Fabrication of Electronic textiles as an alarm for ammonia and hydrogen gases.

- Integration of multifunctional nanomaterials with textiles could be a significant value addition to the bright future of the growing technology of “technical textiles." Due to their distinct qualities, such as high flexibility, wear and wash resistance, mechanical strength, and promising sensing performance, textile materials are attracting a lot of attention for their advanced sensor applications. The development of fabric sensors can be accomplished by functionalizing textile materials with conductive nanomaterials or inks using printing or coating techniques or by incorporating conductive fibers and yarns into textiles using technologies like weaving and sewing.
- Recently, as the government and the entire world shifted to carbon-neutral technology, hydrogen technology has quickly expanded as a replacement. However, hydrogen is a highly flammable and explosive substance, and reports by the Industrial Global Union have raised concerns about potential casualties. Hydrogen gas is extremely diffuse and highly explosive at a certain concentration (>4%) in the air. Early and accurate hydrogen detection should also be required if technology is extended. Implementing a wearable or patchable gas sensor, which can detect hazardous gases in real time, may be the best method to assure gas safety in certain conditions.
- Similarly, ammonia, one of the inorganic chemicals that is most frequently produced is ammonia. A total of 144 million metric tons of nitrogen, or 183 million metric tons of ammonia, have been produced on a large scale worldwide. Ammonia is used to make nitric acid (using the Ostwald process), plastics, fibres, explosives, and intermediates for dyes and pharmaceuticals. Ammonia is one of the most dangerous and flammable environmental pollutants that is produced synthetically or naturally. The Occupational Safety and Health Administration (OSHA) in the United States has established a lower 25 ppm as the minimum exposure limit for ammonia. Therefore, it is essential to develop ammonia sensors that can detect its presence down to the sub-ppm level in order to avoid any major health impacts and for its monitoring in various work areas.

- Workplace safety is still in a miserable state in India. Implementing a wearable or patchable gas sensor, which can detect hazardous gases in real time, may be the best method to assure gas safety in certain conditions.
- This project has been designed with the primary goal of developing smart, intelligent electronic fabrics that can particularly detect ammonia at a minimal concentration of at least 5 ppm. Similarly, an alarming technical fabric for hydrogen detection shows responsiveness at minimal >0.5% H_2 in air.
- Various research teams have worked on the development of fabric-based gas sensors with the use of techniques like dip coating, drop casting, and electroless plating. It is found to be highly feasible and demanding. We have included a few reports below as supporting statements.

Literature report:

- Room-Temperature, Highly Durable Ti3C2Tx MXene/Graphene Hybrid Fibers for NH3 Gas Sensing. ACS Appl. Mater. Interfaces 2020, 12, 10434−10442.
- Flexible fiber-shaped hydrogen gas sensor via coupling palladium with conductive polymer gel fiber. Journal of Hazardous Material 2021, 411, 125008.
- Electrospun Polyaniline Fibers as Highly Sensitive Room Temperature Chemiresistive Sensors for Ammonia and Nitrogen Dioxide Gases. Adv. Funct. Mater. 2014, 24, 4005−4014.
- Flexible fiber-shaped hydrogen gas sensor via coupling palladium with conductive polymer gel fiber. Journal of Hazardous Material 2021, 411, 125008.
- Gas sensor for ammonia detection based on poly(vinyl alcohol) and polyaniline electrospun. J. APPL. POLYM. SCI. 2018, DOI: 10.1002/APP.47288.
- Facile fabrication of flexible SiO2/PANI nanofibers for ammonia gas sensing at room temperature. Colloids and Surfaces A 537 (2018) 532–5.
- Sustainable Approach for Developing Graphene-Based Materials from Natural Resources and Biowastes for Electronic Applications. ACS Appl. Electron. Mater.2022, 4, 2146−2174.
- Flexible Graphene-Based Wearable Gas and Chemical Sensors. ACS Appl. Mater. Interfaces 2017, 9, 34544−34586.
- Ultrasensitive and Highly Selective Graphene-Based Single Yarn for Use in Wearable Gas Sensor. Sci. Rep. 2015, 5, 10904

- Textile Gas Sensors Composed of Molybdenum Disulfide and Reduced Graphene Oxide for High Response and Reliability. Sens. Actuators, B 2017, 248, 829−835.
- Commercial Silk-Based Electronic Textiles for NO2 Sensing. Sensors Actuators, B Chem. 2020, 307 (2), 127596.
- NiOx Nanoflower Modified Cotton Fabric for UV Filter and Gas Sensing Applications. ACS Appl. Mater. Interfaces 2019, 11, 20045−20055.
- Self-Organized Frameworks on Textiles (SOFT): Conductive Fabrics for Simultaneous Sensing, Capture, and Filtration of Gases. J. Am. Chem. Soc. 2017, 139, 16759.
- Room-Temperature, Highly Durable Ti3C2Tx MXene/Graphene Hybrid Fibers for NH3 Gas Sensing. ACS Appl. Mater. Interfaces 2020, 12, 10434−10442.
- Metal−Organic Framework Coated Devices for Gas Sensing. ACS Sens. 2023, 8, 7, 2471−2492.

Our Major Objective:

1. Synthesis of well-defined flexible, wearable electrochemical sensors.
2. Conducting polymer, M-Xene, MOF, and palladium nanoparticle incorporation will be optimized for sensing ammonia and hydrogen gases.
3. Fabrication of alarming fabrics or e-textiles will trigger and alarm everyone at a minimum of 5 ppm of ammonia.
4. Similarly, technical fabrics for hydrogen detection which will show responsiveness at minimal >0.5% H2 in air.
5. Detailed characterization of materials and optimization of sensing properties will be part of the designed project.

Scalable conversion of Carbon dioxide to High Tg polycarbonates

- According to recent research, global greenhouse gas emissions are at their highest level ever, causing the globe to experience "unprecedented" levels of climatic warming. One of the main pollutants contributing to the greenhouse effect is thought to be carbon dioxide (CO2). Scientists from all over the world are very interested in finding ways to reduce the massive amounts of CO2 in the atmosphere. One way to mitigate the greenhouse effect is through the development of hydrogen energy, which has the potential to drastically reduce CO2 emissions and even achieve zero net emissions. Another approach is to transform the greenhouse gas (CO2) into many fine chemicals and commodities. Utilizing CO2 rather than discarding it is highly desirable from an economic and environmental perspective. Employing CO2 to synthesize a variety of polymers with biodegradable and customized properties is one of the cost-effective utilization approaches.
- Aliphatic polycarbonates can be formed by directly copolymerizing CO2 with various epoxides, such as ethylene oxide (EO), propylene oxide (PO), cyclohexene oxide (CHO), or isobutylene oxide (BO). Global Polycarbonate capacity is prepared to see considerable growth over the next five years, potentially increasing from 7.59 mtpa in 2022 to 9.96 mtpa in 2027, registering total growth of 31% according to Business wire.
- Furthermore, compared to traditional PPCs with ether bonds, PPCs with esters have superior thermal, mechanical, and glass transition properties with much higher glass transition and decomposition temperatures. It is generally acknowledged that the molecular weight has a significant impact on the processability and mechanical properties of amorphous polymers. Modification techniques like copolymerization, blending, crosslinking, and the creation of block copolymers are effective ways to further improve some of the properties of PPC.
- One efficient way to increase the range of applications for PPC is to incorporate crystalline segments or bulky or rigid structures (additional monomer and linker) into the core of PPC. CO2 copolymer faces many challenges despite its rapid development, because of its poor cost-performance ratio and lack of commercial-grade properties.

- By 2050, it is anticipated that polymer technology will consume 50 million tons of CO2 Opportunities and challenges coexist in this regard. We anticipate successful commercial-scale production of CO2-based polymers in the future.
- A few businesses have been listed that, on a commercial scale, use poly (aliphatic carbonates) PPCs. Bayer Material Science uses PPC in conjunction with ABS to synthesise a scratch-resistant plastic. Baden Aniline and Soda Factory (BASF) blends poly(propylene carbonate) and poly(hydroxybutyrate) with other polymeric materials or with inorganic solids to develop an alternative plastic to acrylonitrile butadiene styrene. Cardia Bioplastics (CO2 Starch Pty Ltd) has developed a process for producing PPC/starch blends for commercial use. They currently produce a significant amount of biodegradable plastic bags using this blend all over the world.
- Our primary goal under this project is to develop high Tg polycarbonates, using CO2 as raw feedstock. We want to greatly focus on its scalable synthesis and its commercial-grade properties.
- Worldwide, various research teams have worked in this regard. We have included a few reports to show the feasibility of the process.

Literature Report:

- Zinc adipate/tertiary amine catalytic system: efficient synthesis of high molecular weight poly(propylene carbonate), J. Polym. Res. 20 (2013) 190.
- A novel biodegradablepolymeric surfactant synthesized from carbon dioxide, maleic anhydride and propylene epoxide, Polym. Chem. 6 (2015) 2076e2083.
- Copolymerization of propylene oxide and carbon dioxide in the presence of diphenylmet hanediisoyanate, J. Polym. Res. 18 (2011) 1479e1486.
- A novel single-ionconductingpolymer electrolyte derived from CO2-based multifunctional polycarbonate, ACS Appl. Mater. Interfaces 8 (2016) 33642e33648.
- Macrodiols derived from CO2-based polycarbonate as an environmentally friendly and sustainable PVCplasticizer: effect of hydrogen-bond formation, ACS Sustain. Chem. Eng. 6(2018) 8476e8484.
- The use of carbon dioxide (CO2) as a building block in organic synthesis from an industrial perspective. Adv. Synth. Catal. 361, 223–246 (2019).
- Telomerization reactions of butadiene and CO2 catalyzed by phosphine Pd(0) complexes: (E)−2-ethylideneheptden-5-olide and octadienyl esters of 2-ethylidenehepta-4,6-dienoic acid. Inorg. Chim. Acta 28, L147–L148 (1978).

- Highly efficient synthesis of functionalizable polymers from a CO2/1,3-butadiene-derived lactone. ACS Macro Lett. 6, 1373–1378 (2017).
- Braunstein, P., Matt, D. & Nobel, D. Carbon dioxide activation and catalytic lactone synthesis by telomerization of butadiene and CO2. J. Am. Chem. Soc. 110, 3207–3212 (1988).
- Correlating Metal Redox Potentials to Co(III)K(I) Catalyst Performances in Carbon Dioxide and Propene Oxide Ring Opening Copolymerization. Angew. Chem. Int. Ed. 2023, 62, e202308378.

Our Major Objective:

1. Synthesis of skilled catalysts consisting of Zn, Mg, and Co for sustainable co-polymerization of CO2 and the first monomer.
2. Introduction of second and third monomers or linkers (epoxides, anhydrides, isocyanates, etc.) to attain high-Tg polycarbonates.
3. Introduction of additional waste gases like SO2 and NH3 to attain polymers of different functionality and properties.
4. Offering polymers to a nearby industry to gauge their commercial viability.
5. A detailed characterization of the catalyst and polymer will be part of the project.

Design of High-Performance Drilling Fluids for the Efficient Exploitation of Natural Gas Hydrate-bearing Sediments

Objective:

The goal of this research is to investigate and optimize the hydrate dissociation process and mud design for wellbore stability during drilling operations in hydrate-bearing sediments. The primary focus will be on understanding the heat transfer mechanisms involved in hydrate dissociation and developing high-performance drilling fluids to mitigate the associated challenges.

Experimental Setup:

The experimental setup will involve replicating the hydrate dissociation process described in the provided information. This includes the use of a reactor, piston, and coolant circulator to induce hydrate formation and subsequently simulate dissociation. The main materials used in the experiment, as outlined in Table 2, will be employed to recreate the conditions observed in the original study.

Equipment Requirements:

To carry out this research effectively, the following equipment is deemed necessary:

1. Experimental Setup:

a. Reactor System: High-pressure reactor system capable of reaching and maintaining pressures up to 1500 psi ensuring that it allows precise control of temperature, axial pressure, and the ability to accommodate the described piston and upper cap.

b. Coolant Circulator: High-performance coolant circulator with the ability to regulate temperatures in the range required for hydrate formation and dissociation (cooling to 10°C and stabilizing at 0°C).

c. Data Acquisition System: High-precision sensors, including thermocouples, pressure transducers, and other relevant instruments, to continuously monitor and record temperature profiles, axial pressure changes, and any other critical parameters during the experiments.

d. Rheometer: An advanced scientific rheometer to evaluate the rheological properties of different mud formulations at different pressure-temperature conditions. This will provide essential data for optimizing drilling fluid compositions.

e. Filter Press: API and High-Pressure filter press to measure fluid loss in drilling fluids. This data will be crucial for assessing the stability and performance of different mud formulations.

2. Hydrate Formation:

a. Grain Mixture Preparation: A grain mixture consisting of sand, crushed silt, and clay.

b. Saturation with Aqueous THF Solution: The grain mixture saturated with an aqueous tetrahydrofuran (THF) solution in predetermined proportions.

c. Reactor Loading: Saturated mixture into the reactor, tightly packed while pressurizing the mixture with high-pressure nitrogen (HP N2) to 1500 psi.

d. Coolant Circulation: Antifreeze solution circulation through the coolant circulator to cool the mixture to 10°C for 24 hours. Stabilize the hydrate at 0°C for an additional 3 hours.

e. Completion of Hydrate Formation

3. Drilling fluids Design and optimization:

a. Synthesis and Design of compatible Hydrate decomposition inhibitors

b. Drilling Fluid Preparation: Different drilling fluids based on different mud formulations chosen from the rheological and thermal stability tests. The following properties available from the literature can be matched by optimizing the formulations.

Table 1: Suitable mud properties for drilling gas hydrate-bearing sediments.

Properties	Unit	PHB-mud	Poly-mud	KCl/Poly-mud	Advanced Poly-mud
Mud weight	PCF	65	66	66	66
Plastic Viscosity	cP	10	10	14	15
Yield Point	lb/100 ft2	25	15	17	18
Gel 10s/10m/30m	lb/100 ft2	10/15/25	5/7/9	6/8/12	6/8/12
API FL	cc/30min	15	10	7	6

c. Temperature Settings: temperatures of the drilling fluid circulator bath set at 22, 20, 15, and 10°C to simulate hydrate dissociation under thermal stimulation.

d. Rheology and Thermal Stability Tests: Perform rheology and thermal stability tests for different drilling fluid formulations. Select high-performance muds with good rheology properties, low fluid loss, and thermal stability.

4. Hydrate Dissociation Tests: Hydrate dissociation tests with the chosen muds at a stable temperature of 20°C, monitoring their performance in preventing hydrate decomposition.

5. Optimization: Based on the results, optimize the mud formulation by adjusting additive types and concentrations to achieve the best stability and efficiency in preventing hydrate dissociation.

