academia.
·5% share of Green Hydrogen for primary energy supply by 2030.

National Demonstration Projects (At least one pilot project in each):
·Green Hydrogen for Fuel (Hydrogen busses and or trucks) Green Hydrogen for Heat (Replace LPG with Green Methane & Coal by HHO)
·Green Hydrogen for Power (Replace regular generators with Hydrogen generators)
·Green Hydrogen for Process (Integrate Hydrogen in Urea, Food Processing, Mining, and Metal industries)

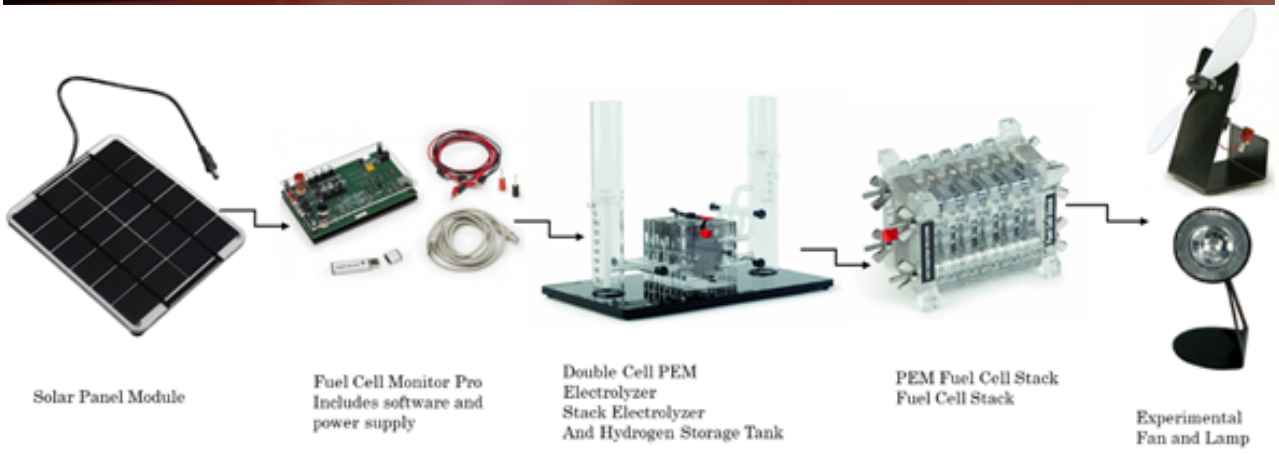
Business Incubation:
·Minimum infrastructure and facilities for the startup business with commercial motives.
·Showcase bankable projects for the attraction of larger investments from local and international investors.
·Business-friendly policy, regulations, and financial flexibility.
·Local industries can fabricate components to support the hydrogen value chain.

Long-term institutional arrangements:
·A government-owned company to plan and execute the commercial activities related to the green hydrogen systems in Nepal.
·A national-level Government entity "Nepal Hydrogen Authority" established to facilitate and regulate hydrogen-related business.

EQUIPMENT

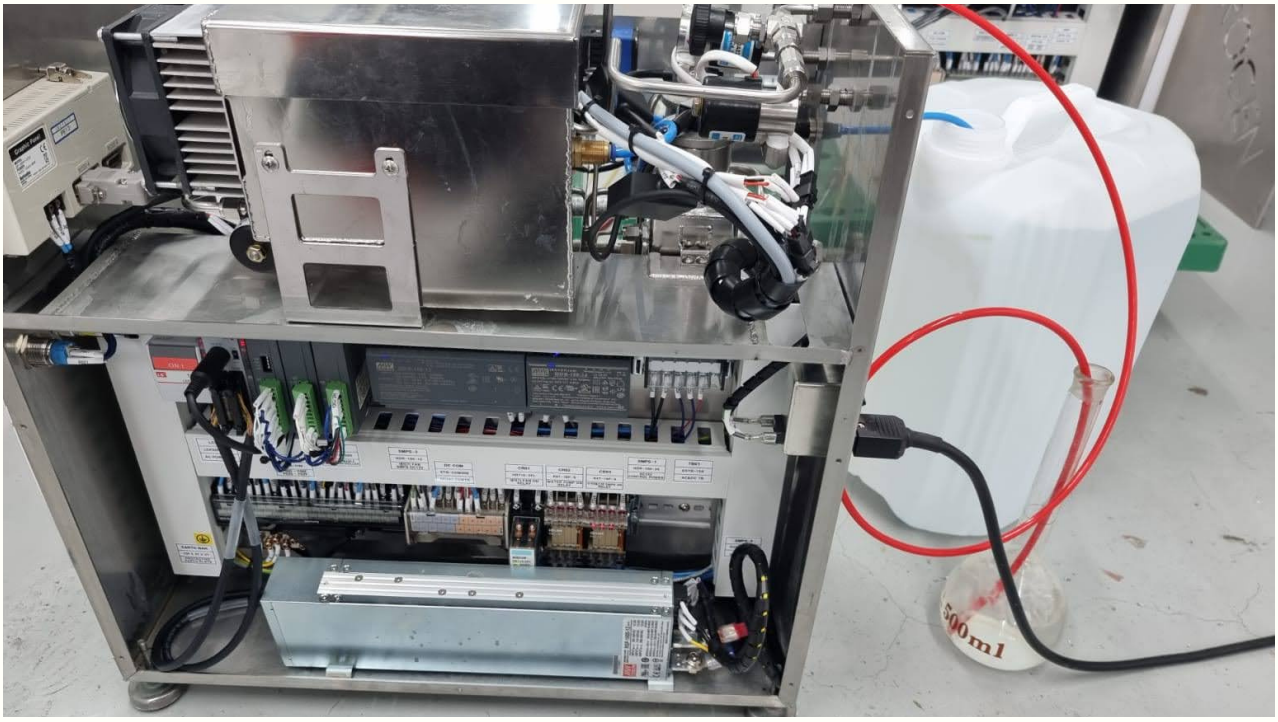
Hydrogen Experimentation 10 W System

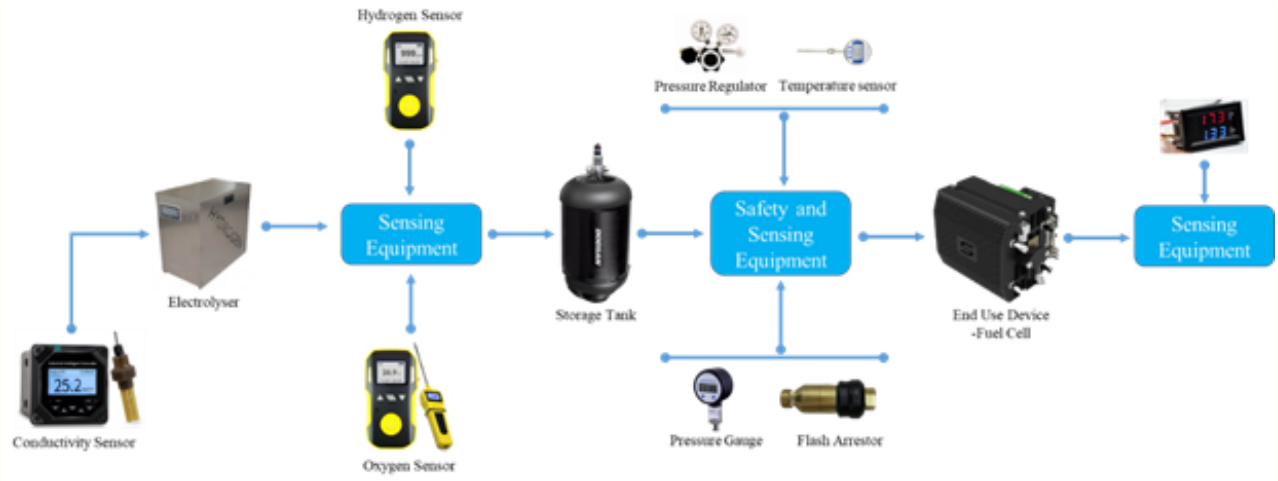
A 10 W Stack Experimentation Set is used as a research and laboratory apparatus in Green Hydrogen Lab. The setup serves as the demonstration kit for the beginners and experimental kit for the students taking theory and practical courses related to hydrogen technologies. The set consists of basic equipment and test kits required to produce, store and use hydrogen gas for re-electrification. List of equipment within the set are: Electrolyzer Stack, Fuel cell Stack, Hydrogen Storage Tank, Solar Module, fan and lamp. It also has the fuel cell monitor pro software to connect device to computer for analytical data-based research.



