13th INTERNATIONAL CONFERENCE ON HYDROGEN PRODUCTION

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Hydrogen for a Green Future

Book of Abstracts

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PREFACE

The International Conference on Hydrogen Production (ICH2P) is one of the key events initiated by Professor Ibrahim Dincer and his colleagues to highlight the state-of-the-art research going on in the area of hydrogen energy. It provides a unique opportunity for scientists, researchers, academicians, and engineers to present their research and findings in the area of hydrogen energy ranging from production to the storage and use of hydrogen in different applications such as fuel cells, power, and transportation. ICH2P does not cover only the recent trends in the area of hydrogen energy but also projects the future of hydrogen energy in the upcoming era.

Pakistan Navy Engineering College (PNEC) - National University of Sciences and Technology, Pakistan is honoured to organize the 13th conference this year on hydrogen production in collaboration with National Hydrogen Association, Turkey, International Association for Hydrogen Energy (IAHE), and Ontario Tech University.

In closing, we are thankful to our esteemed keynote speakers, invited speakers, and all the participants for making this conference a successful one.

Tahir Abdul Hussain Ratlamwala

Conference chair

Submission 166

Title **Design of metal hydride reactor for hydrogen supply to diesel engine**

Abstract Remarkable for the advantages of high fuel efficiency, large output power and long service life, diesel engine is restricted by the exhaust containing a lot of pollutants such as NO, CO and unburned hydrocarbon. In order to improve its environmental friendliness, a combustion system of diesel engine with mixed fuel by injecting hydrogen is proposed in this study. In this system, a magnesium hydride hydrogen storage reactor with rich sources, low price and high hydrogen storage capacity is designed to achieve safe and stable hydrogen supply. It is worth noting that this system can recover the waste heat of engine exhaust and provide the required heat for the reactor desorption process. In addition, a double closed-loop ratio control system is designed to control the injection time and mixed flow of hydrogen. To obtain the optimal emission effect, the numerical simulations have been performed with the various mixed mass fraction of hydrogen addition varying from 0% to 15% in 3% increments. The simulation results show that when the hydrogen mass fraction of the fuel is 3 wt%, the economy of emission reduction is optimal. When the initial torque of the engine is 60 N·m, the CO emission is reduced by 33%, while the 〖" NO" 〗_"X" is reduced by 25%, indicating that the emission performance of this diesel engine system has effectively improved.

Submission 259

Title **An Innovative Renewable Energy-Based Tri-generation System for Electricity, LNG and Hydrogen Production**

Abstract The sustainable disposal of waste is a huge challenge in the present era due to the globally generated waste in result of growing population and industrialization. Waste-to energy incineration is one of the most effective and sustainable waste disposal technique as compared to the landfill, anaerobic digestion, pyrolysis and gasification. It generates useful energy simultaneously reducing the waste volume to almost 90%. However, the efficiency of such plants is relatively low as compared to the conventional fuelled power plants due to the presence of higher moisture content that lowers it calorific value. Solar integration and waste heat recovery are the two proposed solutions that considerably increase the performance of the Waste-to-energy plants. In the present work, solar integrated waste-to-energy tri-generation plant is proposed and investigated that delivers electricity, liquefied natural gas and hydrogen production. Steam conditions at the inlet to the turbine are improved by adding parabolic trough solar collector as a heating source, while condenser of the power generating cycle exchanges heat to the organic Rankin cycle. Power output from organic Rankin cycle is utilized for hydrogen production through electrolyser, while flue gasses provide input heat source for the liquefied natural gas.

Submission 427

Title **Thermodynamic Analysis Of A Geothermal Based Integrated Multi-Generation System And Prediction Of Outputs Via Back Propagation Neural Network Using Matlab**

Abstract In this study, a multigenerational geothermal based system has been developed to obtain power from reheat regenerative Rankine cycle, cooling from double effect absorption cycle, portable water and brine from desalination, hydrogen from PEM electrolyzer, heating and drying effect as a secondary outputs from Absorption cycle. In this integrated system we have three subsystems which are investigated and analyzed on the basis of energy and exergy. EES software has been utilized for the said assessment. Thermal efficiency of the plant is found to be 48.64%. Geothermal source of temperature located is used as input. A Predictive Regression model based on Feed Forward Back Propagation technique is used in this research. The model predicts the Power Output, Mass flow rate of fresh water produced by taking temperature and mass flow rate of geothermal source and saltwater flow rate. All the data used for the back propagation neural network (BPNN) was acquired by the system formulated on EES. The exeregetic and energetic coefficients of performance (COP) are found to be .5047 and .6378, respectively.

Submission 438

Title **Design and Analysis of a novel biomass-based Multigeneration System using a Membrane Gas Separation-Based Bioreactor for Biohydrogen Production**

Abstract Energy and exergy analyses of an integrated system based on anaerobic digestion (AD) of sewage sludge from a wastewater treatment plant (WWTP) for multi-generation are investigated in this study. The multigeneration system is operated by the biogas and Hydrogen produced from the digestion process. The useful outputs of this system are power, freshwater, cooling, and hydrogen while there are some heat recoveries within the system for improving efficiency. An open-air Brayton cycle, as well as a proton exchange membrane fuel cell (PEMFC) using biohydrogen produced from membrane gas separation-based bioreactor (MGSBR), is utilized for power generation. Also, using the waste heat produced from the Brayton cycle, a humidifier dehumidifier system (HDH) is utilized for producing freshwater and a vapor absorption cooling system (VAC) is utilized for cooling.

Submission 530

Title **Sustainable Development in Green Energies, and the Environment**

Abstract The move towards a de-carbonised world, driven partly by climate science and partly by the business opportunities it offers, will need the promotion of environmentally friendly alternatives, if an acceptable stabilisation level of atmospheric carbon dioxide is to be achieved. This requires the harnessing and use of natural resources that produce no air pollution or greenhouse gases and provides comfortable coexistence of human, livestock, and plants. This article presents a comprehensive review of energy sources, and the development of sustainable technologies to explore these energy sources. It also includes potential renewable energy technologies, efficient energy systems, energy savings techniques and other mitigation measures necessary to reduce climate changes. The article concludes with the technical status of the ground source heat pumps (GSHP) technologies.

Submission 650

Title **A Hybridized Ship Powering System With Fuel Cells Using Hydrogen And Methane**

Abstract This paper concerns the development of a new hybridized powering system that uses environmentally benign hydrogen-based mixed with methane. The proposed powering system is uniquely designed and consists of an internal combustion engine (ICE), gas turbine (GT), solid oxide fuel cell (SOFC), and thermoelectric generators (TEG). This system is investigated thermodynamically using the Aspen PLUS simulations. The two traditional ICE engines produce a net power of 21048 kW with a 22.9% energy efficiency and 29.0% exergy efficiency. In conjunction with this, the hybridized GT and ICE system can deliver a maximum power of 24968 kW using a hydrogen-methane fuel blend. The engine energy and exergy efficiencies are 30% and 39%, respectively. The specific fuel consumption decreases to 273 g/kWh by 16%, and the carbon emissions are drastically decreased by about 35% by utilizing a sustainable fuel blend; meanwhile, the overall system performance is increased by more than 25%, respectively.

Submission 764

Title **Thermal, Exergy, And Economic Analysis Of The Fuel Cell Based Multigeneration System Integrated With Iso-Butane Power Cycle**

Abstract Although industrialization marks to the economy of a country yet it increases the pollution and temperature of the environment. The world is now shifting towards green energy because the utilization of fossil fuels is resulting in global warming. There is a dire need to utilize various technologies in order to develop our reliance on the renewable energy sources. In the current study, a biomass-assisted system is used to produce various outputs like fresh water, electricity, cooling effect, etc. The fuel cell is employed to consume the hydrogen-based fuel to power the proposed system. Moreover, the bleed steam that comes out from the high-pressure turbine of the regenerative power cycle has been utilized by the Isobutane power plant. The cooling effect was produced via a Li-Br-based Double Absorption cooling system. A detailed thermos-and-economic analysis was conducted. The rate of power produced by the regenerative power plant is 1407 kW while iso-butane turbine has power producing capacity of 773.3 kW. The fresh water production from the reverse osmosis system was almost 5.8 kg/s.

Submission 778

Title **Modelling and Simulation of Proton Exchange Membrane Fuel Cell(PEMFC) and utilizing it's output in an Industry**

Abstract Even though the Proton Exchange Membrane Fuel Cell (PEMFC) is sought to be an effective power source, about fifty percent of the energy generated by the electrochemical reaction is lost as heat due to the cathodic reaction being irreversible, there is an Ohmic resistance, and there are mass transport overpotentials. This study focuses on how the heat loss from the cell can be recovered and used as source of useful energy, ultimately increasing the efficiency of the cell. The paper further explains how PEMFC fuel cell, working along two external energy sources which are a part of a system using Kalina cycle to extract energy from every source to convert into work. This is to not only power an Industry but also used for wastewater treatment from the industry to regenerate oxygen and hydrogen through a hydrogen power plant, which will be used in fuel cell as well. Paper further presents an overview on the Kalina cycle; effects of the separator, recuperator and basic ammonia mass fraction are investigated. Furthermore, in this research, thermal efficiency of the Kalina cycle is one of the objective and optimum value of the efficiency of the Kalina cycle

is found to be 48.57%. At the optimum thermal efficiency, power of the cycle is calculated to be 34.8 kW and analysis of the choice to opt Kalina cycle over the conventional Rankine cycle is also done. Finally, in this paper a working Simulink model is made to calculate the response of cell against different types of input. This paper carries novelty.

Submission 1027

Title **Production And Use Of Hydrogen In A Phosphoric Acid Fuel Cell Employed In A Commercial Domain, Analysed Using A Matlab/Simulink Environment**

Abstract Hydrogen fuel cells are considered as an alternative to Lithium-Ion batteries as they have a far greater energy storage density than Lithium-ion batteries and are much more environmentally friendly options. Different types of fuel cells are being developed and are used as required. Furthermore, fuel cell technology is being introduced in electric vehicles due to their significant range advantage over conventional batteries. This paper is based on an analysis of Phosphoric Acid Fuel Cells (PAFC) and studies their mathematical model in SIMULINK. The H2 gas is produced in-house using pyrolysis to overcome the logistical issues with its transportation. An analysis of the system response under different ambient conditions was conducted. Moreover, the pressure of produced H2 gas is regulated or adjusted, and the variation of voltage output is noted. Our simulated use case is in the commercial sector however the scaling of the system is adjustable. The exhausted steam is used to generate electricity, further increasing the efficiency of the overall system. Lastly, a heat exchanger may be coupled with the fuel cell to make use of its operating temperature and heat water which can be used for domestic or commercial purposes as required.