Expected Outcomes:

- Optimized Mud Formulations: Identification and development of drilling fluid formulations that exhibit improved rheological properties and reduced hydrate dissociation rates.
- Insights into Hydrate Dissociation: A better understanding of the hydrate dissociation process under different conditions, leading to improved safety and operational efficiency during drilling.

This is an area in which I am planning to target Gas Hydrate Exploration and I need a person with essentially chemistry background (M.SC Chemistry) for this research.

Screening and Development of Plant based-Lost Circulation Material for Challenging High Deviated Wells

Dr. Sidharth Gautam, Assistant Professor, RGIPT, Jais

Loss circulation is one of the major concerns in drilling and well construction and may lead to the uncontrolled flow of fluids into formation while drilling or primary cementing lead to substantial non-productive time (NPT). Traditionally, lost circulation are controlled by wellbore strengthening techniques which typically involves cross-linked polymers, fibrous, flaky or granular materials. However, these materials are of synthetic origin and may pose challenges for recycling and biodegradation. In this regards, oil and gas industry has utilized several bio-degradable organic based lost circulation materials(LCM) such as polyanionic cellulose, carboxymethyl cellulose, cottonseed hulls to effectively control lost circulation. However, the application of these LCM are limited by the temperature of well as at high temperature (> 150ºC) the cellulose based LCM have tendency to degrade.

Therefore, in this regards it is essential to develop a LCM which can withstand high temperature condition and be easily biodegradable. The study aims to identify, evaluate and chemical grafting of plant based bast fiber for possible application as lost circulation material in high temperature and pressure conditions. The plant based bast fiber will be prepared using suitable extracting technique and then is crushed into coarse and fine particle grains, which are then added to the drilling fluid in different concentrations. Further, the particle size of developed LCM will be optimized using RSM assisted central composite design.

The rheological and filtration properties of the mud are evaluated under high temperature conditions and compared with commercially available lost circulating materials. Additionally, the lost circulation performance will be determined using Slotted Filter Disks on both LPLT and HPHT filter press.

Geosequestration of CO2 in Depleted Oil Reservoir and Its Effect on Additional Oil Recovery

(for project fellows to work on target-oriented research projects)

1. Brief write-up of the proposed target-oriented research.

A tremendous amount of fossil fuel is utilized to meet the rising trend in the world's energy demand, leading to the rising level of CO2 in the atmosphere and ultimately contributing to the greenhouse effect. Numerous CO2 mitigation strategies have been used to reverse this upward trend since large-scale decarbonization is still impractical. For multiple reasons, one of the optimal and available solutions is the usage of old depleted oil and gas reservoirs as objects for prospective CO2 utilization.

The methods used in CO2 underground storage are similar to those used in oil exploration and production. However, the process of CO2 storage requires detailed studies conducted experimentally and numerically. When the amount of recoverable oil in an oil reservoir is depleted through primary and secondary production, around 60 to 70% of oil that was originally in the reservoir may still remain. In some cases, carbon dioxide (CO2) flooding may be an ideal tertiary recovery method to recover more of the recoverable oil than could be produced using secondary oil recovery methods. Because of its special properties, CO2 improves oil recovery by lowering interfacial tension, swelling the oil, reducing viscosity of the oil, and by mobilizing the lighter components of the oil. When the injected CO2 and residual oil are miscible, the physical forces holding the two fluids apart effectively disappears. This results in a viscosity reduction of the hydrocarbon and makes it easier to displace the crude oil from the rock pores and sweep it to the production well. In other cases where the CO2 and residual oil are immiscible, the injected CO2may still be used to drive the crude oil through the formation to be produced. One reason this occurs is because the injected CO2 can flow into the minute pores that are unavailable to oil and water. CO2 flooding often has associated limitations with its front, especially the un swept area of the reservoir emerges as a potential problem due to gravity overrides. This contribute in low areal as well as microscopic displacement efficiency. Hence, water alternating gas and surfactant alternating gas techniques can appear a potential solution to minimize these adverse effects. This study shall deal with supercritical CO2 (sc-CO2) as an injection fluid along

with alternate cycle of water and surfactant solution. The objectives of the investigation can further be summarized below.

Objectives:

• Measuring interfacial tension of CO2-water-oil and CO2-surfactant solution-oil at HPHT

Conditions.

Core flooding experiments related to WAG and SAG to quantify additional oil gain and

- CO2 sequestration at both miscible and immiscible conditions.
- Numerical modelling and simulation of three phase flow of WAG and SAG processes using computational fluid dynamics (CFD).

2. Details of existing research scholars/ project scholars and Institute sponsored

Doctoral students available at present.

Institute sponsored doctoral students: 0

Ph.D. Scholars: 0

Project scholars: 0

Investigation of particulate flow behavior and development of phase diagrams for the flow transition due to the presence of bends

Keywords: Particulate flow, Dilute and dense phase flow, Phase diagram, Bends, Pressure drop, Bend point Summary Rising concerns related to health and safety are compelling multiphase conveying industries to use pneumatic conveying systems. This challenge applies in many industries, among which are the mineral, chemical, and energy. In general, measurements are usually made on the material using tabletop tests. Therefore, it lags with the analysis of gas and solid flow rates, different orientations of pipelines, and types of bends, which are very much important in addressing the over challenge of flow regime.

Today, industries are typically using trial and error methods for designing conveying systems for their specific products, which is cumbersome and not necessarily leads to an optimal process (time, money, and energy consuming). The reason for favorizing trial and error is due to the lack of understanding and scientific knowledge of the topic. Among different components of pneumatic particulate flow systems, bends in which the direction of pipes changes play a vital role. They provide flexibility in the design of the overall pipelines. However, the issue of bend type selection is paramount due to which many difficulties arise such as maximum energy loss, particle attrition, and pipe wear, when one tries to design the system with certain conveying parameters.

Therefore, the proposed project aims to solve the bend selection problem by providing a flow regime map for bends by introducing the bend point approach. Moreover, the proposed flow regime map shall incorporate different operating conditions (air and particle mass flow rate) as well as system parameters (pipe diameter, bend ratio R/D, and particle properties), which is also a challenging task. The outcome of the flow regime map will also provide models to calculate bend pressure drop, porosity in the flow and particle velocities across different sections.

However, preliminary analysis showed that additional limitations which we plan to be found by experiments on single bends are required. The research will be performed in a two-way approach, such as what will be the effect of the increase and decrease of air velocity in rope formation and whether the same or different phenomena will happen on particle flow behavior in both approaches. Objective: There are two major objectives for the proposal, which is further divided into five sub-

Objectives:

The first major object is to define a number of equations according to the number of unknowns to transfer the mechanistic single-bend model (at different orientations) to the total pipeline pressure drop. The following describes the unknowns for each bend type:

a) Effective internal friction; Pipe diameter; Bend radius; Void fraction; Bulk density.
b) The second major objective is to conduct an analysis with the relevant threshold velocities to define a non-dimensional flow regime map for the transition of flow.
c) To develop a new bend pressure drop model along with a flow regime map. 4. Particle velocity correlation will be derived by cross-correlation of pressure signals and by the high-speed video camera.

Expected output and outcome of the proposal: This proposed research to develop a flow regime map across bends for pneumatic conveying will advance the understanding and practice of the technology by giving a realistic and usable format to judge the type of flow that can be anticipated from the initial design stage to the operational stage which can vary over a considerable range in every application sectors. The pneumatic particulate flow system while being designed for one conveying condition often find its application being extended to more demanding areas either in smaller or larger capacities. Having a flow regime map to guide the designer and the operating engineers will help to explore new domains and provide extended operating strategies that do not cause upsets to the complete particle handling operations. Successful research enables us to predict in advance the flow regime or to target for a desired one, and then for dilute, dense, or transition flow to accurately calculate the pressure drop. This will have a significant practical outcome by optimizing such flow and transferring other kinds of flows through bends which saves energy and causes negligible damage to the particles.

Project Proposal for Project Fellow Empowering the Independent Micro grid with Electric Vehicles Based on Evolutionary Optimization Algorithms

INTRODUCTION: 1.

1. **Background:** In the rapidly evolving landscape of sustainable energy, the integration of microgrids has emerged as a game-changer, particularly in the context of electric vehicles (EVs). Microgrids, small-scale, localized energy systems, offer a versatile and efficient solution to power EVs. This application holds immense potential for addressing challenges related to grid congestion, energy security, and environmental sustainability. The microgrid refers to the power generation and distribution system composed of distributed energy, a battery storage system (BESS), control device, load, etc.. The conventional structure of microgrid is shown in figure 1. With the increased load forms and capacity in recent years, more and more electric vehicles are becoming involved in the microgrid. Electric vehicles can be connected to the power grid as mobile loads. They also have the characteristics of energy storage devices and can realize energy regulation together with energy storage devices. Connecting EVs to a microgrid with renewable energy and using clean electricity can promote both sides and improve the overall economic and environmental benefits of microgrids. Simultaneously, the evolution of microgrid technology offers decentralized and resilient energy solutions.

1.2. Decentralized charging Infrastructure: Micro grids enable the deployment of decentralized charging stations, reducing the strain on the main power grid. This decentralization promotes a more resilient and reliable charging infrastructure for EVs. By establishing micro grids with integrated renewable energy sources such as solar panels or wind turbines, these charging stations can operate independently, ensuring a continuous power supply even during grid outages.

1.3. Grid Resilience and Load Management: Micro grids enhance the resilience of the power grid by providing a local source of energy generation. In the event of natural disasters or grid failures, micro grids can autonomously supply power to charging stations, ensuring that EVs remain operational. Additionally, micro grids facilitate intelligent load management, optimizing energy distribution and preventing grid congestion during peak charging hours.

1.4. Renewable Energy Integration: The integration of renewable energy sources within microgrid aligns with the goal of creating a sustainable and low-carbon transportation ecosystem. Solar panels and wind turbines can be strategically deployed to generate clean energy for EV charging, reducing reliance on conventional grid power and lowering overall carbon emissions associated with electric mobility.

1.5. Demand Response and Smart Charging: Micro grids empower EV owners and operators to engage in demand response programs. By leveraging smart charging algorithms, micro grids can optimize charging schedules based on electricity prices, grid conditions, and renewable energy availability. This not only reduces charging costs for users but also contributes to grid stability by distributing charging loads intelligently.

1.6. Energy Storage Solutions: Incorporating energy storage systems, such as advanced batteries, within microgrids enhances their ability to store excess energy generated during non-peak hours. This stored energy can then be used during periods of high demand or when renewable sources are not actively producing electricity. Energy storage solutions ensure a constant and reliable power supply for EVs, irrespective of external factors.

2. OBJECTIVE: The primary objectives of this research are to: a) Investigate the symbiotic relationship between independent microgrid and electric Vehicles. b) Apply evolutionary optimization algorithms to enhance the performance of the integrated system. c) Evaluate the impact of the proposed approach on energy management, grid resilience, and overall sustainability.

3. LITERATURE REVIEW:

3.1 Microgrids and Electric Vehicles: Reviewing existing literature on micro grids and electric vehicles provides a foundation for understanding the current state of research in these domains. Studies on microgrid architectures, EV charging infrastructure, and the impact of EV integration on the grid inform the theoretical framework for this research.

3.2 Evolutionary Optimization Algorithms: A comprehensive examination of evolutionary optimization algorithms, including genetic algorithms, particle swarm optimization, and simulated annealing, elucidates their potential in optimizing

complex systems. Previous applications of these algorithms in energy management and system optimization lay the groundwork for their integration into the proposed framework.

4. Methodology:

4.1 System Architecture: Define the architecture of the independent micro grid integrated with electric vehicles. Discuss the components, including renewable energy sources, energy storage systems, charging infrastructure, and communication systems.

4.2 Evolutionary Optimization Algorithms: Detail the selection and implementation of evolutionary optimization algorithms suitable for enhancing the performance of the integrated system. Highlight the algorithmic parameters and optimization objectives.

4.3 Simulation and Validation: Describe the simulation environment used to validate the proposed framework. Present scenarios and parameters used to evaluate the system's performance under various conditions.

5. Result and Discussion: The proposed work analyses the impact of evolutionary optimization algorithms on energy management within the integrated microgrid. Evaluate the efficiency of energy distribution, storage, and utilization, considering factors such as renewable energy variability and EV charging patterns. It will also examine how the integrated system responds to grid disturbances, outages, or fluctuations and assess the resilience of the microgrid in providing continuous power to EVs during adverse conditions. Moreover, it will quantify the sustainability metrics, including carbon footprint reduction, energy efficiency, and economic viability and validate the proposed system against traditional grid-dependent EV charging models.

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Experimental investigation on Janus nano-displacing fluid as an Enhanced Oil Recovery (EOR) technique

(for project fellows to work on target-oriented research projects)

1. Brief write-up of the proposed target-oriented research.

With the increase in energy demand, the need for exploration and production has

Significantly increased. Most of the discovered hydrocarbon reservoir has depleted in terms of their natural driving forces and hence are dependent either on secondary or tertiary techniques of recovery. India, which is vastly dependent on crude import has been forced to more rigours exploitation of its own natural resources. But with the down-heave of Oil and Gas industry throughout the world, exploration of new resources has been restricted as it involves great deal of capital expenditure. Hence, recovering the residual hydrocarbon from depleted oil fields or matured fields seems more beneficial. The upstream regulator of India, Directorate General of Hydrocarbon (DGH) had called for stakeholder consultation for the policy in April 2019 and seeks for more Enhanced Oil Recovery (EOR) studies which is a shows that the nation is in severe search for novel and economical EOR techniques. An EOR technique which is a tertiary method of oil recovery comes into existence when both primary and secondary methods (like water flooding, gas injection etc.) cease to produce more oil. Unlike secondary recovery; tertiary recovery alters the surface properties of rock, decreases viscosity of oil, increases viscosity of displacing fluid or improve mobility ratio. Broadly it includes thermal, chemical and microbial methods. One of the most effective method of chemical enhanced oil recovery (EOR) is Surfactant Polymer (SP) Flooding.

A surfactant polymer EOR works on the principle of reducing interfacial tension and increasing the viscosity of the displacing fluid such that, it yields a favorable mobility ratio between the displacing and displaced fluid. Although SP flooding has proven to be a great technique, yet it is a fairly costly affair. A classical surfactant used in polymer surfactant flooding yielding more stable Pickering oil water emulsion shall always have significant recovery over a polymer flooding. But, often these surfactants degrade under high shear or temperature and, become immobile under extreme

capillary pores which are in Nano dimensions. In recent years, nanotechnology has proved to aid SP flooding to render recovery mechanism more effectively.