Hydrogen Experimentation 1 kW System

A 1 kW hydrogen value chain model is setup at Green Hydrogen lab as advanced research equipment. It has 1 kW hydrogen production system, 17 L storage tank and 150 W End use device for re-electrification. Auxiliaries equipment are setup for safety and data logging. The set has 11 different equipment representing the aspects of value chain of hydrogen; production (electrolyzer), storage (tank, safety, and sensing equipment), and end-use (fuel cell for re-electrification).





UNDERGRADUATE PROJECTS

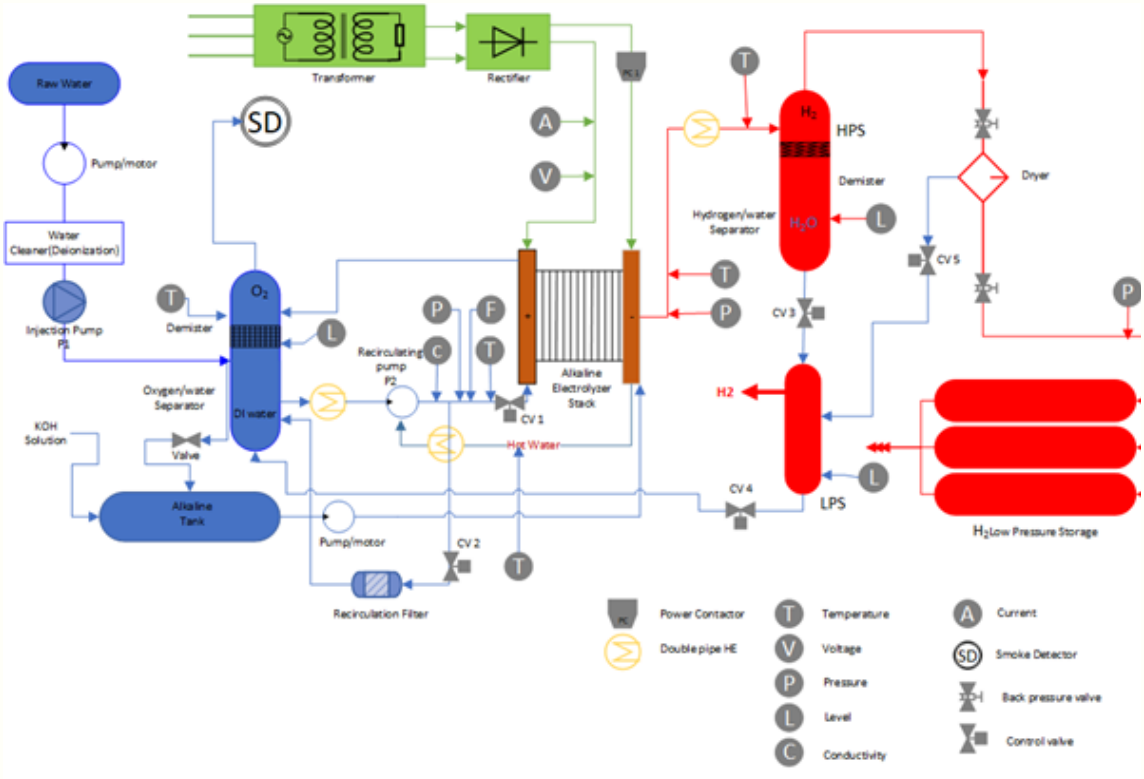
Project ID: **GHLab-UG-P3-1**

Project Group members: **Himanshu Giri, Rohit Joshi, Bikram GC**

Project Title: **Development of Hydrogen Production and Storage System for the Demonstrative use in the Transportation Sector of Nepal**

Abstract: This project will be on the assembly of electrolysis systems, production of hydrogen as a fuel for transportation facilities, and safe buffer storage. For the development of the system, an adequate and efficient electrolyzer is selected. So, the realm for this project is to identify a suitable electrolyzer with calculated results. Hence, produced hydrogen gas will be safely stored in buffer storage tanks. The study will be based on research on the development of the system and also identify the problems faced during the process. So, the purpose of this project is to eliminate those problems and design the optimized electrolyzer system that can provide the required hydrogen for the demonstrative use in the hydrogen FCEV. The team will be working on building the storage system for produced hydrogen gas to be stored safely which will be further used for the demonstration purpose of hydrogen fueled cell vehicle.

Project Schematics:



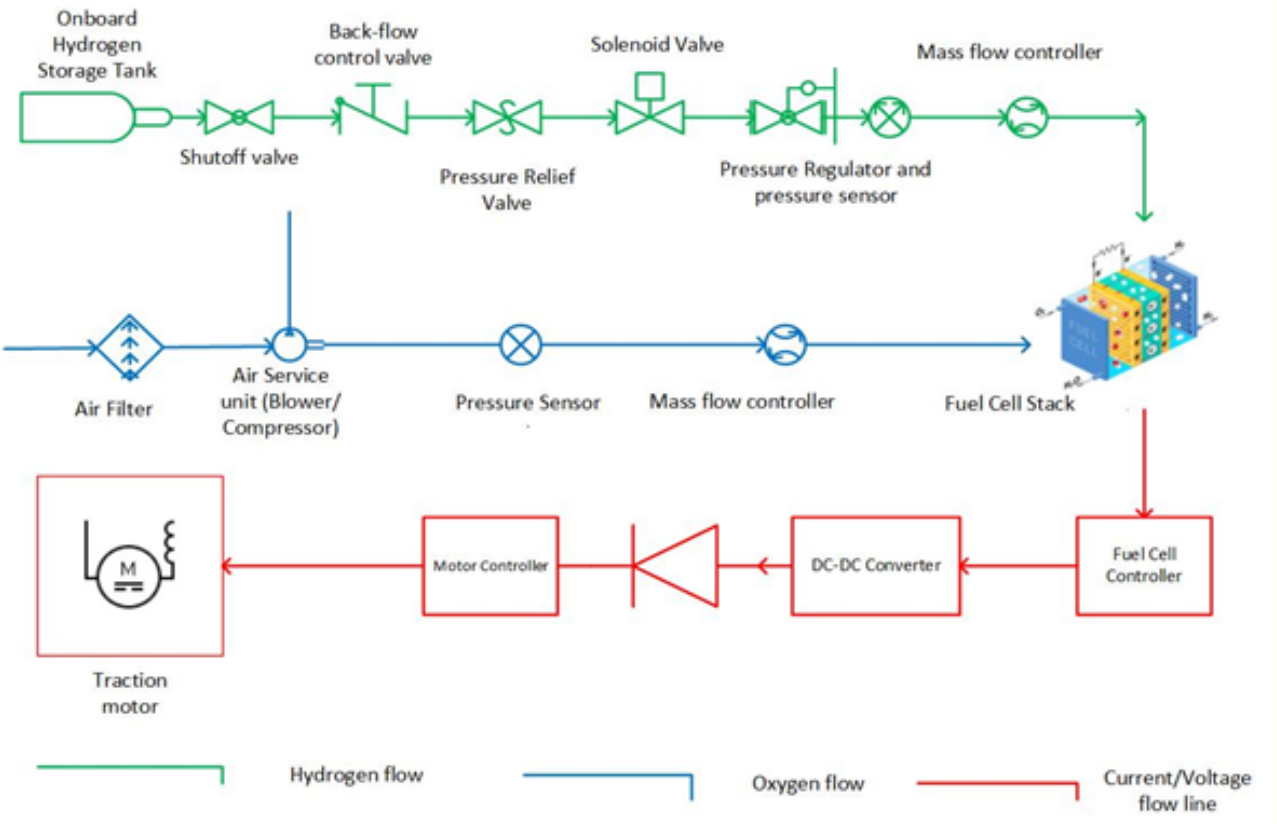
Project ID: **GHLab-UG-P3-2**

Project Group members: **Abhishek Subedi, Manish Sapkota, Pawan Paudel, Yaju Shrestha**