Submission 1061

Title **Evaluation of bioelectrochemical hydrogen production from various feedstock**

Abstract Hydrogen is a high-density energy carrier suitable for power generation and direct combustion processes. It is considered a clean energy source due to its potential towards sustainable development. While hydrogen production is conventionally carried out using non-renewable fossil fuel sources, renewable and waste feedstock has been the focus of biohydrogen production. Among these, bioelectrochemical processes have emerged as promising technologies for biohydrogen production from various waste organic feedstock in recent years. This paper will examine various bioelectrochemical configurations investigated for bioenergy production. Energy performance, production capacities, economic and sustainability aspects of these configurations will be compared and discussed. Finally, technological limitations and process challenges to be overcome for advancing sustainable bioelectrochemical hydrogen production will be presented.

Submission 1307

Title **Thermodynamic Analysis Of High Temperature Proton Exchange Membrane Fuel Cell (Ht-Pemfc) With Consideration Of Efficient Energy Recovery System**

Abstract In addition to battery electrification and renewable fuels, hydrogen has the potential to be a revolution that will have a significant impact on the development of the carbon-neutral society of the future. A fuel with characteristics like hydrogen can lower the overall amount of greenhouse gas emissions. A fuel cell utilizes the chemical energy of Hydrogen or other fuels to efficiently generate electricity. Using Hydrogen and Oxygen as inputs we get electricity, steam and heat. It offers the possibility of zero-emission electricity generation. In this paper, we will be focusing on the thermodynamic analysis of a power generation system consisting of a Proton Exchange Membrane (PEMFC) fuel cell whose solid electrolyte system also averts the need to contain corrosive liquids and is thus preferred by many developers over alkaline, phosphoric, or molten carbonate fuel cells. An operating temperature of 100–200 °C is desired which will allow for the co-generation of heat and power. Waste heat recovery is also done using the Rankine Cycle which is a process used to harness the thermal energy of a fuel or other heat source using a pump, heat exchangers, turbine and a condenser to generate work. MATLAB/Simulink R2022a is used for the modelling of this power generation system.

Submission 1399

Title **Membrane Technology Enhancing Integration Of Hydrogen In Hard-To-Abate Sectors Of The Global Economy**

Abstract Hydrogen will play a key role in the decarbonisation of hard-to-abate sectors such as transportation, iron & steel, cement, and chemicals. These sectors will constitute the pillars of the tools necessary to empower global emission reduction targets. While the progress had so far been stalling and challenges remain, including Russia's war against Ukraine which has resurrected deep fault lines in international relations not seen since after the Cold War. The resulting sanctions against Russian oil and gas have created a rush to exploit more fossil fuels causing demand spikes making energy security a priority and putting climate change policy in the background. Nevertheless, recent climatic events ranging from record floods in Nigeria and Pakistan to record droughts in China and parts of Europe exacerbated by heat waves continue to remind the world that climate change is real, and the problem is worsening. Opportunities for membrane technology in a rapid transformation of hard-to-decarbonise sectors are there for the taking.

Submission 1471

Title **Modelling And Simulations Of Pemfc Along With The Combination And Utilization Of Various Renewable Energy Resources To Produce Power To Run A Green Campus On Matlab Simulink**

Abstract The PEMFC is a sustainable and environmentally friendly source of renewable energy. This paper incorporates the modelling of PEMFC on MATLAB SIMULINK alongside the waste energy recovery system of the fuel cell by introducing the MERCURY CYCLE for the recovery of the heat of the PEMFC as it can be run on low heat output. The MERCURY CYCLE output response is also modelled and studied. The variable inputs, like the concentration and pressure of H2 and O2, were taken as ramped inputs blocks, whereas the waste heat from PEMFC is taken as constant blocks. Also, the biomass heat input, the solar, PEMFC CELL

operating temperature and wind energy output were all taken as constant block. The fuel cell used is the BALLARD V MODEL and designed using the same concepts and equations, whereas the use of unique heat recovery system and multiple energy sources bears novelty. The PEMFC gives a power output of 8.325 KW (combined output of 100 cells). This output of the cell is used to run a grid system that supplies power to the CAMPUS BLOCK. A wind turbine and solar panels are also installed in parallel with the PEMFC to provide additional power to the grid system. Thus, the overall power produced is the sum of PEMFC, WIND TURBINE and the MERCURY CYCLE outputs. The heat produced as the by-product of the cell is used to run a MERCURY CYCLE from which a turbine is run, and power is produced, which is supplied to the computer labs and research laboratory, in contrast the water vapors from PEMFC are condensed and cooled to provide water to the laboratory for various cleansing purpose. MATLAB SIMULINK R2018a is used to model and study the PEMFC, MERCURY CYCLE, and the WIND TURBINE outputs

Submission 1540

Title **Ultrasonic pretreatment of algal biomass for enhanced biogas and biohydrogen production via anaerobic digestion**

Abstract Enteromorpha is a kind of red tide that is seriously contaminating the sea. It is rich in protein, carbohydrates, crude fiber, and minerals. Therefore, micro-organisms can degrade it to produce biohydrogen (Bio-H2) through anaerobic digestion (AD). Algae biomass is a potential feedstock for bio-energy production. However, due to its complex structure, including resistant cell walls, hydrolysis of algal biomass often is slow and incomplete, leading to ineffective extraction of lipids. This study focused on ultrasonic (US) pretreatment of Enteromorpha before AD. The aim of pretreatment is the dissolution of cell walls. The pretreatment process is optimized by using response surface methodology (RSM). Batch experiments were conducted to optimize the AD process of green algae at different temperatures (25–45 oC), initial pH (5–9), and US pretreatment time range (5–15 min). The cumulative biogas, biohydrogen (% v/v) production, and other soluble indexes for control and optimized values are presented. In addition, two mathematical kinetic models named Modified Gompertz Model and Logistic Function Model are used for finding the effect of US pretreatment on the enhancement of reaction kinetics. The kinetic parameters, such as the biogas production potential (Bp), the maximum biogas production rate (MBPR), and the biogas production delay time (BPDT), were calculated for each experimental case. The results showed a 14% and 32% (v/v) increase in biogas and biohydrogen production, respectively, compared with the control sample. This study is applicable to all lignocellulose and other biomass with resistant cell walls or cellulose structure to improve the hydrolysis stage to produce a high amount of energy.

Submission 1613

Title **Modeling Of Hydrogen Production From Microwave Steam Plasma**

Abstract Hydrogen, as an effective energy carrier, plays a vital role in replacing fossil fuels with renewable energy. However, hydrogen production methods are still under extensive investigation to obtain the most feasible way. In this study, hydrogen production is proposed through microwave steam plasma. The system is modelled and solved numerically in the COMSOL Multiphysics software. Forty-one reactions and fourteen species are considered for the steam plasma kinetics. In the case of 800 W microwave power and 110°C steam temperature, hydrogen production rate and energy efficiency are found as 0.48 µg/s and 3.32%, respectively. Moreover, it is parametrically demonstrated that steam temperature enhances the system performance.

Submission 1787

Title **Hydrogen Fuel Cell**

Abstract Nowadays where everything is based around protecting the environment and reducing global warming, people are trying to find cleaner ways of producing energy one such way is using hydrogen fuel cells. Minimization of greenhouse gases from vehicles while big car manufacturers are going towards hybrid and fully electrical path, but there is another route which is using hydrogen technology, is dis fuel cell cars. Energy unit vehicles use hydrogen gas to produce power which is stored batteries. Regular vehicles create power from gas or diesel combustion, fuel cell vehicles use hydrogen gas which is combusted with oxygen gas to create power. That power created then used to drive the wheels. Hydrogen gas is drawn from an installed tank that responds on the spur. In the cycle hydrogen electrons are separated, liberating them to power the electric engine and control a vehicle. There are some problems related to the fuel cell technology relating safety efficiency and power output that halts its production but with further enhancing technology, the fuel cell can be perfected and provide a form of energy for cars that can be an efficient and easy to use. Fuel cells can cover some of the short comings of electric vehicles further explained below, on the contents of a fuel cell car and the individual components required. Fuel cell technology can be a great asset in the future.

Submission 1820

Title **Feasibility Of A Renewable Multi-Power Energy System Involving The Use Of Fuel Cell In Multi-Purpose Farm-House Environment Via Simulation In Matlab/Simulink.**

Abstract Non-renewable sources have conventionally been used for energy which produce a large waste material which harm the environment. As such, there are major incentives to develop renewable sources. This paper aims to produce a multi-power generation system with an emphasis on renewable energy sources. PEMFC Fuel Cells & supporting sub-systems such as solar cell as electrolyzer & bio-gas reactor for recycling have been implemented. A closed loop turbine shall reuse waste heat. We expect 450 Watt power generation from turbine with an efficiency of 30%. This power shall be employed the processing of sugar cane in industry & its refining and reuse of its material. For our specific case, we have simulated a farm-house environment. Our system shall play a role in all potential uses; energy for harvesting machinery & household power, house heating, bio-gas sludge for fertilizer. We shall observe further recyclability via animal and plant waste to produce a symbiotic output for the system. Modelling & simulation of the sub-system is made via Simulink/MATLAB. This allows us to research various scenarios by manipulating O2 Input, Temperature etc. and corresponding outputs to optimize our system and produce renewable system with feasible power output with great future energy prospects.Fuel Cells, Renewable Energy, Bio-Gas Reactor, Solar Cells, Simulation Analysis

Submission 2033

Title **Gas Transport In Low-Content Platinum Dispersed Porous Membranes**

Abstract A key aspect in controlling the catalytic membrane properties containing disperse platinum group metals is the adjustment of the morphology and physicochemical properties of the catalytic phase existing within the porous network of the substrate material. It is desirable to provide a high catalyst surface area per unit volume without destroying the membrane perm-selectivity. The TiO2/γ-alumina membrane supports are tubular ceramic membrane comprising three concentric layers with average pore diameters 12 μm (outer), 0.2 μm and 4 nm (inner). The preparation process is based on dip-coating and resulted in active metallic

particles of average diameter 1.3 nm, with 0.2, 0.04 and 0.02 weight per cent metal being deposited in the pore structure.