Due to the high surface area to volume ratio it promotes more active sites and hence are highly effective. Some particles like oxides of Aluminum and Iron tends to reduce viscosity of oil while Silica and Nickle Nanoparticles reduces the interfacial tension between oil/water system. Janus particle (derived from dual faced Greek God Janus) has recently caught attention of many research Areas like in bio medical, food and mining. It has also been established that Janus particle exhibiting dual wettability, thereby yields more stable pickering emulsion than a homogeneous particle. Its amphiphilicity allows it to behave as a classical surfactant with more stability. Hence, it is envisaged that Janus particle has best of the both, i.e. the size in nano dimension provides more activity and its dual wettability nature enabling it to behave like a surfactant. This proposal aims to study the effect of Janus particle in a suitable polymer carrier fluid for enhance oil recovery to reduce residual saturation of oil.

Objectives:

• Synthesis and characterization of Janus nanoparticle.

• Characterization of Janus nano-displacing fluid and pickering emulsion at different

Temperature conditions for stability using rheological measurements.

• Evaluate interfacial tension (IFT) and contact angle at different Janus nanoparticle

Concentration to study change in minimum interfacial tension and alteration in wettability.

• Carry out microfluidic investigation to determine reduction in residual oil saturation and increment in recovery factor.

2. Details of existing research scholars/ project scholars and Institute sponsored

Doctoral students available at present.
Institute sponsored doctoral students: 0
Part time Ph.D. Scholars: 3
Project scholars: 0

Performance Enhancement for Hydrogen run Dual Fuel Diesel Engine

Diesel engines have made significant contribution in the progress of human race. They are the most dependable and efficacious medium for generation of power. However, the major disadvantage of diesel engines is emittance of harmful environmental pollutants such as CO, UHC, oxides of nitrogen, and soot that are injurious for the health of human beings. In this connection, nano particles enriched biodiesel blends technology has proven to provide an amicable solution to this problem. In this regard, an attempt will be made to extract bio-oils from locally available seeds in upper Assam zone using an automatic oil expeller and transform the bio-oils into respective biodiesels through transesterification process in the Biodiesel Production Plant available in the fuel lab of AEI, Sivasagar. Then 5%, 10%, 15%, 20%, 25% and 100% blends of biodiesels will be prepared, and then these blends will be run in the four stroke VCR diesel engine at standard diesel operating condition, i.e ,Compression Ratio (CR) of 17.5 along with fuel injection timing (FIT) of 23º before Top Dead Centre (bTDC). Engine Load (EL) will be varied from 20% to 100% at the steps of 20% for the biodiesel blends. From the engine runs, the present study will be able to identify the biodiesel blend for which the best performance, combustion and emission results will be obtained. This will be followed by further enhancement of the identified fuel properties by addition of Alumina (Al_2O_3) and Graphene nano particles, respectively. Review of literature reveals that drop in emission levels of carbon monoxide and hydrocarbons are observed when CR is increased along with the advancement or retard of FIT for nano particles blended biodiesel. The presence of nano particles in the biodiesel diesel blends as well the presence of oxygen in biodiesel leads to complete combustions, thereby, lowering the CO and HC emissions. Nevertheless, running nano particles enriched biodiesel blends at standard diesel operating condition may not give optimum engine efficiency and emission properties. Thus, the present study is targeted to investigate and improve efficiency and emissions of biodiesel blends enriched with nanoparticles when used in diesel engines under operating conditions such, EL, CR and FIT. Efficiency and emissions of Alumina (Al_2O_3) and Graphene nano particles enriched biodiesels fueled diesel engine will be further improvised by optimization of the operating parameters. In the present investigation, CR will be varied from 17 to 18,

whereas FIT and EL of 19°, 21°, 23°, 25°, 27° bTDCs and 20%, 40%, 60%, 80% 100% are considered. From the said experimental investigations, we will get the optimized value of FIT, CR and EL for the nano particles enriched biodiesel blend fueled diesel engine at which we will get the maximum efficiency and least value of emissions. Further, the present investigation will run the diesel engine under dual fuel mode, i.e, by injecting H_2 gas along with air and nano particles enriched biodiesel blend at the optimized operating parameters and will study the performance, combustion and emission characteristics of the dual fuel run diesel engine. The study will also try to validate the findings (optimized operating conditions) obtained from the experimental investigations by applying Response Surface Methodology (RSM) and Artificial Neural Network (ANN) techniques. For experimentation, a diesel engine with one cylinder having VCR provision with 3.5 kW power output will be used.

The motive of this experimental investigation is to run H_2 gas along nano particles enriched biodiesel blends in diesel engines for production of electricity as well for pumping water in agricultural sector especially for developing countries like India. Also, such engines can be extensively used in the oil well drilling rigs for generation of power.

Developing a Model for instrument health monitoring with a setup of transducers, camera array and processing of images using AI/ML techniques

Health monitoring of instruments is vital for all industries. Generally, the industries employ large machinery and equipment whose regular health monitoring is a challenge. Further, it becomes challenging to identify the pre-conditions of a hazard due to the bad health of equipment. Additionally, there can be multiple reasons for inducing the lousy health of equipment: wrong handling of the machinery, substandard input to the equipment, not following the maintenance protocol, etc. The output of the equipment may also hint towards bad health and/or a change in the quality of input. The detailed monitoring of this information all the time at every location becomes impossible. Manual checking can provide specific inputs periodically. But manual inspection overlooks the inside processing of equipment. It may also ignore subtle changes in temperature, fine cracks, and the quality of input. Managing detailed information of each instrument in the industry is difficult, time-consuming, and rough in nature. There is thus a need to develop a technique to collect the health of equipment by an overall assessment of input to the machinery, output from the machinery, and overall changes in the equipment structure. This is possible using 24 X 7 monitoring using noise transducers, spectral cameras, and thermal sensors. Using the transducers, we can get an acoustic image of the equipment. Multi-spectral and hyperspectral cameras will be used for capturing image-level changes of the input to and output of the equipment and overall equipment. Integrated information from all these sources will help us judge the machinery's health and alarm us when significant changes are observed from the normal functioning of the equipment. The whole setup will be tried and tested on the sewage treatment plant, DG set of RGIPT Jais, and on a proposed biofuel plant. The procedure will involve monitoring the input sewage, the heath of the machinery deployed for processing and handling the sewage, and the quality of the treatment plant's output; and similarly for other machineries. The procedure will involve acoustic imaging, multispectral and hyperspectral imaging, and thermal imaging. AI/ML-based classification and feature extraction algorithms will be utilized to determine the status of input/output and the equipment's health as normal or not normal.

Brief write-up of the proposed target oriented research Project Title: Design of a Multiphase Voltage Source Inverter for EV Application Based on Wide Band Gap Devices

Problem Statement

Despite the wide band gap (WBG) based power electronics converters' appealing benefits for electrical AC motor drives, there are many issues with their technical execution. Examples include the trade-off between high switching frequency and EMI, insulation and bearing damage brought on by high dv/dt, and the difficulties associated with packaging high-voltage and high-temperature devices. Therefore, it is necessary to address the aforementioned problems while implementing the WBG-based voltage source inverter (VSI) for EVs in this research and come up with workable solutions.

Challenges

- WBG device selection and their technical challenges for converters fed motor drives.
- Design a pulse width modulation (PWM) strategy to utilize the WBG device at its full capacity to overcome the high cost.
- Design a control technique to ensure that the insulation and bearing failures are prevented by keeping the dv/dt ratio as low as possible.
- WBG device protection scheme development for post-fault operation of high capacity EV applications.

Potential benefits-

This project is beneficial towards development of high efficient light weight automotive vehicles for various applications. Desirable Outcomes and Deliverables

- High efficient WBG converter for multiphase motor drive for automotive applications.
- Test the multiphase motor drive with WBG based converter for EV application at various operating conditions.
- Design a post-fault control strategy for WBG based multiphase converters for EV application.
- Development of prototype electric vehicle based on SiC-IGBT VSI fed multiphase traction motor

(a) Five-phase VSI fed five-phase motor, (b) Product will be designed like same as above with WBG based VSI for multiphase Details of existing research scholars

Project fellow for the target oriented research

1. Proposed project:

Title: Development of high-efficiency chalcogenide semiconductors for "waste heat" to "electrical energy" conversion

b. **Description:** The majority portion of the electrical energy used in India still comes from the burning of coal, petroleum, and natural gas. Unfortunately, nearly 65% of that produced electrical energy irreversibly gets wasted as heat. Thermoelectric materials allow a direct and reversible conversion of this "waste heat" into useful "electrical energy". Thermoelectric power generally has been extensively used in supplying electrical power in various deep space missions and the technology has been used for various niche application. However, the commercial mass-market adoption of thermoelectric technology is limited by high cost and relaBvely low conversion efficiency. The conversion efficiency primarily depends on the dimensionless figure of merit defined as zT = S2 sT/k, where S is the Seebeck coefficient, s is the electrical conductivity, and k is the thermal conductivity at absolute temperature T. While the concept of Seebeck coefficient and the underlying formula is known for a long time, the challenge is to find a material that simultaneously shows high s, high S, and low k values. Chalcogenide-based semiconductors such as PbTe, GeTe, (Bi,Sb)2Te3 have been known for a long time as champion thermoelectric materials for near-room temperature and mid-temperature thermoelectric power generation. Currently, the maximum zT value that can be obtained in these materials is about 2.5. However, the toxicity of Pb and high cost due to the low earth abundance of Te restrict their commercial applications. Therefore, in this project, we will develop new thermoelectric materials based on relaBvely low-cost sulfur and selenium. The primary objectives will be:

i. Development of high-efficiency S and Se-based thermoelectric materials

ii. Development of thermoelectric materials with peak zT ~ 2.5

iii. Enhancing not only the peak zT value but also improving zTavg, i.e., zT value over the entire temperature range.

In this project, we will first synthesize the polycrystalline bulk materials such as SnS and GeSe. These materials have recently attracted tremendous attention from the scientific community. We will use doping and alloying to tune their electronic structure and thermal transport. For example, we plan to alloy SnS with I-V-VI2

compounds (such as AgBiSe2, AgSbSe2, etc.) and tune the chemical bonding and crystal structure of these materials. Similarly, we will use doping to improve thermoelectric performance using various well-known strategies such as band convergence and formation of resonance level. After the synthesis of the polycrystalline materials, we will carefully characterize their crystal structure using XRD, and compositional homogeneity and microstructure using SEM and TEM. After these characterizations, we will measure the temperature dependent electrical conductivity, Seebeck coefficient, and thermal conductivity. We will use external collaboration for the measurement of some of these thermoelectric proper in addition to developing in-house facilities at RGIPT.

Target: Geological sequestration of bulk CO_2 in saline aquifers.

Today, rapid accumulation of carbon dioxide (CO2) are raising concerns about the potential of global climate change. Furthermore, prevailing geopolitical conditions and technical constraints have forced nations, especially developing country like India, to continue to rely on fossil fuels (coal, crude oil, and natural gas) to meet their surplus energy needs. However, Indian Government has committed to attain "net-zero" carbon footprint by 2070.

To attain the vision of "net-zero", bulk storage of captured CO2 is the most feasible way ahead and saline aquifers are the most suitable sites due to their well-formed petrography, established fluid holding capacity, and injection infrastructure. Thus, in this research, I aim to target and develop a sustainable route of CO2 sequestration in Indian saline aquifers.

Development and Evaluation of Polyacrylate-Graphene-Iron Oxide Nanocomposites as Enhanced Cold Climate Lubricant Additives

Problem Introduction and Research Gap: Using polymer nanocomposites (PNCs) in the lubricant industry has garnered significant attention due to their remarkable properties and enhancements compared to neat polymers. Building upon this concept, we aim to explore the potential of graphene-iron oxide nanocomposites (GINCs) as advanced additives for lubricants specifically tailored to operate efficiently in extreme sub-zero conditions.

The recent study on the synthesis of magnetite (Fe3O4) nanoparticles (NPs) and their reinforcement into the homopolymer of dodecyl acrylate to create PNCs has inspired our research direction. Our proposed endeavour will advance these findings by developing GINCs and assessing their efficacy as high-performance cold climate lubricant additives.

Objective:

The primary objective of this proposal is to synthesize Polyacrylate-Graphene-Iron Oxide Nanocomposites and conduct an in-depth evaluation of their suitability as additives for lubricants intended to operate flawlessly under sub-zero conditions, such as those encountered in cold environments and high-altitude applications.

Methodology:

Preparation of dodecyl acrylate: Dodecyl acrylate (DDA) will be prepared by esterification of acrylic acid with dodecyl alcohol in a 1.1:1 mol ratio. The reaction will be carried out in a resin kettle with concentrated sulfuric acid as the catalyst (0.25% hydroquinone relative to reactants as polymerization inhibitor), toluene as the solvent, and under a nitrogen atmosphere. The reaction mixture will be gradually heated from room temperature to 403 K. Reaction progress will be monitored by measuring liberated water. Upon completion, the dodecyl acrylate (DDA) ester product will be collected.

DDA ester purification: Charcoal will be added to the DDA ester, refluxed for 3h, and then filtered. The filtrate will be washed repeatedly with 0.5N sodium hydroxide to remove unreacted acid, followed by distilled water to remove residual sodium

hydroxide. The ester will be left overnight on calcium chloride and then distilled under reduced pressure.

DDA homopolymer synthesis: The polymerization will be carried in a four-necked round bottom flask fitted with a condenser, stirrer, thermometer, and nitrogen inlet. Dodecyl acrylate and initiator AIBN (0.5% w/w) will be added with toluene solvent. The reaction will be held at 353 K for 6h under a nitrogen atmosphere. The mixture will be poured into methanol to cease polymerization and precipitate the poly dodecyl acrylate (PDDA), which will be further purified through repeated hexane solution precipitation in methanol and vacuum drying at 313K.

Preparation of Graphene-Iron Oxide nanoparticles: Graphene-Iron Oxide nanoparticles will be synthesized using the method of Bruce et al. Iron (II) sulphate solution was prepared in deionized water with CTAB surfactant under vigorous stirring. Potassium nitrate solution will be mixed in, followed by slow potassium hydroxide addition. This will be heated to 100°C under nitrogen for 2 hours and then cooled to room temperature. The black Graphene-Iron Oxide nanoparticle precipitate will be washed repeatedly with deionized water, centrifuged, and vacuum-dried overnight at 323K.

PDDA-Graphene-Iron Oxide nanocomposite preparation: The nanocomposite will be prepared by blending PDDA/toluene solution with the Graphene-Iron Oxide nanoparticles under ultra-sonication and vigorous stirring. The suspension will be poured onto a glass plate to allow toluene evaporation, leaving a polymer-nanocomposite semi-solid mass, which will be characterized.

Characterization and Performance Evaluation: Thorough characterization studies will be conducted using various analytical techniques to assess the thermal stability and other crucial properties of the GINCs. Furthermore, the GINCs will be evaluated for their performance as viscosity index improvers, pour point depressants, and antiwear additives by blending them with a mineral base stock at different percentage ratios. Standard ASTM methods will be employed to carry out these evaluations.