Project Title: **Design and Development of Drive System and Safety Considerations for a Demonstrative Fuel Cell Driven Car**

Abstract: Recent developments of alternatives to internal combustion engines (ICEs) have driven the world towards building clean energy sources such as in hydrogen fuel cells to address pollution issues associated with ICE vehicles. Conversion of an ICE vehicle to a hydrogen fuel cell vehicle would further aid the progress since the old ICE vehicles need not be discarded. The objective of this project is to replicate the performance of a hydrogen fuel cell driven motor in the internal combustion engine vehicle chassis, and compare the fuel consumption with the initial case. A mathematical model of the drive system is made to estimate the fuel cell energy consumption. Then drive system components are designed and a vehicle chassis is selected. A CAD model is built to perform structural analysis so as to determine appropriate placement of the components in the chassis. The energy consumption estimated by the model provides an accurate range of the demonstrative vehicle which is compared with ICE counterpart. The results are validated through on-road testing. Detailed specification of the drive system component ensures reproducibility of the demonstrative vehicle.

Project Schematics:



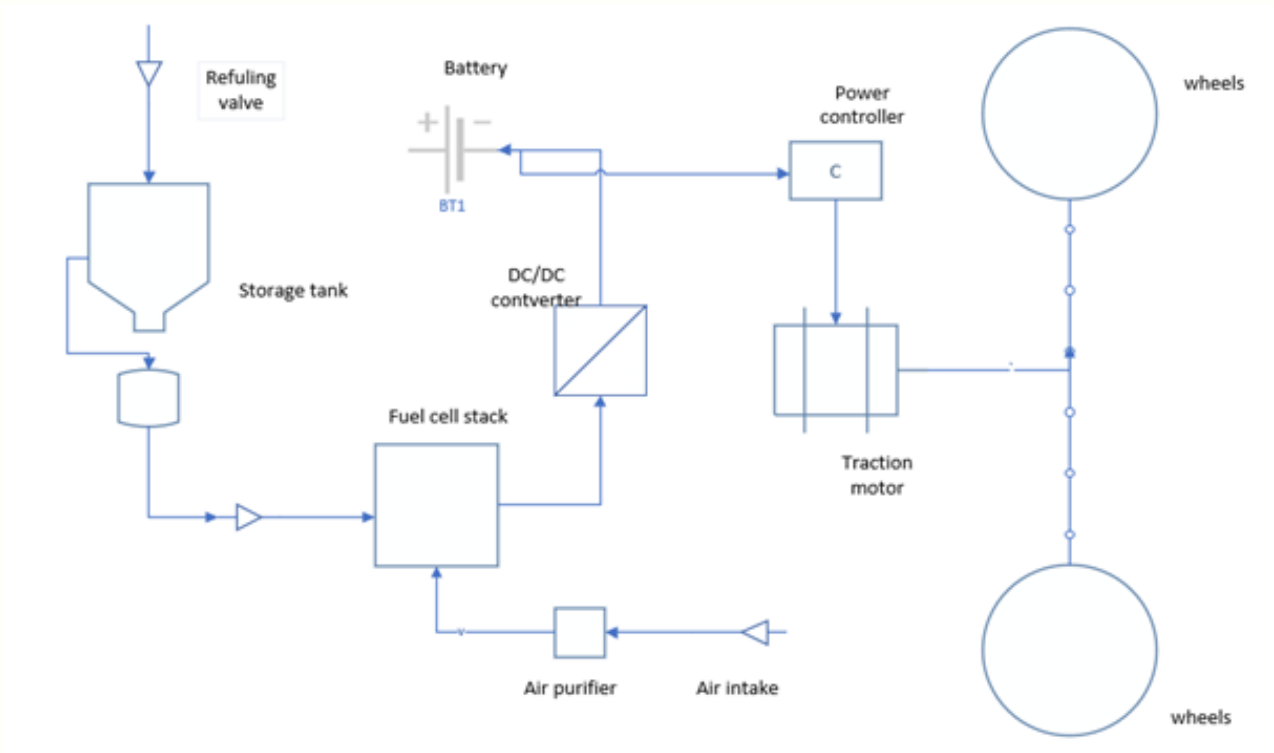
Project ID: **GHLab-UG-P3-3**

Project Group members: **Abhishek Mishra, Biraj Kharel, Nabin Mishra, Tejraj Tharu**

Project Title: **Conversion of an IC Engine Car Chassis to be used for a demonstrative Fuel Cell-Driven Hydrogen Car**

Abstract: The gradual increase in carbon emission along with greenhouse gases resulting in increased global warming due to the smoke emission from the IC engine vehicles has adversely degraded the environment quality and human health. Different alternatives have been adopted and among them, hydrogen fuel cell vehicles seem to be a more energy efficient and prominent solution for emission reduction. This project works on a detailed and step-by-step process regarding how one can systematically disassemble the different components of an IC engine vehicle for its conversion to the fuel cell-driven hydrogen vehicle. The project is divided into several objectives and activities. The first activity is to generate the standard steps/guidelines to be followed while disassembling the vehicle for conversion, which is prepared after studying the standard documents. The second activity is to develop the step-by-step guidelines to install the motor, fuel cell components, electric controllers, and do it practically based on the guidelines. The third activity is to perform the mathematical modeling of the subsystem in the MATLAB/Simulink and optimize it for better performance and the fourth activity includes the 3D CAD modeling of how the systems are arranged and placed in the car. The project also studies on the safety protocols to be followed during the disassembly of IC engine and the assembly of the fuel cell vehicle.

Graphical Abstract/Image/Project Schematics:



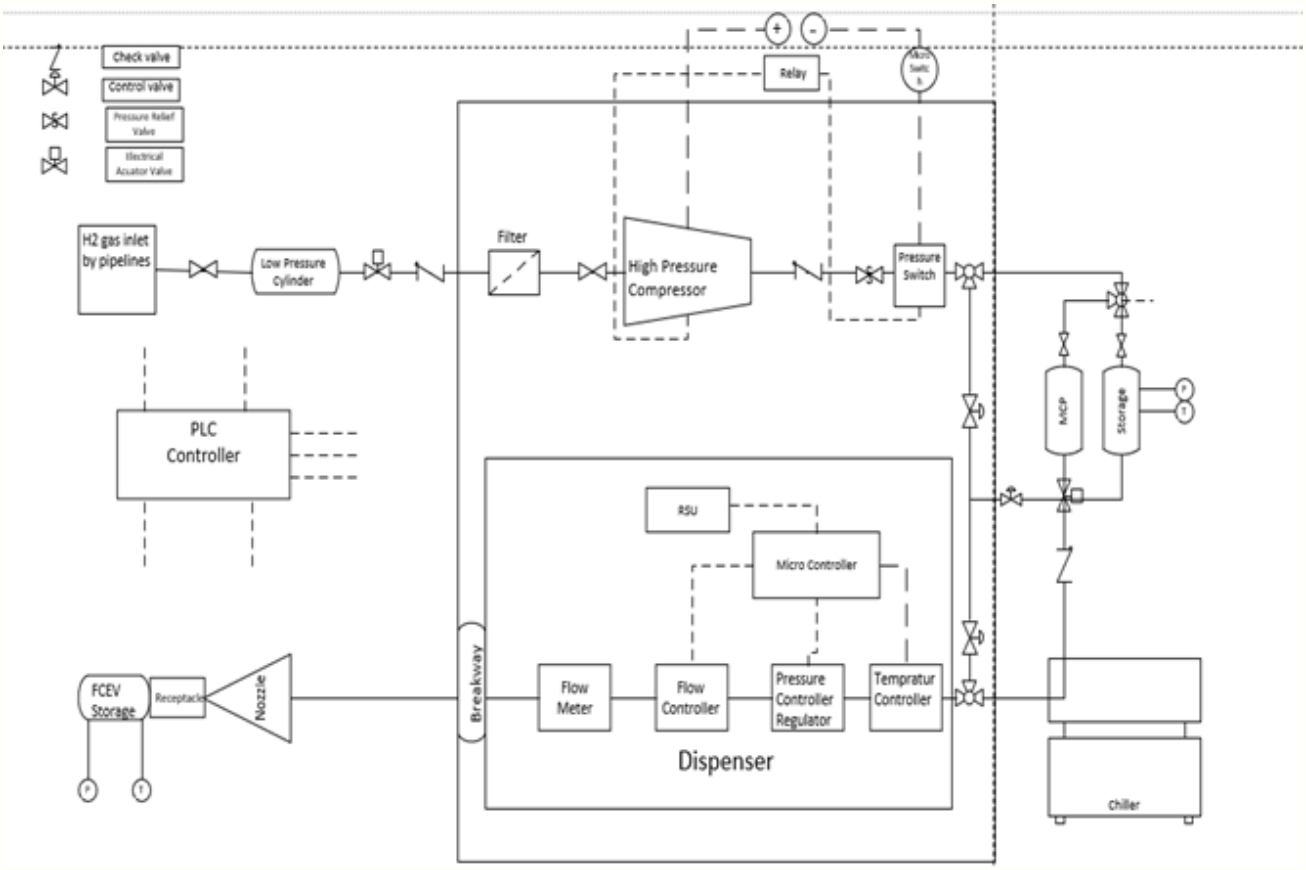
Project ID: **GHLab-UG-P3-4**

Project Group members: **Abin Thapa, Sangam Limbu, Mridul Bhattrai, Shrayad Chapagain**

Project Title: **Design and Development of Hydrogen Transmission and Refueling Station for Demonstrative Purpose**

Abstract: Energy crisis and vehicle emission effects can be highly mitigated by hydrogen technology such as in the transportation sector. Hydrogen as an alternative fuel in FCEVs has many advantages over battery driven EVs like faster fueling, high energy density carrier, etc. But FCEVs efficiency is low and it's dangerous to operate in high pressure. The objective of this project is to build a safe refueling system to refuel the demonstrative light duty FCEV which has less travel range and lower operating pressure. This project will be on compression of hydrogen via compressor booster, transmission with simple system design and dispensing system with calculated pressure rate & fueling time. Selected components will be able to withstand desired pressure and assembly will be done to ensure minimum leakages. SAE protocols for fueling, purity of hydrogen, dispenser coupling, etc. are overviewed in this project.

Project Schematics:



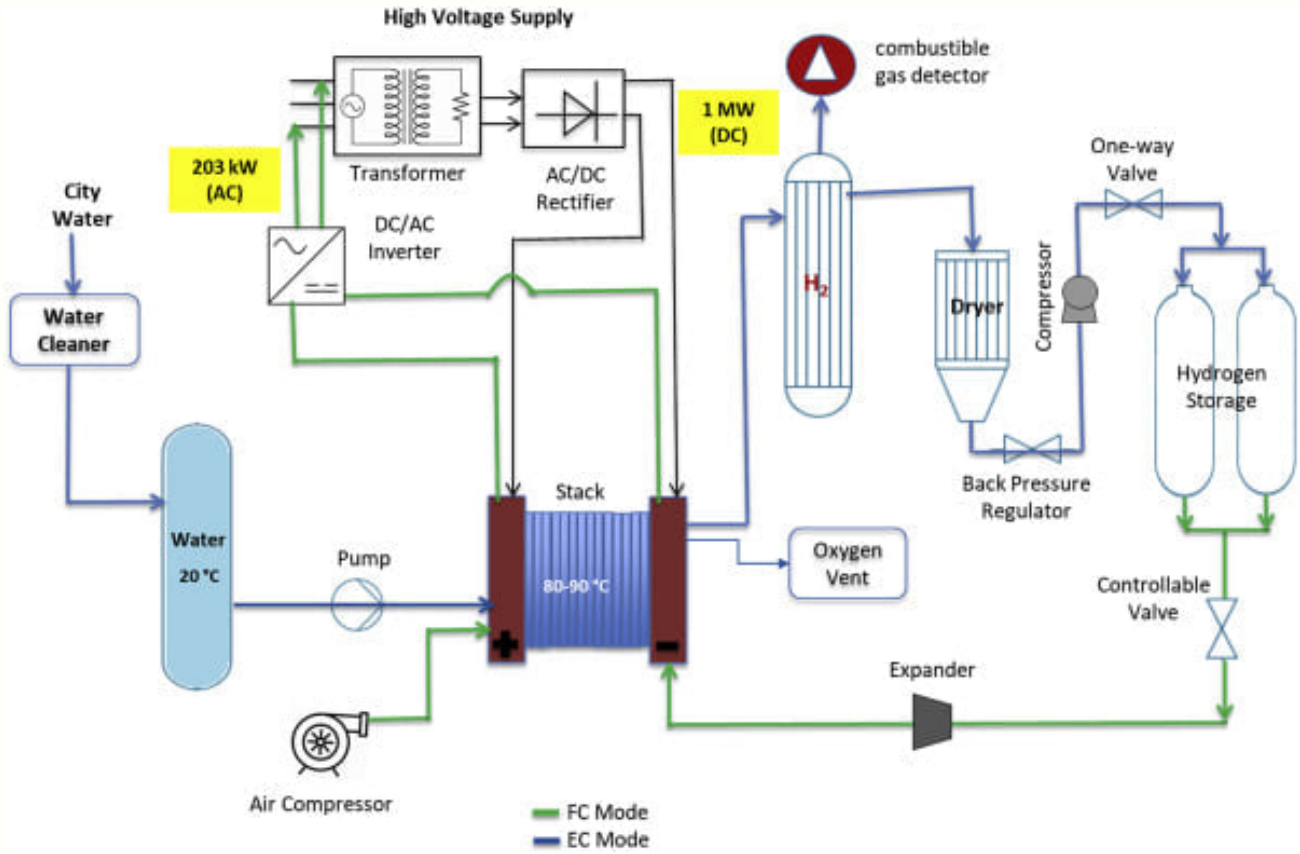
Project ID: **GHLab-UG-P4-1**

Project Group members: **Narendra Chaudhary, Asheem Khanal**

Project Title: **System Design and Optimization of Safety Management in Hydrogen Value Chain for Nepal**

Abstract: Hydrogen is considered future fuel after the evolution of the IC engine, a green energy but it is not a primary energy source but rather an energy carrier, a means of storing, transporting and distributing energy, which has to be generated by other means. It works in a chain called hydrogen value chain which includes production, storage, distribution and end use. With the development of the hydrogen production facility and its uses, safety concerns must be studied to bring it into practical use. The main risk involved with hydrogen production is fire or explosion due to its high flammability range. Due to low density of hydrogen gas during storage it requires high compression which may cause high chances for leakages and cause inflammation. The more important hazards of hydrogen distribution are its ready flammability, a frequently invisible, high temperature flame and its eagerness to burn or form explosive mixtures with air. Gas station leakages have shown some major drawbacks in hydrogen value chain's end use. These reasons brought the need of safety management in the hydrogen value chain that is from production to end use.