Submission 2120

Title **Hotel Power Supply Using Molten Carbonate Fuel Cell**

Abstract This abstract presents a sophisticated dynamic model for a molten carbonate fuel cell (MCFC) that incorporates geometric resolution and dynamic modelling of physical and electrochemical processes in the stream-wise direction. The model was created utilising electrochemical and chemical reaction processes, mass and momentum conservation, and heat transfer. The model's output is contrasted with information from an experimental MCFC unit. The model was also used to forecast the dynamic changes in voltage, current, and temperature that an MCFC would experience in response to shifting load demands. Another uses typical local pressures and temperatures to simplify equations. The findings demonstrate that both models may be used to forecast the voltage and dynamic response properties of an MCFC, and the Simulink model both confirms the findings and displays voltage production as an output.

Submission 2167

Title **Servi Dut Pekmezi (Mulberry Molasses) Thin Films: Preparation, Characterization And Application As Anode Materials For Direct Methanol Fuel Cells**

Abstract One of the drawbacks of the electrodes in direct methanol fuel cells (DMFC) is their oxidation or corrosion. The coating electrode surface with conductive and protective films may provide good protection. In this study, a novel thin film was applied a substrate for this aim. For this aim, self-assembly monolayer (SAM) film of Servi Dut Pekmezi (mulberry molasses, Servi MM) was fabricated on a copper electrode (Cu/Servi MM-SAM). The film was assembled in an absolute ethanol. The modified electrode was tested as anode for electrooxidation of methanol in 0.1 M KOH solution in the presence of 1 M CH3COOH solution. Surface characterization studies indicated that a very adherent and homogenously distributed SAM film was assembled on the copper surface. The film was very durable. The films enhances the rate of methanol electrooxidation with respect to the bare copper. The increased activity was assigned to the presence of many electroactive and charge transfer activity of components in the assembled film and increased surface porosity.

Submission 2343

Title **Hydrogen Potential From Hybrid Solar And Hydro-Piezoelectric Energy Harvesting System**

Abstract One of the major concerns for the world is the rapid depletion of hydrocarbon reserves and the subsequent increase in global warming due to the excess usage of said resources. Renewable energy resources are the alternative, and researchers struggle to increase energy density and consistency. An experiment has been conducted to evaluate the integration of solar PV, Piezoelectric and Proton Exchange Membrane (PEM). The data has been collected from the first two sources through a lab-scale experiment using a water tunnel coupled with a solar simulator. Hydrogen production has been estimated through numerical calculations, which can serve as a consistent energy source. The proposed system has three advantages stacked together, i.e., the energy density has been increased due to the reduction in solar panel thermal losses, less evaporation rate of water and the production of hydrogen. Results

showed that the energy density was increased by up to 5% for a PV of 0.01m2 approximately. Solar energy loss due to heating was also reduced by up to 7%.

Submission 2406

Title **Simulink Model Multi Generation System Based On Phosphoric Acid Fuelcell Stack, Steam Turbine And Wind Power Generation**

Abstract Fuel-cell power technology, which has various benefits including tremendous power efficiency and excellent environmental compatibility, is one of the most promising new power-generation technologies. To fulfil the rising energy demand, there is a greater need for renewable energy sources due to the limited availability of conventional energy carriers. Our initiative primarily focuses on phosphoric acid fuel cells (PAFCs), outlining how they work and offering ideas for practical uses. The numerous components of PAFCs, such as the electrolyte, catalysts, and bipolar plates, are listed along with their proportionate contribution to the final product. This abstract describes how acid leaching causes numerous cell components to degrade. We will also discuss how scientists helped develop the first phosphoric acid fuel cells. Bipolar plates must have anticorrosive coatings to increase cell performance and increase cell life Significant improvements have been made in PAFC modelling (Simulink model), and this work will be evaluated. The following section will cover a range of applications with power ratings from 20 kW to 500 kW as well as impending technical and material requirements. Additionally, we recycle extra hydrogen and use it in regeneration. Fuel cell heat is used to generate output through the Rankine cycle. Wind turbine electricity is used to run the pump and condenser. In addition to being a cogeneration system, electricity is used in companies, hospitals, hotels, sewage treatment plants, schools, and other establishments. We use a range of energy sources, such as fuel cells that use the heat produced by chemical reactions and tidal wave electric generating.

Submission 2670

Title **From Various Bio-Sources To Green Hydrogen Production: A Critical Technical Comparison And Discussion**

Abstract Hydrogen production is of paramount importance nowadays as it displays a wide range of applications either as a chemical compound, zero-emission fuel, heat source, or as a power energy carrier. Hydrogen is commercially produced from various raw-materials (i.e., fossil fuels such as natural gas and coal, or renewable sources such as biomass, biogas, bioethanol, bio-glycerol, etc.) using diverse technologies (i.e., reforming, gasification, fermentation, etc.). The present research is focused on the green hydrogen production using different bio-sources as feedstock. Hydrogen is produced starting from biogas, bio-glycerol, and bioethanol obtained from corn stover and cereal straw following either reforming or fermentation as manufacturing technologies. Four scenarios for green H2 production were simulated and evaluated using a commercial process simulation software (i.e., ChemCAD). As benchmark case hydrogen production using natural gas steam reforming was considered. All cases consider a hydrogen productivity of 1,000 kg/h and a purity higher than 99%. The main model's assumptions, as well as discussions in regards to the most relevant technical key performance indicators (i.e., productivity, purity, and thermal and electrical energy consumption/generation) are reported.

Submission 2883

Title **Hydrogen Transport From Gas To Liquid Phase (Water): Comparison Of Palladium And Platinum Membrane Catalyst Systems In Three Phase Reactions**

Abstract Hydrogen transport from gas to liquid phase (water) through palladium and platinum-dispersed membrane catalysts was investigated in connection with dissolved oxygen removal. The hydrogen flux in three phase transfer was considerably reduced compared with that from gas to gas in two-phase transfer. The reason of such a significant reduction in the flux was discussed by analysing the mass transfer resistances caused by solubility issues. Tests on the catalytic properties of the membrane for the removal of dissolved oxygen from water, showed that the properties of platinum and palladium particles within the porous network were very similar to those of a conventionally supported catalyst (platinum 0.6 weight per cent, 1.5 nm average particle diameter).

Submission 2966

Title **Performance analysis of a solar assisted optimized combined heat power plant utilizing a heat recovery steam generator (HRSG) for hydrogen production and multiple outputs**

Abstract In this study, a parabolic trough collector (PTC) integrated with a conventional gas turbine and a steam cycle assisted with a heat recovery steam generator (HRSG) is proposed. The proposed configuration is capable of producing multiple important outputs like electricity, hydrogen, freshwater from a feed of seawater, and district heating. A comprehensive thermodynamic study was carried out with certain design parameters was also taken into account. Crucial parameters for the whole cycle like compression ratio of the gas turbine and evaporation pressure were varied and different results were plotted against them. An optimized configuration was also proposed keeping in lieu the compression ratio and evaporation pressure, and finally, the best compromise was highlighted. The power production from the proposed multigeneration cycle and rate of hydrogen production was also reported. The rate of hydrogen, one of the objective functions for our study was reported to be around 650 mg/s.

Submission 2983

Title **Improvement Potential of a Liquid Air Energy Storage and Multigeneration System Based on Advanced Exergy Analysis**

Abstract In this study, an advanced exergy analysis was applied to a liquid air energy storage (LAES) system which can simultaneously produce electricity, refrigeration, heating, and hydrogen. The analysis was to determine the endogenous, exogenous, avoidable, and unavoidable exergy destruction in the system. The findings reveal that the avoidable exergy destruction is highest in the compressors, turbines, and the ARS. The avoidable endogenous exergy destruction is also highest in the compressors, turbines, and PEM which gives them priority for improvement that can benefit the system.

Submission 3121

Title **Solar Photovoltaic Systems Thermal Efficiency Improvement Through Low-Grade Heat Extraction And Hydrogen Production Through Methanol Steam Reforming**

Abstract In this study, real-time temperatures are measured on the back surfaces of solar panels installed in a parking lot to increase solar PV efficiency at lower temperatures by cycling water on the back surfaces. Solar panels heated water is utilized to generate hydrogen by utilizing low gradient heat (30-40C0) and Methanol Steam Reforming (MSR). One week of back surface temperature measurements is performed on Grid-Tied PV panels during peak seasons. The Ansys software is used to simulate heat extraction through water based on real-world data. Ansys results are used to calculate the total heat availability from the 100 KW grid-tied solar PV system. A mathematical model has been prepared to calculate the energy savings while utilizing solar PV-extracted heat to produce hydrogen through MSR.

Submission 3171

Title **Thermodynamic Assesment Of A Novel Geothermal And Solar Integrated Multigeneration System With Hydrogen Generation**

Abstract The aim of this paper is to present a multi-generation cycle that works completely based on renewable resources without having any harmful effect on the environment. This system uses Parabolic Trough Collectors (PTC) for collecting solar energy to heat water. This water is used to run a Power Cycle, Vapor Absorption Cycle (VAC) and to heat water. We extract hot water from the earth and use it to generate electricity, space heating and to produce fresh water and hydrogen. The system works on the basic thermodynamic principles, but it uses renewable resources such as solar energy and geothermal energy to produce power, hydrogen, and fresh water. VAC is used to produce cooling. Renewable resources do not harm environment, so we can use them without worrying about environmental and health crisis, as compared with other resources such as coal or oil which harm atmosphere and atomic energy which causes health problems in workers and it also needs careful handling and radioactive waste if disposed of improperly causes severe environmental and health problems.