Expected Outcomes:

The characterization studies will provide insights into the thermal stability and dispersion characteristics of the synthesized GINCs, crucial for their effectiveness in extreme cold climate conditions.

Evaluation, as viscosity index improvers pour point depressants and antiwear additives, are anticipated to showcase the enhanced performance of lubricants formulated with GINCs compared to conventional additives, affirming their suitability for sub-zero operating environments.

Project Title: Study of hydrate promoters for development of transport system for CO2 as gas hydrate

Sponsored by: DST-SERB (SRG/2023/000193)

Project duration: 2 years

Synopsis: CCUS has been widely accepted as a feasible technique for reducing global warming. The success of CCUS projects relies on the transport of CO2 captured from its source to the location of its utilization. Currently, the transportation of CO2 is costly, and small-scale CCUS projects are not implementable due to lack of economical and efficient techniques for CO2 transport. The project will focus on studies of carboxybetaine based zwitterionic surfactants as hydrate promoters for transport of CO2 as gas hydrate. The transport of CO2 in the form of gas hydrate using hydrate promoters will be an economical method as hydrate promoters can shift the hydrate stability zone from low temperature to ambient temperature for the same pressure condition, thus, removing the need for refrigeration and its subsequent capital expenditure. In the proposed work, carboxybetaine based zwitterionic surfactants will be synthesized, and their efficiency as hydrate promoters will be tested. Anionic and cationic surfactants have been found to act as hydrate promoters due to their capability to reduce the interfacial tension of CO2 and water interface. Zwitterionic surfactants, which are more efficient in reducing the interfacial tension, will be more efficient as hydrate promoters. The shift of hydrate stability zone will be determined by gas hydrate setup. The experimental data will be used to determine the amount of CO2 utilized for hydrate formation, the rate of hydrate formation and dissolution, and storage capacity.

The synthesized hydrate promoter can be utilized for transportation of CO2 in the form of gas hydrate using gas vessels and carried from the site of CO2 source to its utilization or sequestration site. As the use of synthesized zwitterionic surfactants as hydrate promoters can reduce the amount of CAPEX and OPEX of CCUS projects, small-scale industries will be able to implement CCUS projects successfully.

Title of the Proposal: Electrochemical Production of Hydrogen and Acetic Acid from lignocellulosic Biomass Derived Ethanol

Introduction

The rising consumption of fossil fuels, increasing energy demand, and environmental challenges associated with the use of fossil fuels have led to the recognition of hydrogen energy as a promising solution to address these existing problems [1]. Alike to electricity, hydrogen serves as a secondary form of energy rather than a primary source. Though hydrogen is not naturally available in nature, it can be produced through various methods using both nonrenewable and renewable resources. Nonrenewable sources release CO_2 into the atmosphere, contributing to global warming. Moreover, these resources have a limited lifespan. On the other hand, renewable resources offer the advantage of being carbon neutral and hold the potential to produce hydrogen through suitable technologies. The renewable sources contributing to hydrogen production include biomass, solar, wind, and water. Among them, biomass can generate hydrogen directly through gasification, while the other renewable sources undergo electrolysis for hydrogen production [2]. The electrolysis of these renewable sources generally involves minimal marginal costs. However, exploring the electro-oxidation of biomass-derived feedstocks has the potential to yield economically substantial chemicals. This capability not only offers the prospect of generating additional income but also presents a more cost-competitive alternative.

Issues in biomass gasification

Gasification of biomass at high temperature leading to the production of syngas containing hydrogen, carbon monoxide, methane and carbon dioxide. These gases are utilized as a fuel once separated and purified, but suffering from high energy consumption along with significant CO_2 emission. Moreover, biomass gasification presents various challenges, including operational issues, catalyst deactivation, reduced syngas quality, releases CO_2 and formation of tar compounds. Formation of tar during biomass gasification possesses a significant challenge as it can lead to catalyst deactivation, affecting the efficiency and stability of catalysts employed. Additionally, it has a negatively impact on the quality of syngas [3, 4]. Addressing

this issue is crucial as eliminating tar formation is imperative for enhancing hydrogen yield in the final product.

Resolution to address the issues

Electro catalytic H_2 production with Nano catalysts presents distinctive advantages. Considering the environmental concerns and process efficiency, water electrolysis emerges as a promising method for hydrogen production. However, the water electrolysis involves two half reactions: oxygen evolution reaction (OER) at anode and hydrogen evolution reaction (HER) at cathode. Compared with HER, the OER is complicated four electron involved multistep process and more energy-intensive, thereby affecting the overall water splitting efficiency. Further, presence of reaction barriers necessitates a higher potential value (~ 2 V) to drive water electrolysis. A viable alternative is replacing the OER with biomass reforming reactions (BRR). This substitution allows for the simultaneous production of hydrogen and value added chemicals such as acetic acid, acetaldehyde and ethyl acetate. Importantly, this modification reduces the cell potential to 0.2 V, much lower than that of 1.23 V required for the OER [5, 6]. By coupling the BRR with HER, we can achieve a sustainable method for hydrogen production. This approach not only conserves energy in the electrolyzer but also facilitates the generation of value added products and achieve negative carbon emissions. Recently, Liu and coworkers replace the OER in water splitting with the oxidation of ethanol molecule and achieving a low voltage input of only 0.61 V to afford a current density of 10 mA cm^{-2} [7]. Vizza *et al.* reported the replacement of the OER with ethanol oxidation, resulting in an attained cell potential of 0.7 V at 492 mA cm^{-2}. The electrical energy required for H_2 production was reported as 9.6 kW h kg^{-1} H_2 which is 4 times lower than the one reported by the DOE for PEM water electrolyzer (45 kW h kg^{-1} H_2) [8].

A higher profits are anticipated when combining the BRR process with HER, as opposed to traditional water electrolysis. The resulting oxidation product from this process, namely acetic acid, is in high demand, with a market size of 14 million tons per year. This indicates that the pathway for converting ethanol to acetic acid not only ensures an ample supply of biomass resources but also beats into a substantial market for the utilization of oxidation products. In contrast to other pertinent ethanol conversion methods, this process offers advantages in terms of energy conversion

efficiency, optimal atomic utilization of reactants, and minimal environmental impact.

Approach

In our approach, we focus on preparing ethanol through the fermentation of lignocellulosic biomass. Subsequently, this ethanol undergoes electrochemical splitting to yield both H_2 and acetic acid. In this regards, we aim to design a suitable catalyst that can lead to the production of hydrogen and value added product under the application of low polarizations of 0.5 V in an electrolyzer, while minimizing the power consumption to ~ 8 kW h kg^{-1} H_2. We aim for our catalyst to exhibit H_2 generation efficiencies within the range of 100-200 mmol g_{cat}^{-1} h^{-1}. To the viability of this project, a significant aspect of the outlined objectives involves the development of a model system for energy conversion machines in order to enhance the project's viability.

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Title: CO2 sequestration in marine hydrate reservoirs with simultaneous energy recovery.

A) Objective: This proposal intends to study the feasibility of CO2 sequestration in offshore hydrate reservoirs (marine environment) with simultaneous energy recovery.

B) Origin of the proposal: To extract CH4 from a hydrate reservoir, hydrate can be dissociated by taking it above the equilibrium conditions (pressure reduction, temperature increase, addition of inhibitors, and gas exchange process). In addition, CO2 hydrate is thermodynamically more stable than CH4 hydrate. CO2 replaces the CH4 trapped in the hydrate crystal by taking its place, resulting in a release of CH4 and trapping or sequestration of CO2. Successful CH4 extraction and simultaneous CO2 sequestration in a marine hydrate reservoir must include detailed lab-scale CH4 and CO2 hydrate studies pertaining to oceanic hydrate reservoir (in-situ conditions and fluid and sediment properties).

C) Problem definition: Dissociating marine hydrates to produce CH4 presents challenges such as uncontrolled rate, unconsolidated sediment destabilization (damaging downhole equipment), potential hazards such as instability leading to earthquakes, greenhouse gas emissions (from the sudden release of CH4), and impact on the marine ecology. Thermal stimulation is likely uneconomical due to heat loss to porous media. To combat instability, sand production, and preserving sediment integrity, the gas exchange seems most appropriate as it occurs slowly without drastic destruction of the hydrate structure. However, due to endothermic process, the temperature around the producing wellbore will decrease, inducing hydrate reformation. Thus, it will reduce the gas exchange rate. Delineating the effect of each of these factors on CO2 hydrate formation (varying sediment properties in a marine environment) and addressing above discussed issues lead to a successful CH4 production with simultaneous CO2 sequestration.

D) Expected Deliverables: This proposal will investigate and provide valuable insights into methods, additives, and their combinations to promote the CO2 sequestration in marine gas hydrate deposits and reduce the sediment production with simultaneous production of cleaner energy in form of methane (CH4). Research findings will be published in peerreviewed journals.

2. Details of existing research scholars/ project scholars and Institute sponsored doctoral students available at present. Mr. Sunil Kumar (Institute sponsored, Background - Geophysics) (Guide – Dr. Piyush Sarkar) (Co-guide – Dr. Siddhant Kumar Prasad)

Project-1: Hydrocarbons-derived Carbon Nanotubes for Electrochemical Hydrogen Peroxide Synthesis

Carbon nanotubes (CNTs) are considered as most promising support for energy storage and conversion applications. However, synthesizing CNTs with control over their cylindrical diameter is challenging. This homogeneity is important which deicide the catalytic properties of CNTs. Some synthetic methods are known in the literature, but they seem complicated and are not relevant for the large-scale CNT synthesis. Therefore, it is being utmost urgent to develop a new facile method to synthesize the CNTs with complete control over their size and shapes.

Considering the availability of hydrocarbons in refineries such as methane or acetylene, these molecules can be directly used as a precursor for the growth of CNTs. Although, some specific metal catalysts will be required to catalyse the formation of CNTs. Not only limited to pure carbon CNTs, N-/P-/S-doped CNTs will also be synthesised using precursors such as aniline or thiophene or phosphenes. These hetero-atoms not only boost the conductivity of the CNTs but also works as non-metallic catalytic sites. Because of presence of metal impurities (~ppm level) and non-metallic catalytic sites, these hydrocarbon-derived CNTs are considered to show the important side reactions such as H_2O_2 formation during the electrochemical O_2 reduction reactions. H_2O_2 is an industrially important molecule which is largely produced in the industry for manufacturing of several value-added chemicals.

Following are the objectives of this proposal:

1. Search for the suitable catalysts for the synthesis of CNTs using hydrocarbons as carbon precursors.
2. Characterization of catalysts and produced CNTs.
3. Targeted production of 10 gm of CNTs per hour.
4. Electrochemical measurements for the peroxide formation using CNTs as catalysts.
5. Fabrication of H_2O_2-elecrolyzer for continuous production (10 mL/h) of hydrogen peroxides.
6. Patent filing for hydrocarbon-derived CNTs
7. Patent filing for electrochemical hydrogen peroxide synthesis

Project Title: Development of a low-cost carbon molecular sieve (CMS) membrane from biochar obtained from lignocellulosic biomass for gas-separation applications.

Submitted by: Dr Gunjan Kumar Agrahari Assistant Professor, CEBE

Summary of the target-oriented project work: Olefins such as ethylene and propylene are important feedstocks used in the petroleum industry to produce valuable chemicals.

However, separation of propane/propylene mixtures through conventional technologies is energy and capitalintensive. Thus, the development of alternative low-cost methods is needed. A less-energy intensive and long-term stable alternative technique can be developed through the use of biochar-based carbon molecular sieve membranes. In the proposed work our team would explore the possible applications of such a CMS-membrane.

Methodology: Preparation of carbon-molecular sieve membranes through pyrolysis process. The project would consider developing a novel biomass-derived material to be prepared as a precursor for coating on a suitable low-cost support and subsequently pyrolyzed to obtain a carbonized sample. Property of polymers used as precursor, in addition to pyrolysis conditions play a vital role in controlling the porous structure of membrane matrix. The objective of the proposed work would be to control the membrane property in such a way so as to achieve high separation efficiencies and long-term employability of the CMS membrane for application in separation and purification of gaseous mixtures. The potential of the developed membrane would be particularly studied with respect to its suitability for olefin/paraffin separation.

Requirement: One Project Fellow (to enroll in the doctoral program subject to fulfilling the Institute admission criteria.)

Duration: Two years, extendable to three years after due permission 0-6 months: Preparation of a porous CMS membrane, property evaluation 6-12 months: Coating of the CMS membrane film on a rigid hollow-fiber support, preparation of suitable rigid support, evaluation of mechanical and thermal properties of the support material.

12-18 months: Applications studies using propylene/propane and various gas-mixtures

18-24 months: Controlling the properties of porous membrane matrix through variations in experimental variables.

24-36 months: Application studies of tuned membrane matrix, Thesis writing, dissemination of results.

Outcome: One patent, 5-6 number of publications in SCI-listed journals, One PhD candidate.

The project outcome would lead to the development of a low-cost separation technique for possible industrial applications in petroleum refining. The successful implementation of project objectives would also produce intellectual property and high skilled personnel with a doctoral-degree.

Research Work Title: Development and evaluation of novel paraffin/asphaltene inhibitors to control organic solid deposition in the oil reservoir, tubing and pipelines

Precipitation of paraffins and asphalteness in the oil reservoir rocks, tubing, and pipelines is one of the major challenges faced by Industries such as OIL, ONGC, HMEL, etc. faces, which is hindering the productivity and transportation in their oil fields. Under normal reservoir pressure and temperature conditions, paraffin stays in equilibrium with the crude oil. Due to the pressure drop during production, the lighter fractions of the crude oil get removed. Thus, the solubility of heavy molecular weight hydrocarbons is reduced, and they become free to deposit in the form of wax along with the asphaltenes in the pores of the reservoir rock. In the proposed research work, the reservoir and crude oil-specific paraffin/asphaltene inhibitors, suitable to control the deposition of organic solids (wax/asphaltenes) would be developed in the laboratory. The performance of developed inhibitors would be evaluated by performing detailed characterization, flow, and core flood studies with crude oil samples and reservoir rock (core samples). The crude oil samples from the problematic fields of India would be collected and characterized thoroughly based on their physico-chemical, rheological, and thermal properties so that the developed inhibitors could be crude oil specific. The developed inhibitors could also be characterized based on their physico-chemical and thermal properties. Improvement in the flow of crude oil after inhibitor doping could be assessed by using an HPHT rheometer. A core flood setup and flow loop setup could be used to evaluate the performance of developed inhibitors for controlling the wax/asphaltene precipitation in the reservoir and in pipeline, respectively. This test would investigate the pressure drop across the core sample/pipeline with time due to wax/asphaltene precipitation in the pores of the core at a constant flow rate of crude oil - with and without treatment with inhibitor. The developed inhibitor would be doped in the test crude oil sample to check wax/asphaltene dissolution through pores of the test core sample during flooding at average reservoir pressure, i.e., 200- 600 psi, and improvement in flow rate would be investigated.