Project Schematics:

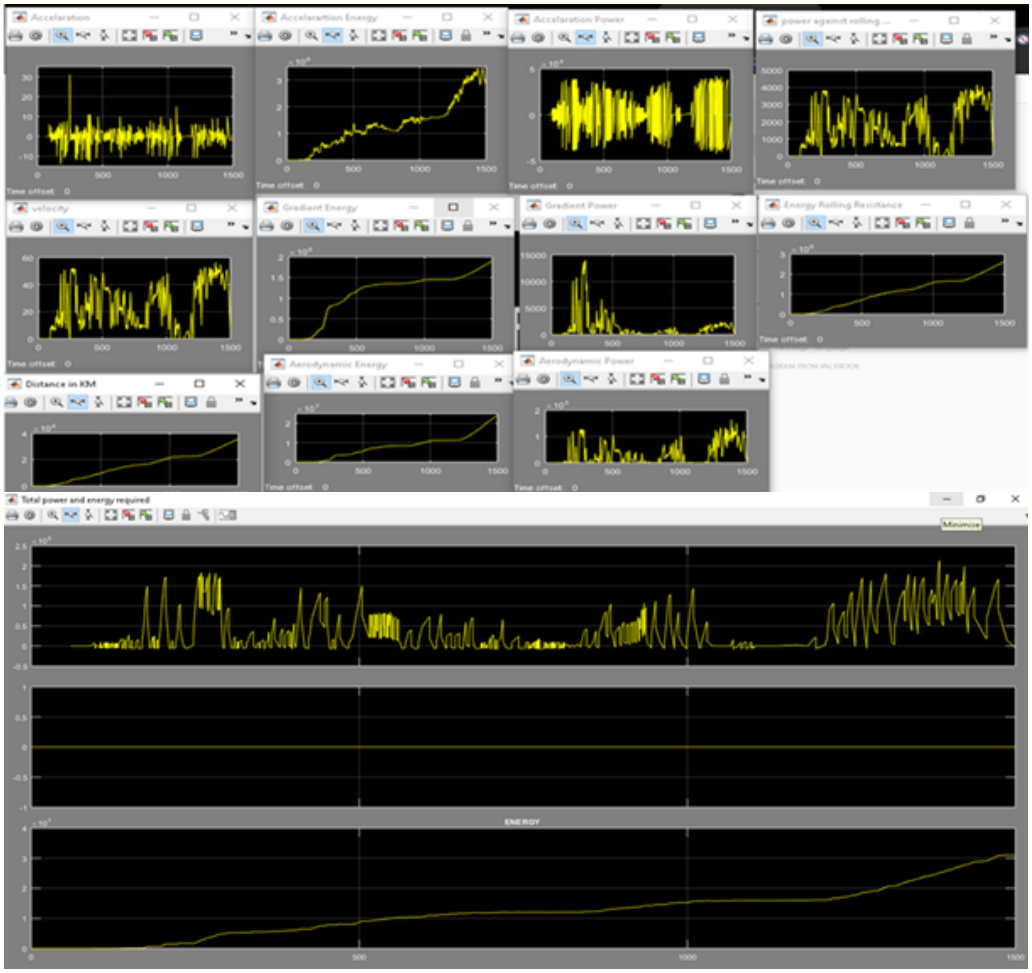


Project ID: **GHLab-UG-P4-2**

Project Group members: **Rewat Katwal, Bishnu Pandey**

Project Title: **Techno-Economic Assessment for Pilot Testing of Hydrogen Fuel-Celled Vehicles in The Context of Nepal**

Abstract: In the context of Nepal, the consumption of petroleum products in the transport sector has increased by an average growth rate of 9% annually. Growth of CO2 emission from the sector has been higher- at an annual average of 11% during 1994-2013. Thus, widening of trade deficit due to small volume exports and steep rise in import has led to severe pressure on foreign currency reserves. Battery Electric Vehicle has been an alternative for light-duty vehicles. In the medium to high duty vehicle segments characterized by long-range or high utilization rates, FCEVs have advantages over current limitations of batteries such as weight, driving range, and refueling time. Thus, for pilot testing, a heavy-duty vehicle i.e truck or bus is selected. Taking the hydropower potential in Nepal and surplus hydropower electricity target of 3500MW by 2028 AD, electrolysis is preferred for hydrogen production. After the selection of a route, GPS data of the vehicle is analyzed using MATLAB software to assess technical parameters like energy modeling, power modeling, range, slope-velocity ratio, etc. FCEVs specifications are modeled from MATLAB and refueling stations are set up accordingly at a calculated distance. An infrastructural map of hydrogen fuel stations for that particular route is obtained. Data collection is done in order to see the real scenario of land transport in Nepal and to forecast FCEV based on BEV data using MS EXCEL. In parallel, a cost-benefit analysis of the pilot testing is carried out to assess the economic aspect of running FCEVs in Nepal.

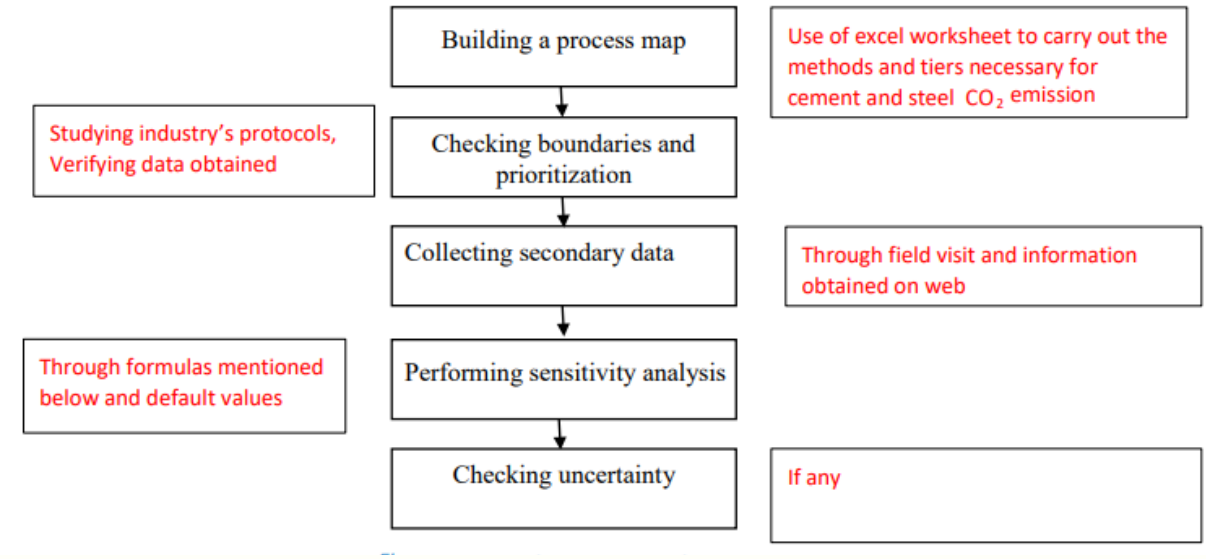


Project ID: **GHLab-UG-P4-3**

Project Group members: **Asha Chalise, Shreya Acharya, Aanan Ghimire**

Project Title: **Modelling of Energy Scenario to Decarbonize Economy with Hydrogen as a Driving in Context of Nepal**

Abstract: There is a dire need to substitute as well as supplement the traditional energy supply system by modern forms of sustainable energy in terms of resources and technology. Because of the country's dependence on imported fossil fuel, high cost of grid connection and low and scattered population density, a decentralized energy supply system becomes the natural and feasible choice. Green hydrogen, in contrast, could almost eliminate emissions by using renewable energy — increasingly abundant and often generated at times — to power the electrolysis of water. Hydrogen can decarbonize intensive CO2 sectors. Developing an enhanced understanding of the energy system benefits of hydrogen production from electrolysis, in particular the economics of seasonal storage of hydrogen for re-electrification during dry season and electrolyser providing ancillary services such as adding demand-side flexibility to power systems in the specific context of Nepal. Developing an enhanced understanding of current cost levels and future cost-reduction potential of different types of electrolyser and their potential capabilities of operating part load based on the availability of variable renewable energy.