Submission 3192

Title **Analysis And Performace Evaluation Of A Hydrogen Producing Renewable Based Multi-Generation System**

Abstract This paper proposes a new renewable energy based multi-generation system which incorporates parabolic trough solar collectors and geothermal energy system to simultaneously generate Hydrogen, electricity, heating, cooling, dry air, fresh water, and hot water. Two Rankine Cycles are used to produce power for electricity and are operated with the same fluid which increases the overall efficiency of the cycles. Useful heat is obtained from the condensers of the Rankine Cycles to operate a Heat Pump and Absorption Chiller to produce space heating, cooling, and hot water. Psychometric study is employed for obtaining the properties and quantity of the dry air being generated. The performance of the system is determined by examining all system components through energy and exergy analysis methods and for a selected case, the overall energetic and exergetic efficiencies of the system are 78% and 64% respectively. Furthermore, to improve the system's performance, parametric and optimization studies are conducted in EES which also let us observe the effects of various inlet and operating conditions on the efficiencies of the overall system and subsystems. In addition to this, MATLAB SIMULINK is also used to analyse the stability of PID controllers located at various points in the system to control the mass flow rate of different fluids which let us maximise the system's overall performance. The system is designed considering the natural environmental conditions of San Diego, California.

Submission 3253

Title **Performance Enhancement Of A Compact Solar Reforming Membrane Reactor Enhanced With Multi-Helical Inserts**

Abstract The concentration polarization phenomenon is a key factor affecting the performance enhancement of solar membrane reactors. To enhance the membrane reactor performance, this study proposes a multi-helical insert reinforced solar methane reforming membrane reactor from the purpose of weakening the concentration difference polarization. Based on the validated three-dimensional multi-physical field coupling model, the effect and mechanism of the helical inserts on the performance of the membrane reactor are investigated. The results show that the helical inserts can significantly and comprehensively improve the membrane reactor performance, especially the 4-helical inserts have the best effect, bringing 16.0%, 17.1% and 16.5% improvement of methane conversion, fuel efficiency and hydrogen recovery, respectively, to the membrane reactor. The major reason is that the helical inserts exchange the hydrogen between the inner and outer sides of the reaction zone well and improve the radial distribution uniformity of hydrogen products in the membrane reactor. The decrease of hydrogen concentration on the outer side of the reaction zone deepens the degree of reactant conversion, while the increase of hydrogen concentration on the membrane side increases the hydrogen partial pressure and improves the hydrogen separation efficiency by 36.5%, which significantly weakens the concentration polarization at the membrane tube.

Submission 3281

Title **A Comparison Analysis Of Production And Storage Of Liquefied Synthetic Natural Gas And Hydrogen With Boil-Off Gas Recovery**

Abstract Synthetic fuels provide variety of advantages that go beyond reducing carbon emissions. With comparable physicochemical qualities to conventional fuels, synthetic fuels may be utilized in existing vehicles and with the present infrastructure. Therefore, the purpose of this study is to compare synthetic fuels namely, liquefied synthetic natural gas and liquefied synthetic hydrogen from technical perspectives. Technical analysis is implemented to calculate how much energy is consumed to produce and store liquefied synthetic fuels. The generated boil-off gas during storage phase is proposed to be recovered and utilized. The results indicate that the total energy consumption to produce 1 MJ of liquefied synthetic natural gas and liquefied synthetic hydrogen is 0.63 kWh and 0.52 kWh respectively. Production of liquefied synthetic natural gas consumes 21% more energy compared to liquefied synthetic hydrogen. Moreover, energy consumption to store liquefied synthetic natural gas and liquefied synthetic hydrogen in a 2,000 m3 on-land storage tank with 100% boil-off gas recovery for 1 day is 25 kWh and 145 kWh respectively. Even though the process to produce liquefied synthetic natural gas is energy-intensive process, it offers efficient energy storage solutions compared to liquefied synthetic hydrogen. Finally, improvement of the liquefied hydrogen storage characteristics results in reducing the generated boil-off gas which consequently improve liquefied hydrogen supply chain effectiveness.

Submission 3355

Title **An Approach to Solve Farmer-Herder's clash through Energy, Water, Food Nexus for Sustainable Development in Rural Communities in Northern Nigeria Using a SOFC integrated Polygeneration Energy System.**

Abstract Fuel cells, thanks to their high electrical efficiency, reduced emissions, and useful heat output, have been singled out as a crucial technological solution for improving energy efficiency and lowering emissions in the face of rising climate change concerns and the ever-increasing cost and scarcity of fuel resources. In this paper, thermodynamic analysis was used to look at an integrated technological strategy that uses renewable energy and polygeneration to strengthen the security of the energy-water-food (EWF) nexus using the conflict between herders and farmers in rural North Central Nigeria as a case study. The system uses a biogas-powered SOFC plant. It produces hydrogen, hot water for dairy, energy, cooling, and drinking and irrigation water. The system is simulated under steady state conditions and the performance of the entire system was also observed under various operating conditions.

Submission 3436

Title **Design Of A New Cement Plant Multigenerational System With Hydrogen Production**

Abstract The presented article aims to design and analyse of a new and unique multigeneration system. The new multigeneration system primarily produces methane or natural gas by extracting the CO2 from cement production through processes such as calcium looping. The H2 generated in the system was synthesized through electrolysis which was supported by hydroelectric power. After this, a portion of the hydrogen produced from the system is reacted with the CO2 to produce methane. The other useful outputs of the system include electricity and space heating. The implemented system design also harnesses other renewable resources, such as solar energy and biomass, to enhance other aspects of its design. The system has an achieved hydrogen and methane production rate of 5.88E-4 kg s-1 and 1.17E-3 kg s-1, respectively.

Submission 3526

Title **Optimization of NaOH-Urea Pretreatment for Biogas Enhancement from Kitchen Waste Anaerobic Digestion**

Abstract As the level of urbanization in the world is intensified, the disposal of kitchen waste as the main part of municipal solid waste (MSW) has become more and more challenging. Kitchen waste accounts for 40–60% of MSW. Kitchen waste has the characteristics of high water content, high organic content, and easy to decompose. If not properly resolved, it will pollute the groundwater, result in greenhouse gases, and the smell problem causes a severe impact on the urban living environment. Based on the nature of kitchen waste, anaerobic digestion (AD) technology has advantages in kitchen waste treatment, such as harmless disposal and co-production of clean biogas. The present study aims to explore the effect of NaOH-urea pretreatment on the anaerobic digestion of kitchen waste and sludge. The pretreatment process is optimized by using response surface methodology (RSM). Batch experiments were conducted to optimize the AD process of kitchen waste at pretreatment time (10 – 50 min), NaOH-urea concentration (10 - 30 g/L), and pretreatment temperature (-40 – 40 oC). Results showed that a high concentration of NaOH-Urea and low pretreatment temperature enhanced biogas yield. In addition, two mathematical kinetic models named Modified Gompertz Model and Logistic Function Model are used for finding the effect of US pretreatment on the enhancement of reaction kinetics. The kinetic parameters, such as the biogas production potential (Bp), the maximum biogas production rate (MBPR), and the biogas production delay time (BPDT), were calculated for each experimental case. The most increased biogas production of 316 ml was achieved by 30g/L-5 oC group, whereas 10g/L-20 oC group produced 111 ml of biogas. This study is applicable to all lignocellulose and other biomass with resistant

cell walls or cellulose structure to improve the hydrolysis stage to produce a high amount of energy.

Submission 3547

Title **Development Of A Linear Fresnel-Based Multigenerational System With Solid-Oxide Electrolysis For Hydrogen Production**

Abstract The present study investigates a linear Fresnel concentrated solar plant driven multigenerational system to produce power, heat, cooling, and hydrogen for a community. A time-dependent analysis is carried out in order to investigate the intermittent availability of the solar system and develop an operational strategy due to the available energy. The overall system is investigated with thermodynamics basis approach from energy and exergy points of view. A 645 MWt capacity linear Fresnel solar plant with a solid-oxide electrolysis system can generate up to 47.3 tons of hydrogen in a day, according to the simulations.

Submission 3793

Title **Gamma Alumina washcoated FeCrAl foam supported catalyst for hydrogen production by dry reforming of methane**

Abstract CO2 reforming of methane to produce syngas is a very important reaction with relevance to the industry and environment. Several Pd containing catalysts were synthesized using various wt% of Pd supported on the washcoated alumina over FeCrAl foam. These Pd catalysts revealed good performance in dry reforming of methane at temperature 500 -900 0C. Among the selected amount of Pd as catalyst material (1, 2 and 4 wt%), maximum conversion of CO2 and CH4 were obtained using a 2 wt% Pd supported catalyst at a reaction temperature of 900)0C and H2 yields of 65.53 % were produced. The catalyst loading above 2 wt% metal content led to a decreased activity probably because of the agglomeration effect. Further, the reforming efficiency of Pd for dry reforming reaction was also influenced by the calcination temperature employed for the preparation of the catalyst. The Pd catalyst calcined at 750 0C for 3 hrs showed enhanced activity for dry reforming of methane as compared to that calcined at 500 0C for 3 hrs. A clear trend of increasing conversion and yield was found with increasing employed calcination temperature. The prolonged calcination time at 750 0C beyond 3 hrs affected the catalyst activity to a smaller extent. Besides the reaction conditions, XPS analyses showed oxidic phases of active material in the form of PdO. Furthermore, the XPS spectra also revealed the stability of catalyst during employed reaction conditions.

Submission 4023

Title **Performance Assessment Of A Hybrid Sulfur-Bromine Cycle-Based Hydrogen Generation For Residential Use**

Abstract In this study, an assessment of a renewable energy-based hybrid sulfur-bromine cycle for hydrogen generation is performed. The hydrogen, produced by the thermochemical cycle, is blended with natural gas and supplied to the community to provide electricity and heating. A desalination unit is also integrated to produce freshwater for the community consisting of 10,000 houses. The integrated system is analyzed through the energy and exergy approach. Here, a 0.71 kg/s of hydrogen and natural gas blend is provided to meet electricity and heating requirements by a gas turbine, a combi boiler, and a gas cooker. A total of 2.97 MW net electricity power is obtained by the gas turbine and an organic Rankine cycle. Moreover, a monthly freshwater need of 8.9 m3 is provided by a multi-effect distillation unit per house. The energy and exergy efficiencies of the hybrid sulfur-bromine cycle are calculated as 27.85% and 29.32%.