Major Objectives:

• Identification/synthesis and characterization of suitable, cost-effective, and novel paraffin/asphaltene inhibitors

• Study the effect of additives on pour point, microscopy, wettability, and IFT of crude oil and core samples.

• Evaluation of the effectiveness of additives in controlling organic solid deposition in the reservoir using Flow Loop Setup/core flood studies. Major experimental facilities available: Rheometer, Core Flooding System, Flow Loop Setup.

Target Industries: Project is revevant to Mehsana Asset-ONGC, IOGPT-ONGC, COEESOIL, HMEL, Cairn India (Vedanta Oil and Gas), etc. Theme: Asphaltene/paraffin Deposition

Research Work Title: Investigation on Modification of CO2-based EOR Slugs for Geological Sequestration in Mature Oil Fields

The increasing concerns towards the prevention of inhabitability of our environment have led to significant research towards the reduction of CO2 emission in the atmosphere, as well as the removal of CO2 from the atmosphere and its storage in geological structures. Among the different geological sites used for sequestration, such as a saline aquifer, coal seams, and depleted reservoirs, the injection of CO2 in reservoirs has been preferred by several oil and gas upstream companies, as the process leads to the additional benefit of enhanced oil recovery from mature and depleted reservoirs. The injection of CO2 has been widely used for the enhancement of oil recovery. However, CO2 injection has several associated pitfalls, such as poor sweep efficiency, gas fingering, and early breakthrough of the injected slug. The injected CO2 also escapes from the production well along with the produced reservoir fluid. Thus, the amount of CO2 trapped in the pores of the reservoir is not significant to achieve the net neutral carbon emission. In the proposed project, modified CO2 slug will be investigated as an EOR slug containing additives that increase minimum miscibility pressure (MMP) to improve retention of CO2 in the reservoir and simultaneously increase the viscosity of slug to improve the macroscopic sweep efficiency of the injected slug. The CO2-based EOR slug containing additives will be formulated using a high-pressure reactor cell. The reduction in MMP and increase in viscosity due to the addition of additives will be determined by the slim tube apparatus. The modified EOR slug will be tested for its EOR potential and sequestration capability by using CO2 gas flooding apparatus.

The proposed work aims for:

• Identification/synthesis of low-cost & readily available additives – CO2 thickeners & minimum miscibility pressure (MMP) improvers.

• Screening of additives as CO2 thickeners by pressure loss studies using slim tube apparatus.

• Evaluation of additives as MMP modifiers by using slim tube apparatus.

• Physico-chemical characterization of crude oil samples under studies.

• Characterization of core samples under studies.

• Investigation of CO2-based EOR slugs having screened additives on oil recovery and CO2 sequestration using core flooding studies Major experimental facilities available:

HPHT Rheometer, HP-HT CO2 Flooding System, TGA, Slim tube Apparatus, Associated Research Project: IRG project P-2225 Target Industries: Project is revevant to IRS-ONGC, KDMIPE-ONGC, COEES-OIL, HPCL, IOCL, etc Theme: Carbon Capture, Utilization and Storage.

Research Work Title: Development of Environmentally friendly Synthetic Oil Based Mud (SOBM) using Natural and Indigenous Resources for HP-HT Wellss

Major basins in India like the Cambay, Cauvery and Krishna-Godavari (K-G) basin hold around 47 tcf of technically recoverable shale oil and gas. Shale in these basins is sticky and highly rich in reactive clay, which leads to significant wellbore stability issues. Drilling fluids with few ecological footprints is extremely desirable, particularly for drilling in the highly complex shale formation zone. Fields in K-G Basin bear high pressure and high temperatute, which makes drilling highly challenging due to dehydration of water, thermal instability of mud, and poor rheological and filtration properties. Water-based muds, being low in cost and environmentally friendly, are the most used fluids in the oil industry. However, swelling and dispersion of shale inside the wellbore during drilling with water-based fluids lead to wellbore instability issues due to the high magnitude of rock-fluid interaction. Moreover, maintaining rheology and filtration properties is technically very complex under high-pressure and high temperature (HP-HT) environments. On the other hand, oil-based muds have been proven to tackle these issues in in HP-HT wells, but environmental concern and economic are constraints to their field usage. Therefore, the suitable choice of drilling fluid additives and composition is very crucial for designing the formulations suitable of SOBM to tackle wellbore instability problems for HPHT formations. Unique properties of nanoparticles, such as high thermal conductivity and wide surface area) can solve numerous drilling fluid challenges by providing a reduction in formation damages, lowering overall drilling fluid cost, controlling mud cake formation and fluid loss, removing hazardous materials, improving heat transfer, providing better lubrication, and improving rheological properties. Major Research

Objectives:

• To synthesize and characterize Nanoparticle-reinforced polymers/surfactants as drilling fluid additives for developing synthetic oil-based muds

• To evaluate and optimize the properties (mud weight, mud, filtration properties, lubricity, static and dynamic stability) of developed muds for drilling HP-HT wells. Experimental/Numerical facilities: HP-HT Rheometer, LP-LT filter Press, HP-HT filter press, TGA, Particle size/Zeta potential analyzer, Core flooding apparatus, Ultrasonic probe sonicator, Roller oven, FT-IR, FESEM, AFM, Ansys Fluent Software, etc. Target Industries: Project is revevant to IDT ONGC, COEES OIL, etc. Theme: Drilling of HPHT Wells.

A Predictive Analysis-Based Dynamic Resource Allocation of IoT Applications in an Integrated Cloud-Fog Environment

We are experiencing a technological shift that is expected to change the world as we interact and program with it. Therefore, the enhancement in the technology introduced several smart devices that have been increasing their capability to generate more data, resulting in the accumulation of a wide variety in data regarding measurement. With the expected extension of the Internet of Things (IoT) to connect these smart devices, it is predicted that all the objects are connected virtually. The connection between the devices with the internet raises the need to transfer, store, and process data requirements and opens the gate for many research issues in the IoT requirements. Computing power and storage demands are increasing day by day for IoT devices. Consequently, the amount of data generated by the devices at the network's edge will also increase. The vast amount of data required an optimal service allocation technique to improve the resource utilization rate and efficiently distribute the load among resources. Various services allocation schemes have been proposed by researchers from 2016 to 2020 for enhancing the resource utilization at cloud data centers but, existing approaches focus on minimizing cost and computation time while not focusing on the Quality-of-services and the SLA violation at the time of virtual machine (VM) deployment. Therefore, it required an intelligent dynamic resource allocation technique to efficiently manage the data and resources and optimally place the IoT application to the available resources. Hence, we plan to use Artificial Intelligence (AI) techniques for the intelligent resource allocation technique. This will reduce the amount of time to serve an IoT application as well as the total cost. Keywords: Cloud computing, Fog Computing, Resource allocation, IoT, Machine learning

1. Introduction numerous emerging computing platform related to areas of IoT research like cloud with IoT (CoT), Mobile Edge Computing model for IoT, cloud-fog computing for IoT, mobile IoT computing, and Web of Things (WoT) comes into play. Cloud Computing has revolutionized the area that required ample computational power among all distributed computing technology of this era. It is enabling the on-demand services of dynamic resources over the network on a pay-per-use basis to their clients. Academic, research, big or small organizations, businesses, and individual users rely on cloud services rather than buying and managing the local server for the rapidly growing computing demand. Consequently, many users are moving towards the cloud computing model to fulfill their computing requirements. Therefore, there are lots of challenges like resource allocation, imbalanced workload, execution cost, energy consumption, SLA violation, elasticity,

availability, etc. in the field of cloud computing due to improper management of cloud resources. Resource allocation challenges occurs due to dispersion, uncertainty and heterogeneity of resources that are difficult to manage with traditional resource 2 mechanisms. To ample, the limitation of cloud computing, the integration of cloud computing to fog computing technology gives the prominent computing models that shown powerful impact on the information technology. While cloud computing has been a very well established and efficient way for acquiring computations and storage services for many applications but it may not be suitable to handle the myriad of data from IoT devices and provided the services to largely heterogeneous applications requirement. Fog computing has been developed to lie between the IoT devices and cloud, providing a hierarchy of computing power that can collect, aggregated and process the data from the IoT devices and send back the results after processing the computing and storage demand. Combining the cloud and fog computing model may reduce the data transfer and communication bottleneck to cloud and also contribute to reduce latencies, as fog computing exit closer to the edge. Cloud-Fog-IoT ecosystem providing insights into new research aspect field, the state-of-art in cloud and fog computing architecture, standard tools, and applications. The developers focus on developing applications that work well in the cloud-fog-based environment across a wide-ranging network terminal. The systematically analysis can expressively support the researchers to explore the taxonomy of various real-world applications and designing the techniques to make sure that the fulfil the functional and non-functional requirements. Designing and developing a dynamic resource allocation framework is the first half of the work, to validate the results and performance evaluation under a specific environment is the most challenging part where need to realize if the developed technique may achieve the defined objectives in a real-world scenario under the various associated constraint. To examine the deigned allocation technique, certain Quality-of-Service (QoS) parameters must be identified to address the issue. To addressing the challenges, a clear understanding of potential metrics which can be used to design the technique. Furthermore, it is a good scope of improvement in optimal allocation and utilization of resources in integrated cloud-fog computing environment by applying various algorithms and predictive analysis. It also depends on kind of work load being generated by the application in the form of data collection and processing. Real time IoT sensory data coming from various devices has different arrival rate and characteristics and generate different work load for the application hosted in cloud. There is a need to optimize the data collection and processing of IoT data so that cloud system is able to execute the application by predicting the workload and

optimizing the resource allocation in the cloud. In this project work, we design a intelligent dynamic resource allocation scheme for the IoT applications.

2. Broad Objectives It is proposed to do more research in this area by creating a real time IoT network with sensors for data collection and study data characteristics and finding optimal data collection, processing of data and come out with efficient mechanisms and algorithms for dynamic resource allocation using the Artificial Intelligence (AI) for IoT applications in cloud-fog computing environment based on predictive analysis. Based on the identified research area and literature gap, the main research objectives of next two year is to explore the predictive analysis-based AI techniques for the dynamic resource allocation framework for IoT applications in high performance computing domain.

The future research objectives are:

1. To understand the limitations and challenges in integrating the IoT devices with integrated cloud-fog computing environment considering different characteristics of data coming from different sensory devices.

2. To design and development a high-level architecture for the IoT-Cloud-Fog Integration for efficient collection, storage and processing of sensory data coming from variety of IOT devices.

3. To develop a mathematical model to optimize the dynamic resource allocation in cloud fog environment system on sensory data from IoT devices based on predictive analysis.

4. To design and development of a dynamic resource allocation based on the AI to optimize the Quality-of-Services (QoS) parameters like energy consumption, computation cost, propagation delay, response time etc.

5. To develop a test bed for experimentation and validation purposes in Cloud-Fog integrated environment.

Proposed Methodology of Research This proposal employs an AI-based technique to analyse dynamic resource allocation in the cloud-fog integrated environment. AI-based techniques are classified into three major categories: machine learning approaches, evolutionary techniques, and combinational methods. Machine learning-based approaches rely on the labelled data set. It creates an artificial neural network model for communication purposes between the input data set and the predictive output after performing the analysis of the previous data set. Evolutionary techniques are based on the natural behaviours of evaluations. It can be further divided into three subcategories based on the nature of the evaluation. Combinational methods are a combination of machine learning techniques and heuristic-based methods. A new algorithm has developed for finding the optimal results in such techniques instead of using the exiting machine learning techniques. We use the

machine learning-based technique to optimize the dynamic resource allocation of the IoT application data in a cloud-fog integrated environment. We perform the following steps to achieve the optimal resource allocation solution.

1. Received the applications from the IoT devices, including the sensor, smart devices, etc.
2. Fog nodes received the application request from the IoT devices, and for each application request, they received the various constraints associated with the applications.
3. Each server trains an Artificial Neural Network (ANN) through the received input data and generates the predictive output solution after performing the past trend analysis.
4. The ANN module sends the predicative analyzed results to the cloud broker to further process IoT applications.
5. According to the ANN module results, the cloud broker distributed the IoT application to the available number of virtual machines.

Facilities to be utilised & their availability/requirement RGIPT Jais, Amethi provides a list of common facilities that are often required in various projects. The following facilities are needed for completing the project.

Laboratory: A well-equipped laboratory with appropriate equipment and instruments for conducting experiments and research. RGIPT Jais, Amethi Computer Labs: Access to computers, software, and internet connectivity for data analysis, programming, simulations, and modelling. RGIPT Jais, Amethi Workspace: A dedicated space equipped with tools and machinery for practical work, prototyping, or manufacturing. RGIPT Jais, Amethi Library: A resourceful library with relevant books, journals, and online databases for literature review and research. RGIPT Jais, Amethi Computing Infrastructure: Sufficient computational resources like servers, high-performance computing clusters, or cloud computing facilities, depending on the project's computational requirements. Deliverables of the

Project: 1. Integration of cloud computing and fog computing model to delivered better services for IoT applications.

2. Development of a mathematical model for understanding the associated constrains, functional, and non-functional requirement of IoT applications.

3. Development of intelligent resource allocation framework in cloud-fog environment while considering various constraints.

4. Implementation of the project to test the performance of the proposed allocation framework under various scenarios with multiple Quality-of-Services parameters.

5. The optimal resource allocation sequence for the distribution of IoT applications on the cloud and fog resources and smart management of data. 6. The number of research

publication in reputed journals and conferences to motivated the other researchers to work on these directions.

5. Activity Timelines / Milestones Activities 1 stYear 2nd Year 3rdYear 4th year

- Literature Review of Resource allocation Techniques
- Literature Review Artificial Intelligence Schemes
- Development of a mathematical model for resource allocation
- Design and Development of dynamic resource allocation framework
- Trains the Artificial Neural Model for each server
- Develop a test bed for the implementation of proposed framework
- Implementation of the proposed framework in Cloud-Fog environment
- Analysis the result and published the outcome in reputed journals
- Preparing the final report and achievements of project

Legacy Software Migration to Linux Platform for Hindustan Aeronautics Limited

1. Introduction Hindustan Aeronautics Limited (HAL): currently relies on legacy Windows 32-bit software and firmware for its operations. This proposal outlines a comprehensive plan to migrate these systems to a platform-independent Linux environment. The project aims to enhance system stability, security, and long-term sustainability, ensuring HAL's continued excellence in the aerospace industry.

2. Objectives:

a) Platform Independence: Migrate existing Windows 32-bit software and firmware to a Linux-based environment, ensuring compatibility across various distributions.

b) Enhanced Security: Implement robust security measures to protect sensitive data and maintain compliance with industry standards.

c) System Stability: Improve system reliability, reduce downtime, and enhance performance by leveraging the advantages of Linux architecture. d) Cost Efficiency: Optimize resource utilization and reduce licensing costs associated with proprietary software.