Process Flow Diagram of the Project

PUBLICATIONS

Journal Papers:

1. **Green Hydrogen as a Future Multi-disciplinary Research at Kathmandu University**

   Biraj Singh Thapa and Bhola Thapa

   Journal of Physics: Conference Series: Volume 1608, Current Research in Hydropower Technologies (CRHT X) 31 March 2020, Kathmandu University Nepal

Abstract: Over 100 million tons of hydrogen are produced every year for a range of industrial purposes. The vast majority of this industrial hydrogen is produced from coal gasification or steam methane reforming, both of which need a lot of energy and generate significant carbon dioxide emissions. A much smaller proportion of hydrogen is produced from the electrolysis of water, which can be a far more sustainable and clean method if the electricity is produced from renewable sources. While the urgency of greenhouse gas emission mitigation has increased, many countries have begun to take action to decarbonize their economies. Nepal is expected to have about a 3000 MW electricity surplus by the Year 2030. It is a time to explore alternative use of electricity to make hydropower projects financially feasible. Hence it is also high time to investigate Hydropower-to-Hydrogen (H2H) technology and transfer the relevant knowledge in the region. Kathmandu University (KU) has been leading to initiate and institutionalize the new academic programs and research avenues to address the future need for this country. KU has played a role model to introduce and establish innovative and unique programs in engineering education in Nepal since it was established in 1994. Since the establishment period, KU carried the vision to establish itself as a research-based university. KU has carried the objective to design its academic programs, courses, and curricula to directly contribute to the research problem the industry or society has been facing. The intuitional realization that Green Hydrogen (GH) is the future academic and research need of this country will be the far-slightness of KU.

2. **Green Hydrogen potentials from surplus hydro energy in Nepal**

   Biraj Singh Thapa, Bishwash Neupane, Ho-seong Yang, Young-Ho Lee

   International Journal of Hydrogen Energy, Volume 46, Issue 43, 23 June 2021, Pages 22256-22267, https://doi.org/10.1016/j.ijhydene.2021.04.096

Abstract: This paper studies the potentials of green hydrogen production from hydropower energy and its application in electricity regeneration and replacement of petroleum products from the transportation sector in Nepal. The potential surplus hydroelectric energy, and hydrogen production potential from the surplus energy considering different scenarios, is forecasted for the study period (2022–2030). The results showed that hydrogen production potential ranges from 63,072 tons to 3,153,360 tons with the utilization of surplus energy at 20% and 100% respectively, in 2030. The economic analysis of hydrogen from hydropower projects that electricity is valued based on per kg of hydrogen when the surplus electricity is provided at feasible lower price values compared to the US $1.17. This study concludes that hydrogen production from spilled hydro energy and its use in the transportation sector and independent electricity generation is a niche opportunity to lead the country towards sustainable energy solutions and an economy running on hydrogen.

GREEN HYDROGEN LAB'S FIRST MASTER BY RESEARCH PROGRAM

On 2nd June 2021 Green Hydrogen Lab started its first MS by research Program with the topic "Green Hydrogen as an alternative and future solution for transportation sector". This MS by research is a part of an agreement signed between Nepal Oil Corporation and Kathmandu University.

Ms. Nashla Shakya is the first Master Candidate in Green Hydrogen Lab to establish green hydrogen as sustainable environmentally friendly fuel in the sector of transportation. She is also a part of the demonstrative modeling team for CAD designing of a hydrogen fuel cell vehicle for demonstrative illustration of hydrogen fuel cell cars.

Proposed Title: Green Hydrogen as an Alternative and Future Fuel for Transportation Sector of Nepal
Implementing Organization: Kathmandu University
Research Centre: Dhulikhel, Kavre
Research Period: 2 years

OBJECTIVES :

1. Evaluate the need of renewable energy systems and technological status to replace fossil fuel from the transportation sector.
2. Techno-economic assessment of the use of green hydrogen as an alternative and future fuel in the transportation sector of Nepal.
3. Identify and propose an optimum case for pilot scale testing of green hydrogen as a fuel for the transportation sector of Nepal at a commercial level.

SCOPE:

1. Explore the future energy requirement of the transportation sector and associated challenges for integrating a hydrogen system as a potential replacement of fossil fuel.
2. Techno-economic feasibility focused to identify economic indicators and technological parameters based on literature, simulations, and calculations.
3. Model development, system optimization, scale factors identification, and validation to determine the optimum case for pilot scale testing.

EXPECTED OUTCOME :

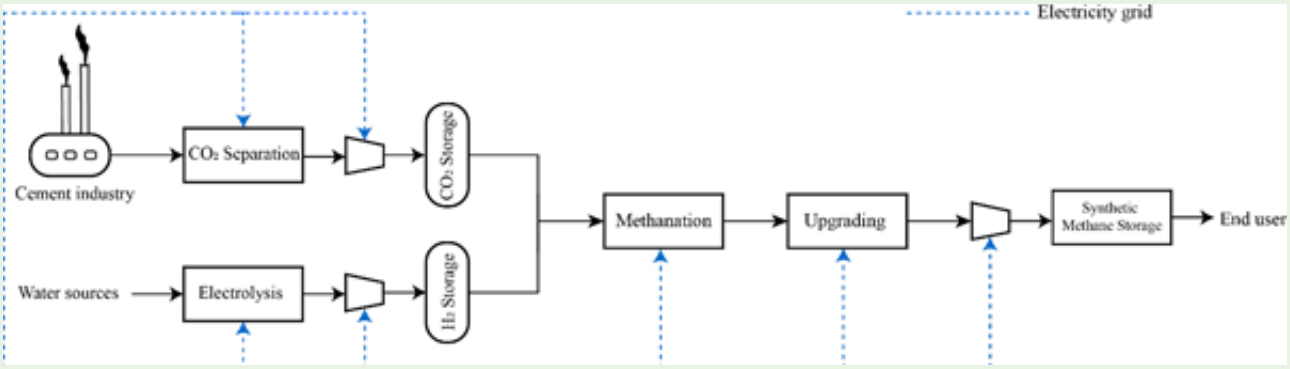
1. Project Commercially viable green hydrogen-fueled cell vehicle in the transportation sector of Nepal through techno-economic assessment and system-level design.
2. Promote the integration of renewable energy in the transportation sector of Nepal through Comprehensive business reports, Comprehensive Business Reports, Feasibility Reports, and Research Papers in international journals
3. Contribute in the advancement of academic research and development within Green Hydrogen Lab through laboratory setup from knowledge of international exposure and research

H_2 APPLICATIONS FOR NEPAL

Green hydrogen-based synthetic methane as an alternative to LPG for clean cooking in Nepal

Firewood is a major source of cooking fuel in Nepal, according to the Annual Household Survey Report of 2016/17, serving more than 52.4% of total households. The other sources are LPG, cow dung, leaves, and biogas. LPG use has skyrocketed in recent years, with 33.1% of households using it now. It accounts for approximately 54.1 % of all cooking fuel used in urban areas making LPG the country's second most common cooking fuel. In the fiscal year 2010/11, about 1, 59, 286 metric tons of LPG was imported from India.
At present, the Nepal Oil Corporation (NOC) is heavily subsidizing the LPG for cooking. The NOC has been running at a loss due to inability to adjust the price of cooking gas. Even the price has hiked for 18 times in year did not encourage the corporation. NOC has been making profit since the fiscal year 2071/72 but after six years in the fiscal year 2077/78, it has to bear a loss which is around Rs. 5 billion.

The direct use of electricity for cooking applications is not being accepted by society at present even the customs duty on kitchen utensils including electric stoves reduced to 25 % with the objective of reducing gas imports. This tends to remaining the same in future. Alternative to the LPG is inevitable, and hydrogen-based renewable cooking fuel is a solution.