Submission 4072

Title **Energy & Exergy Analysis of Electricity & Hydrogen Generation System using Geo-thermal Sourced ORC with Zeotropic Mixture for local district in Pakistan**

Abstract Northern areas of Pakistan are abundant in their natural resources, including geothermal, hydro and solar energy. However, the immense potential these resources goes largely unused. Being a far and distant location, electricity supply is not readily available to many of its places, limiting their growth and development. Tatta-Pani village in Poonch district of Azad Kashmir, is one of such places. This paper presents an Organic Rankine Cycle (ORC) based power and hydrogen generation system utilizing locally available geo-thermal resources. The proposed system uses zeotropic mixture as working fluid to generates 840 kW of power. In this study, the selection of effective zeotropic mixture for the local environmental conditions is described, first law analysis and second law analysis of the analysis of the proposed system is presented.

Submission 4102

Title **Energy and Exergy Analysis of Renewable Source Multigeneration System**

Abstract In this study we designed and simulated a comprehensive multi-generation system providing power, heating, cooling, hot air and dry air for a complete, independent and sustainable off-grid solution. Furthermore, control system analysis was performed using the "MATLAB Simulink" package. For the sustainability, the system was powered by renewable energy sources including a solar parabolic trough collector and biofuel. The system comprised of combined brayton and rankine cycles (operating in binary fashion) with a heat exchanger between them. Power was produced by the cycles in addition to heat rejected which was further utilised in producing hot water among other things. A vapor-absorption cycle was installed to provide the cooling and dry air. The energetic and exergetic analysis of the system was performed whereby the efficiencies and heat and work transfers were evaluated using the Engineering Equation Solver (EES) software package. Furthermore, the system parameters were studied under control theory and PID controllers were installed and fine-tuned. Root-locus analysis was performed and the response curves were obtained for the various transfer functions. Finally, the results were interpreted and validated against the standard literature.

Submission 4206

Title **Water Footprint Of Renewable Hydrogen Production Technologies**

Abstract Water scarcity is a major problem that affects many regions of the world. Water demand, industrialization and climate change contributes to water scarcity. Even though the humanity tries to avoid carbon-based fuels to mitigate climate change, water scarcity is a significant problem humanity yet to challenge. On the other hand, alternative clean energy sources were aimed to avoid fossil fuels. Hydrogen is a promising alternative fuel for energy. However, clean hydrogen production technologies utilize water instead of fossil fuels. This poses a new risk as water scarcity while the renewable hydrogen demand expected to be 130 million metric tons per year by 2050. Therefore, in this study, water consumption of various hydrogen production technologies was assessed by using life cycle assessment methodology. In the life cycle assessment study, the values for AEL and PEM in electrolysis methods in which nuclear energy is used as an energy source were found to be 4.34 and 4.53 m3/kg H2, respectively. The system with the lowest water consumption is conventional hydrogen production.

Submission 4314

Title **Hydrogen Production Using A Multi-Generation System With Pid Stabilisers**

Abstract This paper focuses on the rising concerns of a shortage of non-renewable energy sources soon following the energy crises. The following analysis is done to construct a dynamic solar-wind hybrid multi-generation system to meet the energy demands by means of renewable energy sources in the future. The system depends on green and clean energy to ensure safe environmental effects and a major reduction in the harmful release of pollutants. The energy and exergy analysis and calculations are generated by developing and constructing the codes in Engineering Equation Solver software. The dynamic modelling and stability analysis are done on MATLAB (SIMULINK). The release of residual heat by Heat Pumps, Vapour Compression Cycles, and Rankine systems in the environment is efficiently reused by the concept of regeneration of residual heat and converting it into space heating, space cooling, filtration for freshwater, hot water, and dry air. The combined exergy efficiency of the system is 66.02 % and the energy efficiency of the system is 61.32 %.

Submission 4435

Title **Material Reliability in Hydrogen Storage Applications and Transportation- A Review**

Abstract In the recent years, the enormous emission of carbon from corporate business sectors have motivated the industries to revisit hydrocarbon fuel options green energy sources. Hydrogen is one of the potential green energy source which has been considered as replacement of hydrocarbon fuels in wide industrial sectors. At present, managing hydrogen in terms of its storage, and transportation is challenging primarily because of its small size, issues related to energy density vis-à-vis volumetric and gravimetric density, reversibility criterion for the charging/discharging and reaction towards engineering materials. This review will summarize the performance of different engineering materials widely used in a hydrogen environment; listing conventional to advanced materials. An overview of the different hydrogen damage mechanisms is given to understand the role of hydrogen in the failure of materials in storage applications. Overall, this review highlights the performance and reliability of various materials used in storage applications in a hydrogen-rich environment.

Submission 4621

Title **A Numerical Study On The Dynamic Response Behavior Of Proton Exchange Membrane Water Electrolyzers Under Renewable Energy Fluctuations**

Abstract Proton exchange membrane water electrolyzer (PEMWE) is a promising technology for large-scale hydrogen production via renewable energy sources. However, it has to face the huge challenge from the uncontrollable output fluctuation of renewable energy sources. Unfortunately, the dynamic response regularities of the PEMWE cell physical parameters under fluctuating input are beyond the existing researches focusing on steady state processes. To make up for this deficiency, in this paper, a three-dimensional multi-physics model, which involving mass and heat transfer, fluid flow, hydrogen crossover, and electrochemical reactions, is developed to simulate the dynamic responses of the PEMWE under a fluctuating input condition. A 60 s simulation is conducted under the fluctuating form of square wave and then the responses of critical parameters are analyzed. The results show that when the current density is suddenly increased, the overshoot phenomenon occurs in the response of O2 molar fraction due to the instantaneous accumulation of oxygen in the catalyst layer. The membrane temperature undergoes a sharp rise/fall process within 0.2 s around the fluctuating point, which would deteriorate the membrane durability in the actual long-term operations. The anode H2 in O2 vol.% exceeds the normal stable value by about 0.1% in an instant when the current density is decreased from 2 to 1 A cm-2, which should be avoided for safe operations.

This wok provides a better understanding of the parameter behaviors under fluctuating conditions, which is hard to be observed directly in the experiments

Submission 4983

Title **Investigation Of H2 Production From Flue Gas Methane Reforming Using Nanoparticle Magnesium Oxide Modified Gamma Alumina Membrane**

Abstract Catalytic methane (CH4) reforming experiments using a typical flue gas mixture containing O2, CO2 and N2 were carried out in a tubular membrane reactor at a temperature of 800 °C and 900 °C using four different total feed volumetric flowrates (517, 994, 1,656 and 3,312 mL/min) to determine the conversion rate of CO2, O2, and CH4 to syngas (H2 and CO). Gamma alumina porous membrane support was modified with magnesium oxide nanoparticles using the dip-coating technique. The synthesized membrane was characterized by scanning electron microscopy (SEM) coupled with energy dispersive x-ray (EDAX). The gaseous feed and products were analysed using a Varian CP – 3800 gas chromatograph equipped FID and TCD detectors. The CH4, O2, and CO2 conversions and the H2/CO ratios were calculated using an iterative method and closing the mass balances to within a ± 5 % error margin.

Submission 5257

Title **Analysis Of The Energetic, Economic, And Environmental Performance Of Hydrogen Productions**

Abstract In this work, process simulation is used to calculate material and energy balances for several different hydrogen production processes. Process simulation outcomes are then used to estimate three key performance indicators: the energy return of energy invested, the levelized cost of hydrogen and the life cycle assessment. We compared several hydrogen generation processes, each denoted by a unique colour code: (i) green hydrogen, produced by electrolysis of water using electricity from renewable sources, (ii) grid hydrogen, produced by electrolysis using grid electricity, (iii) grey hydrogen, produced from natural gas using steam reforming and (iv) blue hydrogen, like grey one, but coupled with carbon capture and storage. In conclusion, the most sustainable hydrogen production method is the green hydrogen, produced by water electrolysis.

Submission 5440

Title **Systematic Analysis Of Energy Output From A Pemfc Pertaining For Providing Power To The Electrical Grids Along With Steady Operations Of Cold Storage And Water Treatment Plant**

Abstract Fuel cells are described as electrochemical cells that use chemical energy in a fuel to generate electric power. Among these fuel cells, this research paper mainly focuses on the Proton-Exchange Membrane Fuel Cell (PEMFC) and its real-life applications. PEMFCs are less damaging to the environment and are a perpetual source of energy since the reactants are much abundant. This type of fuel cell has rapidly become the scope of studies and is readily replacing the obsolete alkaline fuel cell technologies. This category of fuel cell has under its belt many advantages; fuel flexibility, high heat and power efficiency, low emissions and low temperature working ranges. The electrochemical reaction between HYDROGEN and OXYGEN converts the chemical energy stored within to the electrical energy, the overall chemical

product being STEAM. The running plant displayed here utilizes the power generated from a PEMFC. The plant is set up adjacent to the coast and some major sources of power generation are used to run it. Combined power extracted from the sources is used to run a WATER TREATMENT PLANT and to power a COLD STORAGE for storing aquatic animals in a local fishery. The reactants required to operate the PEMFC are HYDROGEN and OXYGEN, which is readily available locally, along with the BIOMASS which will be provided from the fish waste, and this cell in turn generates a power output. The main percentage of electrical power is transferred to the URBAN population through power grids, along with SOLAR PANELS installed to do the same. The by-product from this cell is in the form of WATER and HEAT which is circulated in a RANKINE CYCLE consisting of different components, providing power to the WATER TREATMENT PLANT. The fishery waste BIOMASS also acts as a fuel input to another modified RANKINE CYCLE consisting of high pressure and low-pressure turbine with feed water heater to increase its efficiency, which gives the output to COLD STORAGE. The main purpose of this power generation plant is to utilize the benefits of the PEMFC so that it can be put to good use to run the fish and WATER TREATMENT industries, normally located at coastal areas. MATLAB SIMULINK will be the platforms employed to examine the outputs thoroughly.