3. Scope: The project will encompass the following:

a) Software Analysis: Conduct a thorough analysis of the existing Windows- based software and firmware to identify dependencies and components requiring modification.

b) Platform Selection: Evaluate Linux distributions and select a platformthat aligns with HAL's operational needs, considering factors such as performance, support, and community engagement.

c) Code Migration: Port the existing codebase to the chosen Linux platform, addressing compatibility issues and updating libraries as needed.

d) Security Implementation: Integrate security measures, including encryption, access controls, and regular security audits to safeguard HAL's sensitiveinformation.

e) Testing and Validation: Rigorous testing will be conducted to ensure themigrated software and firmware meet performance standards, are error-free, and function seamlessly within the Linux environment.

f) Documentation: Provide comprehensive documentation outlining themigration process, system configurations, and security protocols for futurereference. 4. Methodology: a) Requirements Gathering: Collaborate with HAL's stakeholders to gather requirements and expectations for the Linux-based system. b) Code Refactoring:

Refactor the code base to ensure adherence to Linux coding standards and optimize performance. c) Pilot Implementation: Implement the migration on a limited scale initiallytoidentify and address any unforeseen challenges before full-scale deployment. d) Training: Conduct training sessions for HAL's IT personnel to familiarize them with the new Linux-based environment. 5. Deliverables: Migrated and fully functional Linux-based software and firmware. Documentation detailing the migration process, system configurations, and security measures. Training materials for HAL's IT personnel. 6. Activity Timelines / Milestones The project is expected to be completed within two, with regular updates and milestones communicated to HAL's management. Activities 1 stYear 2nd Year

- Software Analysis:
- Platform Selection
- Code Migration
- Security Implementation
- Testing and Validation
- Documentation

7. No. of Research fellows required: 02 Junior Research Fellow / Senior Research Fellow

8. Conclusion: This project proposal outlines a strategic approach to migrate HAL's legacy Windows 32-bit software and firmware to a platform-independent Linux environment. The successful implementation of this project will position HAL for continued success in the aerospace industry, ensuring enhanced security, stability, and cost efficiency.

9. Details of Principal investigator Dr. Akash Yadav is working as an assistant professor at the Computer Science and Engineering Department at RGIPT. He secured his PhD from IIT Patna in CSE. His research interest lies in Crowdsourcing, IIOT, Computer Networks, Approximation algorithms and Time synchronization in Sensor and Embedded Networks. He managed to publish in various reputed international journals from IEEE, Elsevier etc.

End-to-end Process Optimization for Total Valorization of Rice-Straw: Large Scale Production of Nanocellulose, Bioadhesive, Dimethyl Furan, & Hydrocarbon

Our country has made an international commitment to achieve net zero emissions by 2070. To achieve this ambitious target, Government of India has set a plan to meet half of the country's energy through renewable sources by 2030. Lignocellulosic biomass has long been recognized as an important carbon-neutral energy resource in the country and is widely accessible as well. In this direction, Global Biofuel Alliance has been recently announced for sharing technological advancements in biomass valorization for biofuel production and utilization. Notable Lab-toLand initiatives have been made to utilize crop-residues as a source of energy & fuel are – 10% Co-firing of biomass pellets/briquettes in thermal power plants by NTPC under National Mission SAMARTH; Setting up of 100KL Bioethanol plant (Feedstock: Rice Straw) by Indian Oil Corporation Limited (IOCL) at Panipat, Haryana under Ethanol-Blended Petrol (EBP) Programme and Setting up of 100KL Bioethanol plant (Feedstock: Bamboo) by Assam Bio Refinery Pvt Ltd (ABRPL), a Joint Venture (JV) of Numaligarh Refinery Limited (NRL) at Panipat, Haryana under Ethanol-Blended Petrol (EBP) Programme.

However, the challenges associated with initiatives are-

• The supply chain management of rice straw for Bioethanol plant remains the bottleneck due to short-duration period of their availability and the need for a large storage area owing to the low bulk density (50–120 kg/m3) of rice straw.

• Water and silica contents in biomass pose a serious threat to the operation of thermal power plant.

• Moreover, farmers remain almost aloof from this waste-to-wealth value chain. That has unfortunately resulted in the burning of crop residue that causes foremost environmental and health issues in Northern Indian states - Uttar Pradesh, Haryana, and Punjab. It is estimated that nearly 100 million tons of crop residues are burnt in India itself, even on an annual basis. To overcome these challenges, we have developed process chemistry for production of high-value product, Nano cellulose. A mobile small-scale bio refinery has the potential to increase the farmer's income through valorization of crop-residues and other lignocellulosic biomass. It will allow to create a micro cellulose economy in the country to maintain the supply chain of bioethanol production. Considering a greater translational scope of this research for achieving the target of Net-

Zero emission and boosting rural economy of our country, there is a need for end-to-end process optimization for total valorization of rice straw and other lignocellulosic biomass. The primary objectives of this proposal are

i. Optimization of processes for Nano cellulose production at 2KPD plant.
ii. Process Chemistry protocol development for recycling & treatment of effluent.
iii. Separation & quantification of Nano silica present in rice-straw.
iv. Development of Water-resistant bio adhesive, & vanillin from lignin
v. Thermochemical (HDO) and Electrochemical Production of hydrocarbon from lignin.

Designing of UAV AR/VR based Digital Twin to improve efficiency of Hydrocarbon Industry Processes with AI

In order to increase productivity, efficiency, and safety while lowering capital and operating costs, health and environmental concerns, and variability in oil and gas project life cycles, the hydrocarbon sector is considering a variety of digital technologies. The hydrocarbon sector is gradually moving towards data-oriented solutions as a result of industry 4.0's increased performance, efficiency, and cost-cutting. The simultaneous examination of data from numerous sources is necessary to comprehend such complicated systems. The next generation of real-time production monitoring and optimisation systems is built on Digital Twin (DT) modelling. The combination of information, simulation, and visualisation along the whole value chain of an operational firm, from subterranean machinery to central processing units, results in a solution that increases productivity. The next generation of real-time production monitoring and optimisation systems is built on Digital Twin (DT) modelling. It is a productivity-boosting solution that integrates data, simulation, and visualisation along the whole value chain of an operating organisation, from underground machinery to central production facilities. With the proper application of such cutting-edge technologies, oil and gas firms can greatly benefit from hydrocarbon exploration. This study focuses on DT technological breakthroughs and how the hydrocarbon industry has made use of them. The paper covers the history of the DT concept, its different forms, 5D representation, and DT toolkits. The study also aims to apply DT fields, particularly in the areas of exploration, drilling, and production, in the oil business. Accessibility, confidentiality integration, and maintenance issues related to DT approach are also covered. In the past, digital twins served as IoT technology's extensions, but in recent years, they have come to be utilised in practically every facet of property administration. According to one estimate, 88% of platforms will include at least some functionality for digital twins by 2025, when they are anticipated to be a regular component of IoT applications. The time is now for businesses investing in smart buildings to incorporate digital twins into their office or retail space. The first step is to learn how to construct a digital twin.

While every smart building is unique, this article will provide a step-by-step procedure for creating a digital twin of any physical setting.

Creating Digital Twin

The first thing to keep in mind while creating digital twins is that they are more than just computer simulations of real spaces. They exchange real-time data back and forth with the buildings they are physically connected to. Even integrated building systems like telecommunications networks, content storage platforms, and other business applications can be managed by digital twin infrastructure. Digital twins are not static reproductions; rather, they are extensions of an environment. This guiding idea will help designers create relationships more successfully. Understanding the intended use and scope of your digital twin is crucial, just like with any project. For instance, a hospital would need a fast and secure interior navigation system to direct patients to treatment locations. Retailers may want to automate inventory control by continuously checking and updating virtual shelves. These factors will guide the design of the digital twin and assist you in choosing the best resources to support it.

Addressing the size and scope of your digital twin is also beneficial. Do you plan to portray the complete building or simply a few rooms? Smaller rooms will be simpler to digitise and improve, whereas re-creating an entire structure could need the support of specialised partners.

Making a list of features can be useful when determining your scope. As a starting point, consider the following inquiries:

What features of the building will the digital twin monitor?

• Can users access the digital twin remotely, or do they have to be present?

• Will employees or the broader public use the digital twin?

Choosing AR Design

You can select the elements that will make your digital twin work once you know what it will achieve.Keep the following things in mind as you search:
1. **Data**: Every digital twin exchanges data with and from its physical twin.
At this step, the designer's job is to select the best information type.
Binary data will be plain and basic, like those driving a lighting system.
Equipment tracking will be much more difficult and often call for specialised devices.
2. **Tools**: In order to perform their intended purpose, digital twins require certain equi pment.
As an example, position trackers in a hospital are much more helpful than seismic mo nitors from a gas refinery. This typically includes sensors that can fit your intended pu rpose. Designers must take into consideration the physical infrastructure, wired and wireless networks.

3. **Supporting technology**: The software that runs the digital twin is the final component. The most practical solutions on an architectural level typically involve 3D visualisations and IoT-based device management.

Digitally recording the surrounding environment

Of course, recreating a physical world in three dimensions is the aspect of any digital twin that is most aesthetically striking. Whatever your goal, this calls for a digitization procedure that captures a space's attributes and creates a 1:1 representation. The majority of the time, someone needs to move specialised camera equipment from room to room to capture images of the scene from various angles. This stage can take some time for a large facility, but every detail you give makes the digital twin more realistic.

Designers will have a collection of photographs to piece together into a 3D digital twin building model after the photography is finished. At the architectural scale, machine learning algorithms that gather data and automatically record the distances between walls, fixtures, and objects are the most effective way to accomplish this. Sadly, this is still only a building model; a further step must be taken before it can be considered a complete digital twin.

Adding features to your digital twin

Designers must incorporate details and functionality into the finished digital twin architecture to make sure it functions as planned. Depending on your intended use, these features may differ, however they may include the following:

• **Visual components**: Your first building model will resemble environments created by a video game engine in many ways; it will be spectacular, but it won't yet be rendered. Designers might have to incorporate or improve visual elements like lighting effects or texturing. These visualizations are crucial in fields like real estate where customers can take virtual tours of structures.

• **Navigation nodes**: One of the most popular applications for digital twins is indoor navigation. Designers can place users within the model using wayfinding and placement techniques, or they can provide users directional notifications on their smartphone camera.

Building functionality can be controlled by end users thanks to interactive nodes that designers can attach to any room or object. These could entail switching on a light, adjusting the thermostat, or starting up video conferencing technology.

Designers still need to evaluate and refine the user experience after integrating the digital twin with a building. Consider creating an indoor navigation system that uses directional indications enabled by augmented reality (AR) that are displayed within a smartphone camera. To ensure that virtual notifications accurately reflect any direction end-users face, the navigation app will make use of the digital twin. Designers could also have to take into account furniture or other items that block the camera's view.

- Developing a model for Biofuel Mapping on GIS with UAV and Crowd Sourcing Based Technique using Artificial Intelligence

Precise estimation of crops of various types growing in an area is always a challenge. Generally, the crops grow over a big area which are difficult to monitor all the time. Further, variability of seasons, sowing of seeds, harvesting, controlling of weeds, pests, conditions of irrigation, fertilizers significantly impact growth of vegetation or crops. Further there is a supply chain for the crop to the crop residue and then to the storage of surplus crop residues. Crops or its residues can be located over various lands in the socio-agricultural networks existing in the rural setups. The detailed monitoring of these biomass all the time at every location becomes impossible. Satellite images can provide certain inputs periodically. But getting satellite images of high resolution for all the agricultural areas and at various phases of cultivation is a challenge.

Managing detailed information of production of crop from government body such as Krishi Vigyan Kendra (KVKs) is difficult, time consuming and rough in nature. There is thus a need to come up with a technique to collect the crop data from large agricultural land by the field workers working in agricultural land using crowd source-based platform. Establishing any crowd source-based data capturing technique requires calibration of sample photographs with the detailed and accurate photographs of agricultural lands

captured using UAVs and background satellite images of the areas. Web based interactive GIS portal is planned to be made for a small agricultural area (1000 Acres) of Amethi district in UP. The portal will allow uploading mobile camera fetched images of agricultural land.

The GIS server will integrate the images with for the entire study area and would be calibrated with the detailed high resolution UAV images of the sample area and background satellite images of the area. AI/ML based classification and extraction algorithms will be utilized to determine crop, residue, and surplus volumes accurately and would be mapped over GIS base Bio-Fuel Mapping portal.

- Advancements of Artificial Intelligence in Structural Health Monitoring

Real-time health monitoring of civil infrastructures is performed to maintain their structural integrity, sustainability, and serviceability for a longer time. With smart sensing technology, a large amount of complex monitoring data is generated that require sophisticated Artificial intelligence (AI) techniques for their processing. AI models have shown their potential and usefulness for the early detection, diagnosis, and mitigation of cracks, and seepages in civil and pipeline structures.

A comprehensive review has been performed on applications of AI models for Structural health monitoring (SHM) to maintain the sustainability of various civil infrastructures. Further, three smart data capturing methods of SHM namely, camera-based, smartphone-based and UAV-based methods are primarily discussed that made the utilization of intelligent paradigms easier during heath monitoring of civil structures. A detailed overview of smart sensing techniques and AI applications is made to indicate their pros and cons for SHM. Moreover, the internet of things and smart city concepts are discussed and elaborated the contributions of intelligent SHM systems. Current challenges and future perspectives of AI-based SHM systems are also explained separately. This paper primarily reviewed AI applications in SHM and related significant areas that are becoming more important and efficient for the health monitoring of civil structures to achieve smart cities.

- LiDAR data based optimum cell phone tower distribution modelling in GIS

Cellular phone industry is growing up very fast throughout the world. The costs offsetting up , managing, and maintaining the network infrastructure are high. It is a challenge to provide high quality signal to all users in the last mile of transmission. Cellular towers are required to be placed for the transmission amidst residential buildings, commercial complexes, roads, highways, open spaces, water bodies etc. Over the years attempts have been made to provide reliable, high capacity signal to fixed user locations. Determining optimum location and distribution of cellular towers is a challenge with varying land cover classes and user densities. Often these problems can become NP-hard in nature.

Theoretically, the solutions can be achieved using a fixed point-to-multi point profit maximization principles. GIS primarily uses shape files of various land cover classes (city, high way etc.) and non-spatial attributes of population, income etc. GIS then determines coverage around each cellular tower, minimizing dead or no signal zones. GIS uses distances between potential tower locations and surrounding land cover classes, inter tower

Distances and in some cases analysis of view shades around the tower locations to determine the coverage and the distribution of cellular towers. Existing practices have limitations in terms of usage of average terrain data, 2D data, inadequate understanding of nature of propagation of signal in the outdoor, dynamic nature of the users etc.