Green methane offers an advantageous option to put the economy on a low carbon route and create new business opportunities. Climate change must be dealt with urgently. The ultimate challenge is to achieve the necessary transition to a green energy system at an affordable price while preserving high energy levels. In order to meet this challenge, renewable gas has great features. So, this project recognises that green methane may provide a replacement to liquefied petroleum gas in the country. Climate change must be dealt with urgently.

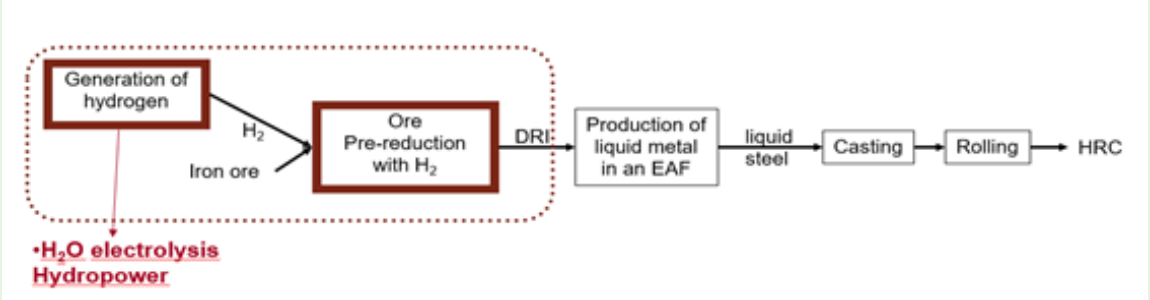
Industrial Application of Green Hydrogen Energy in Nepal

Nepal has huge opportunity to decarbonize the CO2 emissions in industrial processes by utilizing the renewable hydroelectricity and green hydrogen for production of raw iron. With new iron mines being discovered and under study for potential reduction of raw material from those mines, Nepal can lead the path for green steel production using green hydrogen. Nepal is known to have 100.5 million tons of iron ore as of 2015 and now new large quantity of iron ores have been discovered recently.

Hydrogen can be used as green reducing agent in industrial applications. Reduction of iron ore is first step required in steel production, and currently coke is used as the main reduction agent inside the blast furnace. When the coke is burnt, huge amount of CO2 is released. Hydrogen burns with pure flame and the output is only water vapors, so it could be used in high heating process in existing iron and steel industries. Hydrogen can also be used as a high heat source in the steel industries, which are mainly dependent on high quality coal for generating high heat required in smelting and reheating furnace for billet heating.

Cement Industries around the globe are one of the major carbon emission sectors contributing around 8% to global anthropogenic carbon emissions. If all the production of clinker to be done in Nepal based on traditional rotary kiln heating limestone and clay, huge amount of coal is required to burn resulting more carbon emission. However, green hydrogen with high heating flame can be good source of heat generation in these industries.

There are existing industries where green hydrogen can be used to some extent in Nepal at present condition with adapting the new and recent technologies developed in other countries. However, if we are really worried about the climate change and environmental impact of carbon emission and we look forward for the clean and green society, new industries based on the green energy should be focused and prioritized in Nepal. Reliable electricity is still a problem in iron and steel industries in Nepal, and most of the industries are using diesel powered generators for back up electricity. Hydrogen could be used for back up electricity power generation in those industries, leading to the application of clean energy.



Opportunity for Green Hydrogen route for Iron and steel industries in Nepal

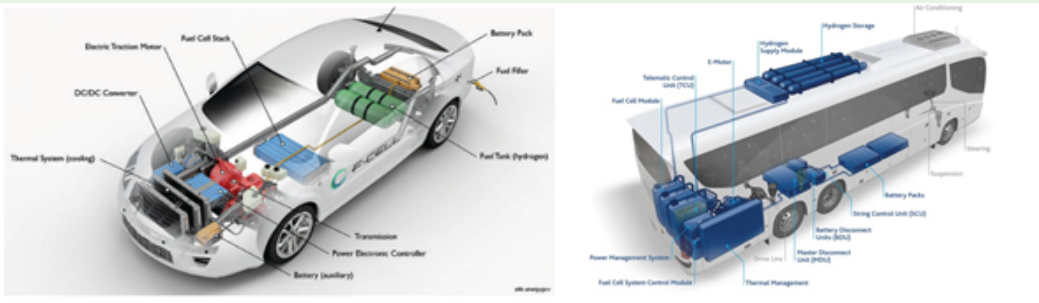
Hydrogen Application in Automobiles

Green Hydrogen has been identified as an energy carrier with great potential for clean, efficient power in stationary portable, and transport applications. In combination with fuel cells, it can improve energy efficiency in transport and contribute to mitigating climate change. Around the world, the application of hydrogen in Transportation is gaining momentum and by 2050, the transportation sector alone is expected to consume around 144 million tons of hydrogen. Hydrogen fuel cell systems operate without pollution when run on pure hydrogen, the only by-products being pure water and heat.

Battery Electric Vehicles (BEV) and Hydrogen Fuel cell electric vehicles are the transportation means for a sustainable emission-free future. However, BEV is limited to small size and short distances whereas Hydrogen fuel-cell electric vehicles (FCEV) can store more energy concerning their weight and can be refueled faster, making them effective for applications that require long ranges and demand duty cycles with minimum downtime. They are preferable for larger vehicles, especially heavy-duty trucks and they do not require consumers to change their behavior when switching from gasoline engines.

The specific energy (energy per unit mass) of Hydrogen is 236 times more than that of lithium-ion batteries. Because of its energy density and lightweight nature, compressed hydrogen and fuel cells can power cars for extended ranges without adding much weight, which is a limitation for electric technology in the aviation industry. 1 gallon of gasoline has about the same amount of energy as 1 kg of hydrogen. Most fuel cell electric cars can carry about 5-6 kg of hydrogen and go twice the distance of a modern internal combustion engine car with equivalent gas in the tank.

Hydrogen infrastructure is developing steadily, albeit slowly. It is giving automakers a second market in the USA. Japan has announced its intention to become the world's first hydrogen society. By 2030, they have aimed to have 900 fuel stations to service 800,000 FCEVs, buses and forklift trucks. South Korean carmaker Hyundai aims to secure FCEV production capacity of 500,000 units per year by 2030, including passenger vehicles and commercial vehicles, in anticipation of high demand for global FCEVs expansion within that timeframe.



source: US Energy Department

Prospects of Green Hydrogen in Nepal

With economic, physical and social development, Nepal has aimed to achieve the sustainable development goals set by the United Nations and reach the level of medium income countries by 2030 A.D. Among the sustainable development goals, the seventh goal is aimed to ensure the accessibility of affordable, reliable, sustainable and modern energy for all whereas the twelfth goal is aimed to promote sustainable and accountable production and use.

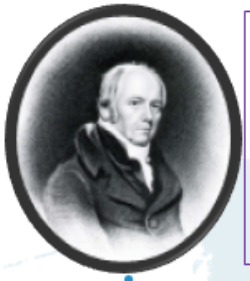
Many study has confirmed that our hydropower projects are spilling during off-peak hours from April to October. The Nepal Electricity Authority estimates that the country will have a surplus of around 6000 megawatts by the year 2025 as its generation capacity is expected to reach 10,924 megawatts while peak demand is likely to reach 4000 megawatts. If demand areas of electricity are not increased, then energy would be completely wasted and country would bear huge economic loss. Therefore, utilization of this surplus energy with means of production of green hydrogen and its use in different chemical and industrial processes.

The value of hydrogen in Nepal's energy sector is its potential contribution to addressing Nepal's energy security issues, which are characterized by heavy dependence on fuel imports, inadequate storage, and extremely limited diversification of domestic electricity generation sources. Additionally, Hydrogen production and utilization can take advantage of complementary seasonal patterns of hydropower supply and electricity demand in Nepal, is expected to have a promising potential to provide an alternative solution to address issues relating to electricity import and energy storage of Nepal.