Submission 5938

Title **Dense Metallic Membranes For High-Density Hydrogen Production From Different Feedstocks For Pem Fuel Cells Power Generation**

Abstract The International Electrotechnical Commission (IEC), through Technical Committee 105 Fuel Cell Technologies, operates to prepare international standards regarding fuel cell technologies for all fuel types and various associated applications such as stationary fuel cell power systems for distributed power generators and combined heat and power systems, fuel cells for transportation such as propulsion systems, range extenders, auxiliary power units and portable power systems, micro power systems; reverse operating power systems and general electrochemical flow systems and processes. The aim of this research is to develop a more compact design for hydrogen production from a variety of feedstocks to offer a viable means for the supply of high-density hydrogen for polymer electrolyte membrane fuel cells (PEMFC). Importantly, we will present results demonstrating our world-class expertise in membrane development in hydrogen transport through metallic membranes.

Submission 6006

Title **Modelling an Efficient Ship System**

Abstract Electricity is the new fuel. To have a co-existential environment between people and Earth in the longer run, the previous approach for coal, oil and gas are being replaced with the "battery packs" as means of transportation, in an attempt towards sustainable environment. In this regard the following discussion emphasizes on the use of "Hydrogen" as a fuel providing a greater energy density as compared to the tradition Lithium-ion batteries currently in use. This paper is the approach towards the potential use of the Proton Exchange Membrane Fuel Cell, (PEMFC) as prime mover in the ship transportation industries. Not only does the paper emphasizes the use of hydrogen as a potential fuel, but also aims to make an efficient system for a ship in which the maximum output can be taken out from every aspect as far as the overall efficiency is concerned, in an environment friendly manner. The system uses a reversible proton membrane assembly that is initially triggered by a battery pack for the hydrolysis of the water, later self-supported. This provides the hydrogen as an input for the PEM fuel cell in the generation of electricity to support the propulsion system largely,

alongside, runs RO plant for fresh water availability, and the use of rejected heat as means for its HVAC system using a heat exchanger as a mediator. Alongside, the use of solar panels, and biomass too is taken into consideration for domestic utility needs, a schematic of the system is provided bellow. The paper presents the mathematical model of the Proton Exchange Fuel Cell using Matlab/Simulink software analysing system's response under ambient conditions, monitoring H2 levels within the fuel cell and respective variations of the output voltages.

Submission 6159

Title **The Revolutionizing Material - Bucky Paper In Hydrogen Fuel Cell**

Abstract Bucky paper is not an ordinary paper, it is a lot more than a paper, in fact, Bucky paper is the next generation paper or material. It can be the next aerospace material. Bucky paper is good for the structure of aircrafts. Bucky paper can provide us mechanical as well as electrical advantages because they exhibit excellent mechanical, electrical, and magnetic properties. Materials used in structure of aircrafts are good but they also have some flaws which cannot be neglected. We can overcome these flaws by using Bucky paper. The prospects of carbon nanotube usage intended for fuselage, satellite weight reduction, lightning protection for aircraft and future space launch are further explored. Bucky paper is the replacement of many materials or composites. Due to its distinctive properties it can be used in the making of light and energy efficient aircrafts. This research paper is all based upon comparative analysis of Bucky paper with different material or composites with respect to their applications in Aeronautical industries.

Submission 6364

Title **Production and performance analysis of hydrogen as a fuel by artificial photosynthesis with solar energy**

Abstract Hydrogen is the energy carrier that is a cleaner, more sustainable energy system and as a fuel has properties such as high burning speed, octane number, no-toxicity, and ozone-forming potential. The major challenge for the development of a clean hydrogen economy remains not only the scaling-up of hydrogen production but also and mainly the transition from carbon-intensive to low-carbon hydrogen production. Over the last decades global annual demand for hydrogen has increased, but 99% of it is still supplied from fossil fuels. Indeed, only 0.7% of current hydrogen production comes from renewable sources. This research aims to artificially replicate the process of photosynthesis in a bid to harness solar energy more efficiently. This process would look to use light energy to generate hydrogen, which could then be used as a zero-emission fuel. Efficient utilization of the ultimate source of solar energy is of great promise to solve these energy and environmental issues, as the solar energy irradiating the Earth's surface greatly exceeds the global human energy consumption. Hydrogen production by artificial photosynthesis with solar energy is the most economical as comparing the other techniques including coal gasification, stream reforming of methane, biomass gasification. Developing reliable and efficient techniques to realize solar energy conversion for practical usage is thus of great significance.

Submission 6470

Title **Analysis And Performance Assessment Of A Hydrogen Producing Multi-Genration System Integrated With A Reheat Brayton Cycle**

Abstract This paper proposes a new hybrid-source multi-generation system that incorporates a gas turbine cycle consisting of multi-stage compression & expansion and a geothermal energy system to produce 7 useful outputs, namely Hydrogen, Power, Space heating, Space cooling, Dry air, Freshwater, and Hot water. Two Rankine cycles are used to produce power for electricity and are operated with the same fluid which increases the overall efficiency of the cycles. The heat released from the condenser of the reheat-regenerative Rankine Cycle is utilized by the Heat Pump for Space Heating. The heat released from the simple Rankine cycle is used to drive the Triple-effect Absorption system as well as produce Hot water. A psychometric study is employed for obtaining the properties and quantity of the dry air being generated. The electricity from one of the turbines is used to operate an electrolyzer to produce Hydrogen and Oxygen. A multi-stage flash desalination plant is used to produce fresh water utilizing the heat from the exhaust of the gas turbine cycle. The performance of the system is determined by examining all system components through energy and exergy analysis methods. The overall energetic and exergetic efficiencies of the system are 78% and 64% respectively. Furthermore, to improve the system's performance, parametric and optimization studies are conducted which help to observe the effects of various inlet and operating conditions on the efficiencies of the overall system and subsystems. The system is designed considering the natural environmental conditions of San Diego, California.

Submission 6868

Title **Thermodynamic Analysis of a Parabolic Trough Solar Collector (PTSC) based integrated multi-generation system.**

Abstract In this study a Parabolic Trough Solar Collector (PTSC) based multi-generation system is thermodynamically analyzed with power, cooling and hydrogen production being the primary objective. The integrated system analyzed in this study consists of a reheat regenerative rankine cycle, double effect absorption cooling system, a double stage flash desalination system and a PEM electrolyzer. The PTSCs convert incident solar energy into thermal energy transferred to the heat transfer fluid (HTF). The energy gained by the heat transfer fluid which is steam, is then distributed to the three heat exchangers supplying energy to the reheat regenerative rankine cycle (RRRC), the absorption cooling system and the flash desalination system. The outputs of the integrated system are power, cooling, space heating, hydrogen production, freshwater, and water heating. Power and heat for space heating is extracted from the RRRC, where some of the power is transferred to the PEM electrolyzer for hydrogen production. Cooling is done by the double effect absorption cooling system and fresh water and water heating are achieved from the double stage flash desalination system. Parametric studies were performed by varying input parameters like solar irradiance, mass flow rate and ambient temperature. It was found that for the variation of solar irradiance from 0.55 kW/m2 to 0.85 kW/m2, the power produced ranged from 17.0 kJ/s to 37.4 kJ/s and hydrogen produced ranged from 0.0205 g/s to 0.0451 g/s.

Submission 7221

Title **Design and Analysis of a multigeneration system with concentrating photovoltaic thermal (CPV/T) and proton exchange membrane fuel cell (PEMFC) with the incorporation of PID controller in MATLAB/SIMULINK**

Abstract Concentrated Photovoltaic (CPV) is a relatively new and expensive technology that can be utilized in both local and large-scale energy distribution and generation systems. Having a longer life span and more than double the efficiency of the standard PV models, it has the potential to be the key to curbing global warming. Therefore, this study proposes a renewable energy-based multigeneration system, which integrates a solar CPV/T system and a fuel cell system to produce electricity and heat for power, heating, cooling, hot water, dry air, hydrogen, and freshwater for a hospital. This paper investigates the design and thermodynamic analysis of the integrated system. A PID controller is incorporated into the system to control various variables and a Simulink model of these controllers has been designed and analyzed. A part of the electricity generated by the CPV is used to power the electrolyzer to produce Hydrogen and Oxygen which is utilized by the Proton Exchange Membrane Fuel Cell (PEMFC) to provide electricity during the night or when daytime conditions are not ideal. The resultant thermal energy from CPV/T is used for the cooling, fresh water, heating, and hot water requirements. The designed system performs at 58.92% of overall exergy efficiency.

Submission 7355

Title **PEMFC Waste Heat Incorporated Into Regenerative Rankine Cycle**

Abstract The world today faces a serious issue, that our means to run our industry i.e. fossil fuels will run out within this century. The system we propose focuses on a combination that allows waste from a cattle farm(bio-fuel) into fuel along with solar water heater used in closed configuration, and convert unwanted heat energy from PEMFC cell into useful energy, therefore making a positive impact on the environment. As PEMFC operates at a temperature of 95 C, the heat energy can't be extracted to heat the boiler at high temperatures. Therefore primarily, biogas is used to heat the furnace, that runs the turbine. But we add a regenerative cycle that extracts extra heat from the turbine, and also adds heat extracted from the PEMFC cell into the system. Therefore increasing the fluid temperature and allowing less heat from the biogas to heat the fluid to reach the required temperature.

Submission 7423

Title **A Practical Approach To Determine The Off-Grid Conditions For Energy Storage Integrated Solar-Driven Power Systems**

Abstract Due to its nature, solar energy is an intermittent energy source and needs to be stored to continue using it when it is unavailable. This work develops a practical approach for solar-driven systems integrated with hydrogen systems as an energy storage option in order to determine the off-grid conditions for remote communities and systems. The proposed approach aims to determine the minimum PV surface area to meet the energy demand without requiring grid power. In order to provide the uninterrupted energy of 1 MWh in Southern Ontario all year by solar power, it is necessary to install 1,856,000 m2 solar PV panels with hydrogen production, storage, and utilization systems, including PEM electrolysis, compressed-gas storage, and PEM fuel cells.