These limitations create incorrect estimation of availability of signal at a place, incorrect coverage estimation around any tower, over or under designing of cellular distribution, and wastages of energy for the maintenance of towers etc. It is thus realized that the cellular distribution should be designed optimally. The distribution necessitates determination of accurate model for prediction of signal strength at an user location. Better modelling is only possible with detailed and accurate data of land cover and land uses. Considering the above needs, a LIDAR data based cellular tower distribution modelling is attempted.

- Developing an intelligent fire alarming, monitoring and rescuing system using UAV, Digital Image Processing , and AI/ML Techniques

The project will work on building resilient infrastructure using innovative technology. The growing infrastructure in India involves developing urban, transportation, industrial, and energy infrastructure.

Each of these infrastructure need to be resilient to remain sustainable during normal and disaster conditions. Offering sustainable infrastructure relates providing secured infrastructure too. The proposed project will develop a technique to capture the information of existing infrastructure using UAV. It would enable creation of 3D Digital Elevation Model of urban area, transportation corridor and industrial infrastructure. Integration of camera and other sensors with IOT platform in this technique will offer unique intelligence to safeguard the infrastructures from fire, natural hazards, and security concerns. The technology will not only inform about the hazards to infrastructure, it will monitor it in real time and inform the rescuer to start the rescuing operation. Further, it will offer a clear evacuation map and guideline for the entrapped people during the accident. World Bank report clearly indicates the importance of better tool and skill (e.g., digital elevation model) to build resilient infrastructure (https://sdg.iisd.org/news/world-bank-report-illustrates-benefits-of-resilient-infrastructure/).

FICCI report suggests hazards of Security and Fire to be the major causes of risk for Infrastructure, Hospitality and Education sector

(http://ficci.in/Sedocument/20416/India-Risk-Survey-2017-Report.pdf). The project will work in this direction. The project will provide very important support for urbanization, secured infrastructure growth and industrial development, which will be sustainable.

UAV IIOT based Digital Twin designing for Improving the efficiency of Cooling Tower

Introduction:

Generic understanding for Cooling Tower CoC enhancement and increasing efficiency.

The overall effectiveness of the cooling process is correlated with the proper operation of the many components that make up cooling towers. Aside from the state of the tower components, the relative humidity of the surrounding air and its wet-bulb temperature would largely determine the cooling tower efficiency. Some elements are considered when designing a cooling tower. The effectiveness of the cooling tower is significantly influenced by the following design criteria.

a) Wet-bulb temperature,
b) Cooling range,
c) Approach,
d) Water circulation rate,
e) Air velocity through the tower's air passageway(s), and of course the
f) Tower height are among these variables.
g) Water Quality
h) Nature of Motor

The makeup water quality and cycles of concentration (COC) are two elements that are highly indicative of cooling tower efficiency. These elements will also aid in determining whether cooling tower efficiency can be increased. Before being released, the water utilised in the tower for cooling is cycled through the device a number of times, and COC is a number that indicates how many cycles there may be. It is regarded as the main metric of cooling tower effectiveness. By comparing the ideal COC with the current one, one can quickly determine whether there is a chance to increase the cooling tower's effectiveness if they are aware of the recommended maximum COC. Now, various water treatment technologies, such as filtration systems and water softeners, might be useful to increase the cycles of concentration even higher if the current COC is close to its optimum value. The maximum concentration cycles for the water in cooling towers are influenced by water composition, as was previously mentioned. The ratio of a parameter relating to some minerals in the cooling water to that parameter in the makeup water is represented by the dimensionless number COC, which follows.

Any of the following formulas can be used to determine the concentration cycles.

COC = Silica in Cooling Water / Silica in Makeup Water

or

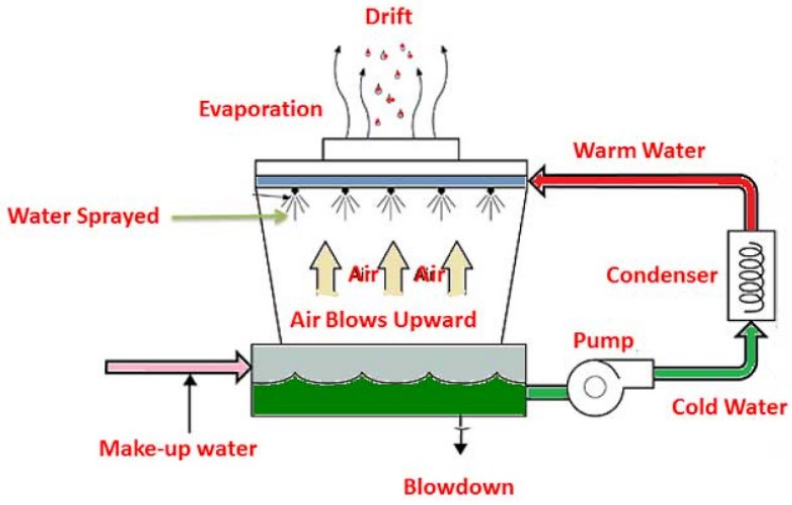
COC = Ca Hardness in the Cooling Water/ Ca Hardness in Makeup water

or

COC = Conductivity of Cooling Water / Conductivity of Makeup water

Higher values of COC are preferable because it is preferable to lower the amount of makeup water in the tower. While this is true, scaling and fouling of the heat transfer components are more likely when the COC is higher for a certain volume of makeup water. As a result, the ideal COC is a compromise between the need for makeup water and the quality of the heat transfer.

The ideal value for the concentration cycles depends significantly on the local water quality. Therefore, understanding the basic water components is crucial. The water can be chemically analysed to obtain this information, which can then be supplied by the party providing the water or by the water treatment departments.The makeup water's impurities cause some scale to form, which, together with information on the water's composition, may help researchers determine the maximum COC.



Working principle of a cooling tower (Reference: **sugarprocesstech.com**)

The range and approach of the cooling tower are the two elements that go into calculating cooling tower efficiency. As was already mentioned, the ambient wet-bulb temperature has a significant impact on the tower's efficiency. This wet-bulb temperature would ideally match the cold water temperature. Of course, nothing in this world is perfect, and in this case that is the case since achieving such a perfect scenario would require a very high tower, which is not only impractical but also has its own issues including significant evaporation and windage. The cooling tower approach is the difference between the wet-bulb temperature outside and the cold water temperature at the tower's outflow. One of the key elements affecting the effectiveness of cooling towers is this measure. The cooling tower range, which is determined by deducting the hot water temperature at the cooling tower's input from the tower's output water temperature, serves as another gauge of its effectiveness.

One can quickly determine the cooling tower efficiency by calculating the cooling tower range and approach. The percentage of water temperature cooling compared to the

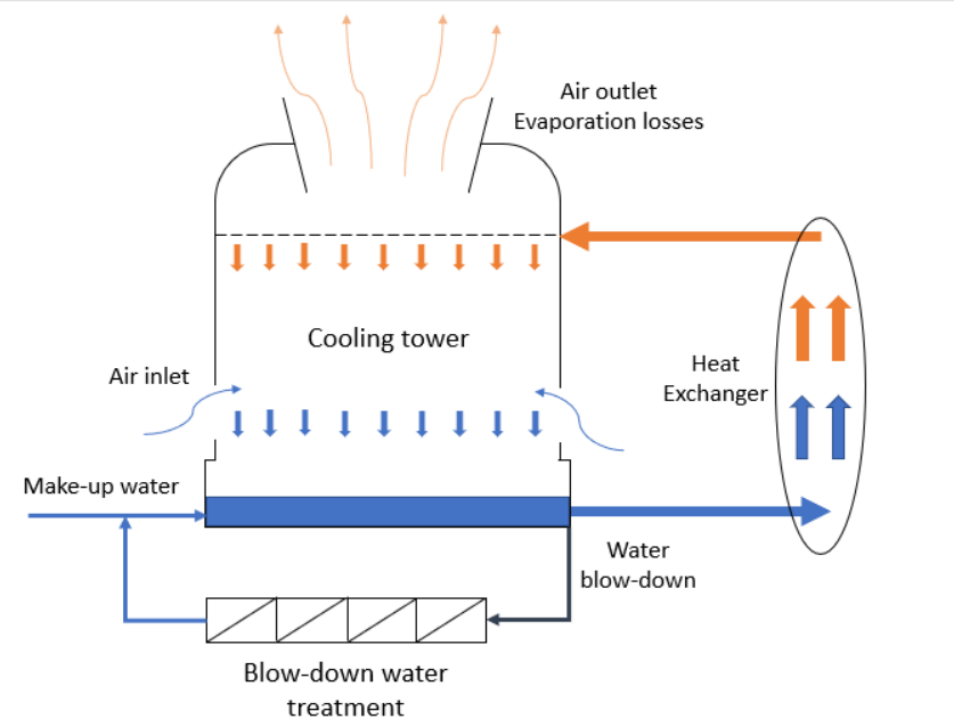
difference between the hot water temperature and the surrounding air's wet-bulb temperature determines the efficiency of the tower.

Cooling Tower Thermal Efficiency = Range/ (Range + Approach) x 100

The efficiency of the cooling tower is negatively associated with the ambient wet-bulb temperature, as can be observed from the equation above. It makes sense that hotter regions require lower cooling tower efficiency because the wet-bulb temperature rises with temperature.

Various losses can be calculated. Some of the water in the cooling tower evaporates while it is being circulated through the system, increasing the concentration of dissolved minerals in the remaining water. Scale development would be a typical outcome of the circumstance where mineral concentrations exceed the water's saturation point.

In a procedure known as cooling tower blowdown or bleed-off, a portion of the cooling tower system water that is highly concentrated with the minerals is flushed down the drain and is replaced with fresh water at the same time to address the issue of scale formation due to high mineral concentrations.



Cooling tower blowdown (Reference: **lenntech.com**)

A portion of the water evaporates during cooling water circulation in the cooling tower, increasing the total dissolved solids in the remaining water. There are conventional approaches to calculate all the process losses and makeup water volume.

In order to get greater COC values, which would increase cooling tower efficiency, the goal is to reduce blowdown. Naturally, reducing blowdown would result in less chemical

waste being discharged, which is excellent for the environment and the operator's financial situation. Minimising water use for the system is one of the cooling towers' most crucial economic and environmental factors. Therefore, employing water-saving techniques could be seen as a crucial step in improving cooling tower efficiency. Any COC that is lower than the maximum value indicates that there is space to increase cooling tower efficiency by boosting COC, which would result in more water savings. The cycles of concentration must be at their highest feasible value for an operation to be considered optimal. To reduce the amount of freshwater utilised, some of the facility's wastewater steams might be used as the cooling water replacement. Such streams of water could be pre-treated and used as a source of makeup water without endangering the machinery or degrading its performance.

The elimination of scaling, fouling, and equipment deterioration as well as the avoidance of heat transfer surface malfunction is made possible by cooling tower water treatment. Therefore, improving the quality of treated cooling tower water with more sophisticated water treatment methods will increase cooling tower efficiency.

Improved motor drive technology found in new cooling tower equipment can boost overall effectiveness while also reducing noise, enhancing reliability, and enhancing safety. Such dynamic drivers frequently take the form of RVSS or VFDs (The two types of cooling tower frequency drives available for this are the Reduced Voltage Soft Starter (RVSS) and the Variable Frequency Drive (VFD)).

Despite the fact that dynamic drivers are significantly more expensive than static ones, the money saved over the long run totally offsets this initial expense and leads to even greater savings because of decreased water and electricity use as well as low maintenance expenses.

In crossflow (forced draught) towers, hot water is dispensed perpendicular to the air flow; whereas, in counterflow towers, hot water is dispensed straight into the airflow. Counterflow systems with induced draft are thought to be more effective.

<table>
<tr><th>Sl No</th><th>Variables</th><th>Dependent Parameters</th><th>Target Function</th></tr>
<tr><td>1</td><td>Wet-bulb temperature, RH, Temperature</td><td rowspan="3">Cooling Tower Range and Approach</td><td rowspan="7">Cycle of Concentration & Efficiency</td></tr>
<tr><td>2</td><td>Hot water temperature</td></tr>
<tr><td>3</td><td>Cold water temperature,</td></tr>
<tr><td>4</td><td>Extent of Damage, Scaling</td><td>Heat flow at different parts</td></tr>
<tr><td>5</td><td>Water circulation rate,</td><td>Hot water inflow, Cold Water Outflow, Makeup and Blowdown flow</td></tr>
<tr><td>6</td><td>Air velocity through the tower's air passageway(s)</td><td>Air Draft, Evaporation</td></tr>
<tr><td>7</td><td>Tower height are among these variables.</td><td>Physical Dimension/Geometry/area for heat transfer/evaporation</td></tr>
</table>

8	Water Quality	Makeup Water and Blowdown water Quality, (Scaling, Hardness, Silica TDS, Conductivity, pH etc)	

Proposal for the given cooling towers

The problem statement 7 has two targets, (i) Improving efficiency and (ii) Reducing fresh water consumption. Reducing fresh water consumption is directly linked with cycle of concentration (CoC) enhancement. Hence both the problem statements can be solved together by using digitalization techniques. Digitalization of cooling tower performance parameters can greatly enhance efficiency, reduce fresh water consumption and enhance CoC. By leveraging data and technology, operators can monitor and optimize cooling tower operations in real-time. Here are some parameters to monitor and action points to improve efficiency and reduce fresh water consumption through digitalization:

1. Temperature Differentials: Continuously monitor the temperature differentials, such as approach and range temperatures, to assess cooling tower performance. Analyze historical data and implement predictive analytics to identify deviations and take proactive measures to optimize heat transfer efficiency.
2. Flow Rates: Monitor and optimize the flow rates of water entering and leaving the cooling tower. Check flow meter readings and utilize data analytics to identify and address any abnormalities or inefficiencies in flow rates. Adjust flow rates based on cooling load requirements to minimize excess water usage.
3. Water Quality Monitoring: Check sensors to monitor key water quality parameters, including conductivity, pH, and levels of dissolved solids. This data can be used to assess water treatment effectiveness, detect potential scaling or fouling issues, and optimize chemical dosing for improved water quality and reduced water wastage.
4. Blowdown Monitoring: Monitor and control blowdown rates to minimize unnecessary water discharge while maintaining appropriate levels of dissolved solids.
5. Remote Monitoring and Control: Implement a centralized monitoring system that provides real-time visibility into cooling tower performance parameters. Utilize IoT (Internet of Things) devices, sensors, and cloud-based platforms to remotely

monitor and control the cooling tower operations. This allows for proactive identification of issues, remote adjustments, and optimization of performance without physically being present at the site.

6. Data Analytics and Predictive Maintenance: Utilize advanced data analytics and machine learning algorithms to analyze historical data and identify patterns, correlations, and potential inefficiencies. Implement predictive maintenance strategies to detect and address potential equipment failures or performance degradation before they occur, ensuring uninterrupted operation and optimal efficiency.
7. Automation and Optimization: Utilize control algorithms and automation systems to optimize cooling tower operations based on real-time data and external factors like weather conditions, cooling demand, and energy costs. Implement smart control strategies that adjust fan speeds, water flow rates, and chemical dosing in real-time for maximum efficiency and reduced water consumption.