Effective End-Use of Hydro Electricity

The most established technology options for producing hydrogen from renewable energy sources are water electrolysis and steam reforming of biomethane/biogas with or without carbon capture and utilization/storage (CCU/CCS). The production of Hydrogen from Hydro electricity through water electrolysis can particularly be utilized in the country like Nepal with huge hydropower potential.
The Himalaya, Hindu-Kush, and Karakoram Mountain range from the greatest band of mountains on the planet binging huge prospects of hydropower development opportunities. This is essentially accurate in Nepal, where more than 20000 MW of hydropower projects are under some stage of development. However, the forecasted domestic demand for electricity falls much lower than its production. Nepal is expected to have about a 3000 MW electricity surplus by the Year 2030. This surplus electricity can be utilized in the production of Green Hydrogen. Different study and evidences indicate that GH energy will be at the center of the global economy by 2050. The surplus hydroelectric power in Nepal produced by then can profitability be converted as hydrogen fuel, and can be utilized, and exported. Hence the production and supply of GH energy from hydropower could be one of the innovative businesses for Nepal in the future. This will have a significant impact on the energy mix scenarios in the country and the energy export alternatives.

Hydrogen Technology Development



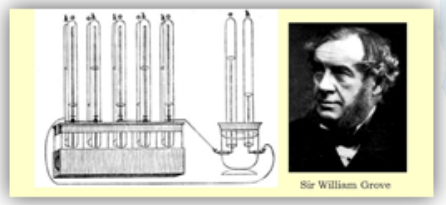
English scientists William Nicholson and Sir Anthony Carlisle found out that applying electric current to water generated hydrogen and oxygen gases.

General Electric (GE) come up with hydrogen fuel cells for generating electricity in the Apollo and Gemini space missions.

- Honda started leasing the FCX Clarity hydrogen fuel cell electric vehicle (2008)
- Toyota launched its first hydrogen fuel cell car, the Toyota Mirai (2016).

- Netherlands first hydrogen-powered housing project to start towards 2020-end.
- NTPC initiated Hydrogen Fuel bus and car project in Leh and New Delhi in India.

1800 | 1838 | 1960 | 2003 | 2008-19 | 2020



First hydrogen fuel cell developed to generate Electricity.

President Bush introduced the Hydrogen Fuel Initiative (HFI) to boost hydrogen fuel cell development..

- Hydrogen Council formed for commercialisation of hydrogen and fuel cell technologies(2017).
- The HyDeploy launched zero-carbon hydrogen into the UK's natural gas network (2018).

- Australia's Arrowsmith hydrogen project obtained an initial $300 m investment for its first round of construction.
- Siemens and Uniper joined hands to develop hydrogen technology in Germany.

Hear From Alumni

“Green Hydrogen Lab, since its inception, has been instrumental in creating a firm foundation to develop Green Hydrogen ecosystem in Nepal. The interventions that have been undertaken through the first ever Hydrogen energy lab in Nepal over a period of a year is appreciable and makes me believe that Nepal can achieve its mission given that the activities and collaborations expand in this pace. As a KU alumnus who received the opportunity to start a career with GHLab, I am convinced from my experience that, with the contagious energy GHLAB team carries, it is destined to provide vivid advancements in alternative energy sector. Hydrogen ecosystem establishment in Nepal might seem distant at present, but the prospect of the technology in Nepal is enormous. For this, GHLAB needs to work in a full-fledged manner to link the idea of using Hydrogen as a transition to the Hydrogen economy. With R&D initiatives of GHLAB, Nepal can offer efficient and eco-friendly Hydrogen production strategies." - **Anmol Parajuli**

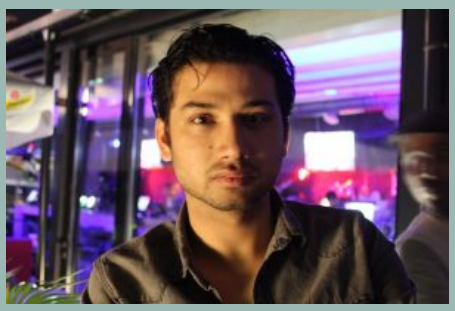
"I am extremely overwhelmed to be a part of Green Hydrogen Lab during its pioneering days in Nepal. The broad dream envisaged by tenacious leadership of the lab was a strong motivation for every novice researcher and intern. The meticulous and prudent guidance to explore more and more on hydrogen economy from wherever possible kindled diligence and perseverance within every team member. GHLab proved to be a plausible decision that emerged out of headstrong and judicious leadership as we see the recognitions, successes, research activities, government support, and assiduous interests of people on hydrogen-related activities of the lab. My experience working on the hydrogen ecosystem for Nepal and research entitled “Hydrogen trucks for Nepal: why and how?” in fact helped my research experience and also a few of the research projects in the lab. Numerous webinars, discussions, presentations, and activities helped the conglomeration of diverse knowledge and ideas in the initial days which progressively generated opportunities and successes. Major project collaboration with Nepal Oil Corporation within few months of the establishment of lab, partnerships, and collaborations with various organizations, government support, etc. was all result of persistent hard work of the dexterous and juvenile team. It feels like yesterday when we had our first official meeting but then now when we realize it’s the very first anniversary of GHLab, so many wonderful achievements had been attained in such a limited journey. I want to cherish this occasion and wish"- **Prabin Ngasuki**

"I was at GHLAB since its start in August 2020 up until April 2021. During those nine months, I saw an idea mature into existence and all the background hustle required to bring the abstract idea into reality. Those nine months which I had dedicated to the flourishment of GHLAB were time well spent. Since its inception, GHLAB has made itself known on the national and international stages with its ambitious projects. Since my time in GHLAB, I have had a change in my outlook on the energy scenario of Nepal. The GHLAB comes into the energy equation of Nepal with the hopes of improving the reliability of the energy grid, making Nepal more independent in the sector of energy (electricity and alternative fuels), optimizing the production potential of Nepalese hydropower to its extent. GHLAB aims to incorporate renewable energy and provide end-use for the unused potential of energy production in Nepal. Currently, with MOU and agreements with NOC, Jade and, AEPC, GHLAB has already made strides towards becoming an impactful institution. And with National Hydrogen Initiative (NHI) under its wings. I believe that all this progress of GHLAB in the past year is an indication of its upcoming exponential ascent towards the development and implementation of clean energy technology in Nepal."-**Roshan Parajuli**

"With the exponentially fast-growing renewable energy technologies in nook and corners of the globe, the demand for sustainable energy storage technologies increases, which exposes the necessity of hydrogen in the energy scheme. Nepal possesses tremendous prospects of producing green hydrogen and developing a sustainable hydrogen economy in the country due to the vast capacity of hydroelectricity generation. A more in-depth R&D on green-hydrogen, and its utilization for end-uses such as clean transportation, industries, stationary powerplants, and residence in the context of Nepal, opens a gateway for a gamechanger technology, and GHLab aims to lead it from the front. The penetration of hydrogen in the national energy market not only revolutionizes the industries and power sectors but also supports the nation's financial growth." -**Pralhad Gupta**, **Visiting Researcher**

REMARKS FROM THE VISITING RESEARCHERS

"Hello every hydrogen enthusiast all over the world, this is my pleasure to be linked with the innovative Green Hydrogen Lab. I have been contributing to the lab as a Visiting Researcher by coordinating various sub projects. I am mainly responsible for techno economic analysis of the hydrogen economy in the context of Nepal. I also feel very fortunate to come in contact with this vibrant team, enthusiastic engineers and visionary project leader. One year has passed. This means we are only some metres away from making our country's mobility sector greener as never before. If you have any idea or share the same intention and passion, please come in contact with us. We will grow green together."



Nishan Dhakal
Master in Industrial Engineering and Management

Anup Dahal
Lawyer/Researcher

"Electricity supply must be reliable and affordable to meet consumer demand. There has always been a gap between demand & supply. Thus, the energy mix plays a significant role in the energy system. Currently, global debate for future energy systems has changed from “Electricity to Gas and Hydrogen”. With the development of technology and effective regulatory authority, Green Hydrogen will be a prime option for energy mix”.