Submission 7670

Title **Effect Of Change In Tarrif And Tax Policies On Pv System Feasibility For An Average Consumer In Pakistan**

Abstract Modern Grids are becoming smart by each passing day integration of distributed generation(DG) is now a necessity, due to its economic advantages. Solar PV is one of the widest spread and modular form of DG. Recently it has become popular because of its scalability as well as the environmental prospective. Recently policies have supported the deployment of PV across the world specially in Pakistan. Currently net metering is the prevalent policy in the country which has reduced the payback time period for prosumers thus an exponential increase in deployment has been observed. More over recently The cost of electricity is rising day by day which is enhancing feasibility of solar PV systems. The research Work done focuses on the aspect of assessment of solar PV feasibility of an average consumer in Pakistan. The research provides a wide range of sensitivity analysis regarding the prices and taxes being imposed on initial costs of solar PV and the cost of electricity in the country high escalation rate of electricity tariff makes the most impact on net present values. The research concludes that initial cost increment has a minimum and annual escalation in electricity rates has maximum effect on NPVs.

Submission 7673

Title **Numerical Investigation Of Sugarcane Bagasse As Potential Feedstock In Pakistan For Biohydrogen Production Through Gasification**

Abstract Pakistan is amongst the topmost vulnerable countries to climate change, which, as per world bank estimates, has suffered more than USD 30 billion losses in flood damages. Biohydrogen can play a significant role in a carbon-free economy. In the current study, we investigate the potential of sugarcane bagasse as a promising biomass generated in Pakistan for hydrogen production through the gasification process. Investigation of hydrogen production from synthesis gas obtained through gasification of sugar cane bagasse is carried out through modelling and simulation study using Aspen Hysys chemical process simulation software. Raw synthesis gas obtained after gasification process is cleaned, its hydrocarbon content is reformed, water gas shift reaction is carried out for hydrogen enrichment followed by a separator. After modelling and simulation study for hydrogen enrichment, maximum H2 mole fraction of 49.19% is obtained. In future work, hydrogen will be separated from the gaseous mixture using PSA unit. Moreover, energy, exergy, and economic analysis of gasification process will also be carried out.

Submission 7713

Title **Analysis Of Ocean Thermal And Solar Energy Based Multigeneration System For Sustainable Community: Energy And Exergy Perspectives**

Abstract Although industrialization marks to the economy of a country yet it increases the pollution and temperature of the environment. The world is now shifting towards green energy because the utilization of fossil fuels is resulting in global warming. There is a need to develop systems that can operate on renewable energy resources and have low heat losses. The combined solar and ocean thermal multigeneration system can solve this issue. Rather than making Rankine cycle purely a solar-driven, heat from solar is used to drive absorption cooling cycle and preheat seawater to generate power using ocean thermal reservoir. The results are displayed by using Engineering Equation Solver software, where inputs are varied

to optimize the energy and exergy efficiencies of the system. This eco-friendly multigeneration system is capable of eliminating the use of fossil fuels and producing hydrogen from electrolysis, cooling effect (188.8 KW), net-work output (117.46 kW), fresh water (118 liters/hr) and reducing resultant emission of 482 tons of CO2 per year for sustainable community.

Submission 7994

Title **Geothermal-Solar Integrated Multigeneration System With Hydrogen Production Capabilities: Comparative Study On Heat Transfer Working Fluids**

Abstract For this study, adsorption cooling system with an integration of parabolic trough collector for the generator input is used along with Regenerative Rankine cycle operating at geothermal source is used. The absorption fluid used in the solar collectors was Syltherm 800. A comparative analysis of different fluids including R245fa, R114 and Water for Regenerative Rankine cycle is calculated and plotted against their different results. The results show that R245fa has highest energy and exergy efficiency in comparison to the others used. For absorption cycle LiBr and Water solution is used as a working Fluid. Parameters used to change the output of the system are, the mass flow rate of the geothermal well, Ambient Temperature, Solar Irradiance, Pressure of working Fluid, output temperature of PTC. Some part of Power is utilized in hydrogen production. In Regenerative Rankine cycle Condenser rejected heat is used for desalination of water. In absorption cycle Condenser heat is used for space heating and Hot water output is also obtained from PTC. Detailed energy, exergy analysis and power output for the system is calculated at different parameters for the ease of understanding the system and comparison of the results.

Submission 8008

Title **Phosphoric Acid Fuel Cell Based CCHP System for a Sustainable Commercial Farm and Crop Research Facility**

Abstract This paper analyzes the technical and economic feasibility of introducing a Phosphoric Acid Fuel Cell (PAFC) based CHCP system to supply an agriculture farm, a crop research facility and the surrounding residential areas with electric power and heat. In the controlled system considered, PAFCs are used in conjunction with solar panels and biomass power plants to generate power. In this thesis, PAFCs are chosen because of their impressive electrical efficiency (up to 70%) and moderate operating temperature (150℃-210 ℃). The latter is extremely important for the CHP to successfully run. The overall efficiency of the fuel cell is further maximized by utilizing the waste heat from the cell effluents as input for absorption chillers. The novelty of the design considered is that the fuel cell has an external reformer, which extracts hydrogen from ethanol rather than methane gas. Plus, waste heat from the biomass power plant and the fuel cell stack makes it possible to run a heat-driven refrigeration cycle that produces a cooling effect by recovering low-temperature waste heat. The proposed PAFC system along with its control schemes is modeled and simulated on MATLAB/Simulink software.

Submission 8043

Title **MXENE / NI Porous Composites For Hydrogen Production And Energy Storage Application**

Abstract The emergence of new multifunctional materials continuously increases the expectations for the performance of energy conversion and storage devices. MXenes, a family of two-dimensional transition metal carbides has been discovered as an exciting candidate for these applications [1, 2, 3, 4]. Ni-based electrodes are commonly used as cathodes in alkaline electrolysers for hydrogen production, provided by their low cost, appropriate electrocatalytic activity and corrosion resistance [5, 6]. This work explores the possibilities for the processing of Ni- and Ti3C2(OH)x MXene- containing composite electrodes for H2 production. In order to tune the Ti3C2 interlayer distance in Ti3C2Al MAX phase, an introduction of additional Al to form Ti3C2Alz materials with z>1 was attempted. Synthesis of powder mixtures with extra Ni and Al content (e.g. Ni:Ti:Al:C = 1:2:3:1) resulted in products containing Ti3C2Alz z>1 material and Ni-Al alloys [7]. Further etching of these products in 10M NaOH allowed the direct formation of electrodes with active surface containing Ti3C2T(OH)x MXene- and Raney nickel-containing composites. The electrochemical studies were focused on H2 evolution and showed the potential for boosting the electrochemical reaction in such electrodes. The guidelines for the processing of MXenes under fluorine-free conditions are proposed and discussed.

Submission 8062

Title **An Assessment Of Hydrogen Production By Harvesting Wind Energy In A Sub Urban Environment: A Machine Learning Approach**

Abstract The exponential rise in energy consumption makes conventional energy production technologies unsustainable. Owing to this increase renewable energy sources are favored as an alternative clean energy source. Wind energy is the source that has undergone the least amount of work as its conduct is inconsistent and expensive as compared to solar energy extraction. The problem is addressed by incorporating artificial intelligence algorithms for forecasting of wind energy extraction in a suburban setting. The study makes use of machine learning techniques to evaluate the hydrogen production from wind energy. In order to assure seasonal variety, machine learning techniques are supplied with wind information from the past year. Site location was at latitude 33.64 °N, Longitude 72.98 °N, and elevation 500 m above mean sea level with a sampling frequency of 10 Minutes. After collecting the data Long Short Term Memory (LSTM), Support Vector Regression (SVR) and linear regression Machine Learning models were trained to estimate daily hydrogen production. LSTM produced the greatest outcomes out of all the trained models. Additionally, it was determined that artificial intelligence techniques (LSTM), which are ideally suited for time-series data, can be used to harvest an average of 202.8 kg/month of hydrogen from a 1.5 MW turbine.

Submission 8210

Title **Concept design of low-emission fuel cell-based ship propulsion system for maritime export industry**

Abstract The current trends in international oil prices and general consensus depicts that peak oil production has been attained and projects a dramatic increase in fuel costs over next 50 years. Moreover, in a bid to curtail oxides of sulphur and nitrogen, ever tightening emission regulations are being applied to international shipping, with further proposal to impose 'Carbon Levies'. All these factors combine to inflate the through life cost of marine vessel ownership. In particular, warships are prone due to uneconomical propulsion plants and operating profiles. Therefore, future designs are to be low carbon emission vessels/ships. There are a few giants in defence maritime sector who build warships and export them to other countries. Due to increasing emphasis on low carbon vessels in future, these companies will have to build low carbon affordable vessels for export market. Numerous conflicting

requirements and tradeoffs between low emissions and export quality are the major challenges at present. The main conflicting areas are, operating profile, speed, area of operations, type of fuel and number of personnel onboard. This paper review the present need of low carbon vessels in maritime industry particularly in the defence sector. It discusses at length the conflicting requirements and tradeoffs during the development of a low carbon vessel with export capabilities. This research explores market for seagoing vessels and requirements of different navies in terms of size, capabilities, to maintain a balance while developing a low emission design for maritime defence export industry. Finally, as a new concept this paper proposes fuels cells for propulsion system for future ships.

Submission 8615

Title **Simulink Modelling of Water Sewage treatment Plant Powered by Renewable Energy**

Abstract Fuel cells have started to emerge as the modern solution to environmental pollution due to their ability to produce "clean" energy. Fuel cells are also preferred over other power-producing devices because they operate at a higher overall working efficiency. Fuel Cells can be further classified into various types depending on their working principles and the components they contain. Of the many types of Fuel cells that exist, Proton Exchange Membrane Fuel cells are mostly used because of their low installation and maintenance costs. PEMFCs are built out of membrane electrode assemblies (MEA) which include the electrodes, electrolyte, catalyst, and gas diffusion layers, and a mixture of air and methane is generally used as the fuel for the cell (electrolyte). A large amount of heat is generated as a byproduct of the fuel cell, which is eventually rejected into the environment and is considered a waste of energy. For further development of fuel cells, efforts are being made to utilize this waste energy productively. This research paper focuses on utilizing the waste energy released by an installed Proton Exchange Membrane Fuel Cell to solve "The Clean Water Crisis". An Organic Rankine cycle is accommodated with the fuel cell to convert the rejected heat energy into electricity, which is used to power the pumps being operated in the Reverse Osmosis Area, of a "Sewage Water Treatment Plant". The sludge (organic waste), which is filtered out of the sewage water is processed to extract methane, which is used as the fuel for the installed Proton Exchange Membrane Fuel Cell. Mathematical Modelling and system simulations are included in the text as references to portray the proposed solution's effect and showcase the improvements in the cost-effectiveness of the water treatment plant.