Of the seven points discussed above, the first four parameters are of primary importance which directly have a greater influence in efficiency improvement, fresh water consumption reduction and CoC enhancement.

Practical difficulties

There are several practical difficulties ensued in fully solving the problems. They are listed below:

1. Availability of historical data is essential through which a comparison can be made on the cooling tower performance.
2. Not having enough registered data in certain sensors.
3. Precise data is important for proper prediction.
4. Sensor error should be reduced as much as possible by calibrating at regular intervals.
5. CAD model of the system can give idea about placing additional sensors.

Long Term Goal

Once the project is successfully carried out, a common model or framework can be developed which can assess all the cooling towers.

Strategy to improve Cooling Tower Efficiency and CoC

When looking for strategies to improve cooling tower efficiency, there are a few things to consider.

Detailed Data collection: It is required to determine the dependent parameters and estimate the CoC and Efficiency for the required Cooling Tower(s). The available current data and historical data (variables) are to be collected, rectified, compared with the past performances and/or of the same of other cooling tower(s). (For example, measured flow and qualities of makeup water, blowdown water, various temperatures etc.)

Data generation: Using low cost IIOT, LiDAR surveying and UAV based Thermal Infrared Imaging.

Historical data, and Live data of various process parameters are to be integrated to design virtual digitalized model of Cooling Tower, which can then be analysed using AI/ML to find the fault in current system and suggest the solutions for improvement. The digitalization technique will offer solutions for day-to-day optimum running of cooling tower, and for long term solutions to run to run the cooling water efficiently.

Timeline	Month 1-3	Month 3-6	Month 6-9	Month 10-12
Activities	Activities: Site Visit, collection of Initial available data: Deliverable: Prima facie report on problem or challenges of cooling tower(s) and identifying how to collect other required parameters for digitalization	Activities: Setting up of IIoT and UAV based system for data collection and a system to integrate the data with available data for digitalization and detailed fault identification. Deliverables: Setting up a system for Digitalization	Activities: Digitalization. Deliverables: Initiation for finding the faults	Activities: Derivation of solution to challenges. Deliverables: Implementation of solution and improvement in efficiency

Expense: RGIPT has its LiDAR, UAV based sensors, it may require setting up IIOT based sensor network for digitalization and generation of solution.

Digitalisation of energy industry with GIS based Digital Twins for ESG, estimating Carbon Footprint

Even if digital twins (DTs) are becoming more and more popular in geospatial technology, the scientific Thoughts on DTs are not universal, and literature is still in its infancy. From popular viewpoints, the main DTs aim to lower physical system uncertainty in real-world projects in order to cut costs. Therefore, the purpose of this study is to create a structural schematic or Framework for a Geographic Information System- GIS geospatial technologies that can help with the deployment of a DT system for a real-world project—specifically, for the sustainable evaluation of carbon emissions—and investigating GIS-enabled DT systems.

The three main sections of the schematic are

(1) analytics and data collecting and visualisation,

(2) deployment, and

(3) analytics. To suggest the best course of action for lowering carbon emissions in a Energy Industry –(e.g., Refinery), at different involved phases.

Using the carbon emission values calculated in accordance with the Standards, a GIS map was used to spatially portray the most vulnerable area in the first stage of the analytics phase. Next, spatial trends of carbon emissions can be predicted using a machine learning technique called the radial basis function (RBF) kernel algorithm. Using a backpropagation neural network (BPNN), one can quantitatively ascertain which of the various data sources—such as electricity, gas, fluid flow, garbage, etc.—had the most influence. The locations of the industrial area's high carbon emission clusters can then be determined using a hot spot analysis. This study on the evolution of DTs helps in two ways: first, DTs will enhance sustainable energy management systems and generate new ideas and increased public awareness.

In the end, these enhancements can lessen the likelihood that projects will fail due to poor planning and management. Second, this structural schematic follows a data-driven methodology, which produces more dependable and practical results. In the end, cutting-edge methods emerge and services undergo transformation. Hence, the system can be utilised by policy makers or industrial planners for scenario-based approaches.

Keywords: digital twins; geospatial technology; carbon dioxide emissions; machine learning; artificial neural network; ESG; Energy Industry

Design of an Efficient Battery Charger for Electric Vehicle (EV) Based on Wide Band Gap (WBG) Devices

Objective of the Project: The project objective is to design of an efficient battery charger circuit for electric vehicle (EV) using wide band gap (WBG) devices: WBG device advantages over Si power semiconductors are lower power losses, higher switching frequencies, and higher junction temperatures, which enhance the charging time and efficiency of the charger. Thus, using WBG power semiconductor devices for EV power electronic systems improves EV efficiency, reliability, and mileage. Further, the prototype EV charger can be designed based on the outcome achieved from the project.

Expected Outcomes:

• To design a highly efficient WBG-based power electronic converter for EV battery charger.

• Design and test the WBG-based converter for various types of EV charger applications.
• Ultimate expected outcome shall include to design a prototype of an efficient commercial working EV battery charger

Problem Statement

Despite the desirable advantages of WBG-based power electronics converters for EV charger applications, there are various issues/limitations with their technical implementation.

The trade-off between high switching frequency and EMI, device characterization, parasitic inductance, power converters, and Gate driver circuit design, the challenges of packaging high-voltage and high-temperature devices are a few examples.

In order to implement the WBG-based charger for EVs in this proposal, the aforementioned issues must be addressed, and workable solutions must be found. Challenges

• WBG device selection and their technical challenges for EV battery charger

• Designing of a PWM technique to make the WBG devices work with its maximum potential to reduce the high cost

• Designing of a control strategy that insures the reduction in the EMI and effect of parasitic inductance

• Development of a protection strategy for WBG devices

Targeted research proposal: The target of this research is to design an ML aided device that assists a visually impaired user. Following steps will be involved in project execution.

1) Use of ML/DL for localization and shortest path finding: To the best of our knowledge, for the first time, a prototype development involving the

microcontroller controlled execution of ML/DL for localization and shortest path identification by analysing the RSS and sonar sensor data has been proposed for a visually impaired user. Use of ML and DL for localization and shortest path identification significantly reduces the localization and obstacle identification errors.

2) Using already deployed LED light sources: The proposed prototype uses the already deployed LED light sources for navigation unlike the RFID based systems which involve additional hardware for installation of RFID tags into the existing communication infrastructure.
3) A unique combination of technologies: The project proposes a unique combination of sonar sensor and VLC technologies. In the process of prototype development for performing localization, obstacle detection and shortest path detection for navigating a visually impaired user through an unknown public place, ML and DL based algorithms are used to analyze data from the VLC transmitters and sonar sensors. Such a unique integration of VLC technology and sonar sensor technology for achieving the above objective has not been proposed earlier to the best of our knowledge.

10. Methodology:

Our response: The project involves localizing the visually impaired user precisely, finding obstacles around it, and navigating it to its destination through the shortest path. Thus, the project will be completed in three major tasks: 1) Localization: Designing ML assisted VLC based localization of the user, 2) Obstacle Detection: Designing sonar sensor based obstacle detection, and 3) Shortest path Detection: Designing DL based shortest path detection based on the obstacles around. Assisting this system by Machine Learning can significantly enhance the performance specially when there are insufficient light sources. We explain the methodology step by step ahead in the next section. A schematic diagram illustrating the proposed mechanism for providing navigation to visually impaired people in indoor spaces is as follows:

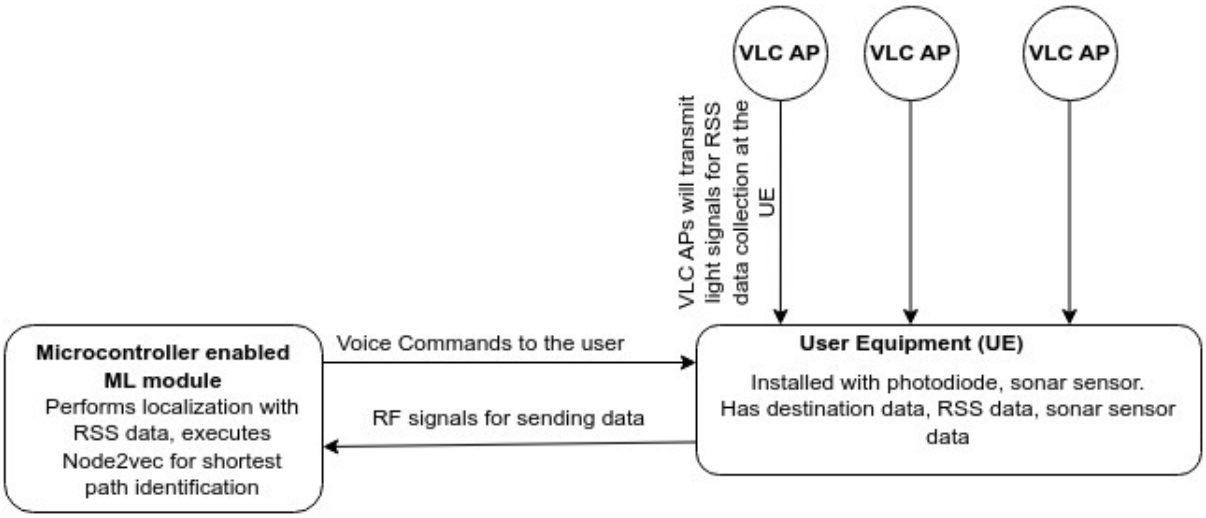


Figure: Schematic diagram representing the proposed mechanism

Figure: A schematic diagram illustrating a typical scenario under consideration with a visually impaired person in a public place with light sources.

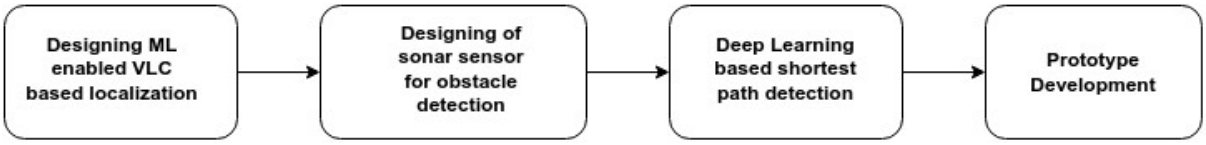


Figure: The flowchart of the project proposal.

Manpower needed: One project assistant

Duration: As per norms

Development of Adsorbed Bio-Gas Storage System: An Effective Energy solution for household Application

Objectives:

1.1. Development of a novel nano-structured material to store biogas by adsorption at ambient temperature and 35 bar conditions for household application.

1.3. Design of a 5 L of adsorbed biogas (ABG) prototype storage tank

1.2. Formulation of storage target related polices for the ABG for static household application.

Summary :

Biogas, one of the prominent and eco-friendly fuels, needs to be stored using an alternate storage technique (compression, liquefaction and adsorption) due to its lower volumetric energy density compare to that of liquid fuels. Among all storage methods, the adsorption-based biogas storage system for household applications can be considered simply because of its moderate storage conditions. This work is intended to develop a highly porous novel adsorbent for biogas storage by adsorption at room temperature and pressure up to 35 bar. In addition, the present proposal aims at framing storage targets for adsorbed bio-gas storage tanks for household application as well as preparing the techno-economic feasibility and viability report on the usage of adsorbed bio-gas storage systems for static application in the Indian market. In order to achieve these targets, a multi-disciplinary research including, (a) synthesis group of preparing Carbon Materials, (b) adsorption group for the characterization of adsorbents as well as to perform high pressure adsorption and dynamic cyclic studies and (c) marketing & energy Research group for framing storage targets and preparing market feasibility roadmap for using adsorbed bio-gas storage tanks in the domestic sector in consultation with their research groups, has been proposed. The successful completion of this research work will help our nation to use biogas for the household application in a most efficient manner as well as to reduce the environmental problems.

Development of Efficient Corrosion Inhibitor Formulation for Biorefineries

Objectives: (1) Develop an efficient corrosion inhibitor formulation suitable for highly acidic environments in biorefineries.

(2) Characterize the inhibitor formulations using different surface investigation techniques and assess their performance by taking ferrous alloy (steel) as the substrate.

(3) Perform market analysis by comparing the cost of the developed product with available products in the market.

Summary: Ethanol is a promising alternative fuel with many advantages over conventional fuels such as low carbon footprint and high energy density. However, it has a major drawback: its corrosive nature, which can cause severe damage to the components of biorefineries during the production process. This is a major concern for biorefineries since they need to maintain a safe and cost-effective operation. With India joining the Global Biofuel Alliance and recent developments in the field of bioethanol, it is high time to address this issue. The proposed project aims to develop an efficient and cost-effective corrosion inhibitor for biorefineries to reduce the damage caused by ethanol's corrosivity.

Timeline: 1 year

Major Deliverables: This project aims to develop a cost-effective corrosion inhibitor that is acceptable for use in biorefineries.

Project title: A metagenomic exploration of accelerated Biotransformation dynamics during vermicomposting and biogas production.

Time duration: 1 year (2024-25)

Work plan:

- *Literature Review:* Conduct a comprehensive review of existing literature on vermicomposting, biogas production, and metagenomics to inform the study design.
- *Experimental design and Sampling:* Develop protocols for sampling microbial communities from vermicompost and biogas reactors at various stages of the process.
- *Characterization and Metagenomic Sequencing:* To perform metagenomic sequencing on collected samples to characterize microbial communities and functional potentials.
- *Physio-chemical characteristics and Data Analysis:* Utilize bioinformatics tools for taxonomic profiling, functional annotation, and identification of key microbial taxa and metabolic pathways.
- *Statistical Analysis:* To employ statistical methods to identify significant patterns and relationships within the metagenomic data along with microbial community compositions in relation to process parameters to elucidate their roles in accelerating biotransformation.
- *Reporting and Dissemination:* To prepare a comprehensive report and disseminate results through scientific publications and presentations.

Deliverable:

- This metagenomic exploration provides insights into the microbial consortia orchestrating biotransformation processes, offering valuable implications for optimizing vermicomposting and biogas production for sustainable waste management and renewable energy generation.
- The study aims to conduct a comprehensive metagenomic exploration of the accelerated biotransformation dynamics occurring during vermicomposting and biogas production processes.
- By employing metagenomic sequencing techniques, we intend to unravel the intricate microbial communities driving the efficient degradation of organic matter and the production of biogas.
- Understanding these dynamics at a molecular level, we aim to identify potential strategies for enhancing the efficiency and sustainability of vermicomposting and biogas production practices.
- Finally, this research holds promise for informing the development of novel biotechnological approaches for waste management and renewable energy generation, contributing to advancements in both environmental sustainability and bioresource utilization.