Submission 8751

Title **Using an SOFC System with Cogeneration to power a Commercial Scale Poultry Farm**

Abstract Poultry accounts for 40-45% of the annual meat consumption in Pakistan and is an emerging sector. Currently, the industry suffers from lack of access to modern technology and reliance on fossil fuels for broiler heating processes, raising concerns for detrimental environmental effects of such power sources. Several systems have already been designed and implemented that use renewable energy sources to provide the required power, including photovoltaic (PV) cells, solar collectors, and microbial fuel cells. In this paper, a proposed system that uses energy from PV cells, an SOFC fuel cell, and heating from biogas is examined and subjected to entropy and exergy analysis. The fuel cell itself is modeled in MATLAB and Simulink and its response to different input conditions is determined via simulation to validate the proposed system with a reasonably low exergy destruction. The system utilizes the waste heat of a fuel cell as the heat input of a steam power cycle, the output of which is then provided to a heat pump that cools a meat storage facility, simultaneously heating the broiler. The aforementioned Rankine power cycle produces work in two stages via a high and a low pressure turbine, with reheating in-between in a boiler heated by burning biogas produced

on the poultry farm. The electrical power output of the fuel cell is supplied to the main grid and supplemented by that produced by photovoltaic panels. It is then used as a source of power wherever required, for example, in running all the compressors and pumps that are a part of the system and powering the radiant heaters in the brooding chambers, and the lighting and fans used in the broilers and elsewhere. The flue gas of the SOFC is incorporated to power Rankine Cycles which provide work input for a Poultry Feed Plant.

Submission 8991

Title **Development And Exergo-Economic Analysis Of An Innovative Solar-Aided Integrated Waste-To-Energy Plant For Multiple Outputs**

Abstract The growth of municipal solid waste generation is rapid due to the urbanization and industrial expansion. Waste-to-energy incineration is an effective approach to dispose the waste by generating energy in a sustainable manner. However, the efficiency of the conventional waste-to-energy plants is limited to only 20-24 % due to the presence of higher moisture content and low heating value of the feedstock. The renewable energy integration and achieving multiple products utilizing single energy source are the proposed solutions to enhance the power plant performance in a suitable manner. In the present study, solar integrated waste-to-energy plant is proposed, developed and investigated, where parabolic dish collector is used to re-heat the steam from high pressure turbine to low pressure turbine and simultaneously providing heat to run a single effect absorption chiller for cooling/heating purpose. In addition, flue gas from incineration boiler has enough temperature to run an organic Rankin cycle and its power is utilized for hydrogen production and fresh water production through electrolyser and reverse osmosis desalination unit, respectively. Proposed system is investigated by varying more influential input parameters such as direct normal irradiation, turbine inlet temperature, pressure, extracted steam fraction etc. Exergo-economic analysis indicates the components with higher exergy cost.

Submission 9071

Title **Response Surface Optimization And Transient Analysis Of A Solar Methane Reforming Reactor With Passive Thermal Management**

Abstract To improve the operation of the passive thermal managed volumetric reactor under different radiation intensities, BBD (Box-Behnken Design) in RSM (Response Surface Methodology) was applied to establish the Multi non-linear regression (MNLR) model, which could be used to predict the effect of perturbations on the response variable. By adding specific constraints to the factors and responses in the MNLR model, the optimal set of solutions that meet the conditions were obtained and analyzed. Then, the PI controller was coupled with the multi-physical model to ensure the stable operation of the reactor, and the relationship between the controlled condition and the characteristic of the fluctuating radiation was analyzed. The control effect was tested under actual solar radiation, and the results show that the combination of passive thermal management and active control greatly improves the stability of the reactor operation.

Submission 9259

Title **The Use Of Composite Materials In Contrast To Aluminium Alloys In Hydrogen Fuel Aircrafts**

Abstract The era we live in depends a lot on air carriers. Millions of flights take place every using up considerable amount of fuel. To reduce the fuel consumption and minimize cost is what makes the materials in aircrafts so much important. Which is why newer materials are always being introduced, one of which are composite materials. These composite materials like Carbon fiber composite have incredibly high strength for their weights. They weigh half as much as Aluminum and can be twice as stiff. Numerous factors along with the ones stated are the reason why some engineers are claiming it to be the future of aircraft designs where as some suggest that this rather unlikely. This study covers the mechanical properties of composite materials in the use aircrafts such as Carbon fiber, fiberglass and other promising composite materials in contrast with the latest Aluminum alloys being used in manufacturing.

Submission 9305

Title **Multi-Objective Optimization of a Geothermal Based Hydrogen Production System**

Abstract Depleting fossil fuels have emphasized on use of renewable energy sources. Multi-generation systems driven by renewables such as geothermal, biomass solar etc. have proved to be cutting-edge technologies in order to produce different useful by-products. This study proposes a novel multi-generation system using geothermal steam as its main source. The main outputs include power, heating, cooling, fresh water, hot water, dry air and hydrogen. The novelty of the proposed model is that it not only produces electrical power but also some valuable by-products while having only one source of energy as input. The system consists of three subsystems which include Regenerative Rankine Cycle, Double effect absorption cycle and double flash desalination cycle. A significant amount of electrical power, hydrogen and fresh water are generated which can be used for commercial or domestic purposes. The power output is 103 MW. The thermal efficiency is found to be 24.42% while energetic and exergetic efficiencies are 48.72% and 37.86%, respectively. The coefficients of performance of energy and exergy are 1.836 and 1.678 respectively. The hydrogen and fresh water are produced at a rate 0.1266 kg/s and 37.6 kg/s. The system is integrated and optimized using EES to understand the effects of operating conditions. Major exergy destruction areas have also been identified.

Submission 9374

Title **Reconfigured Metallic Membrane Technology For Maintaining Hydrogen Concentration Below 4% In Fuel Debris Canisters**

Abstract The use of hydrogen in the energy sector has been in the headlines in recent times due to its promising future as a replacement for fossils and its sustainable production from a wide variety of feedstocks including traditional hydrocarbons derived from fossil fuel and biomass, residual hydrocarbons or wastes, and even other molecules out of the carbon cycle, such as ammonia or water. There are, however, other applications where the presence of hydrogen is not desired. One of such processes is in the storage waste streams from nuclear reactors where pressure build-up due to hydrogen gas generation by decomposition of water during transportation and storage of fuel debris canisters can result in catastrophic explosion and damage of facilities. In this research a reconfigured metallic hydrogen permeable membrane is tested to act as a valve on the canister lid to maintain hydrogen concentration below 4% in fuel debris canisters.

Submission 9395

Title **Operating Vapor Absorption Cycle From Twin Spool Biodiesel Powered Gas Turbine Exhaust**

Abstract In this study the Vapor Absorption Cycle is powered by gas turbine. The configuration of the gas turbine used is twin spool and it is powered by biodiesel. Vapor absorption cycle makes use of ammonia water as a refrigerant. Biodiesel can be used to power the combustion chamber of the gas turbine. B20 biodiesel consists of 20% of biodiesel mixed with 80% of Petro diesel. B20 is manufactured in Pakistan using the plant Jakarta Falkus by Pakistan State Oil Limited. A model has been prepared for this cycle which identifies the energetic and exergetic efficiency. Using EES at different state points, pressure, temperature, enthalpy, entropy, mass fraction, and quality is obtained using thermodynamic principles. At different mass flow rates of the gas turbine, different amount of electrical energy was obtained. Similarly, the change in mass flow rate caused change in temperature across the vapor absorption cycle. This variation in temperature across the generator causes change in COP. To get the maximum efficiency across the vapor absorption cycle, the mass flow rate across gas turbine has been optimized. Finally, at different mass flow rate of air in the gas turbine, energetic, exergetic, COP, and heat absorption of vapor absorption cycle trend is plotted. Hydrogen is produced from electrolysis through energy produced from gas turbine.

Submission 9422

Title **An Integrated Waste To Energy Multigeneration System Based On Plastic Wastes Pyrolysis**

Abstract In this study, a novel multigeneration system is proposed. The system will utilize solar energy coupled with plastic waste pyrolysis as the main sources of energy to produce hydrogen, electricity, heating, and cooling. Plastic wastes are a major environmental challenge, and the system presented in this study aims to propose a viable and environmentally benign solution through multigeneration. Hydrogen production is emphasized in this study, as hydrogen is the most environmentally friendly fuel that can contribute to achieving future sustainability goals. The reference case for the proposed system shows the energy and exergy efficiencies of 11.17% and 8.61%, respectively, while the hydrogen production rate is calculated at 1.53 kg/s.

Submission 9621

Title **Transport Enhanced Bioinspired Methanol Steam Reforming Monolithic Catalyst Support Based On Triply Periodic Minimal Surfaces**

Abstract Methanol reforming catalyst support plays a crucial role in microreactors design. Benefiting from small anisotropy and high specific surface area, porous catalyst supports can greatly enhance the heat mass transfer process. Triply periodic minimal surfaces (TPMS) are spatially smooth continuous bioinspired surfaces derived from mathematical equations, which can be easily programmed and controlled. With the computer-aided design and 3D print, the synthesis of customized TPMS porous catalyst supports offers completely different opportunities. In present study, one bioinspired Fischer-Koch S TPMS-based monolithic catalyst support is designed and compared with the well-developed micro pin structure. A comparative study on heat mass transfer and reforming characteristics of the two is carried out by establishing mathematical physics models, coupling the surface reaction, flow and heat mass transfer processes. The results show the S structure effectively enhances the heat mass transfer performance and reforming efficiency over micro pin at identical operating conditions.

Specifically, the S porous catalyst support shows a 75% reduction in flow resistance, an 87% improvement in heat mass transfer performance and a 10%~45% improvement in methanol conversion efficiency than micro pin, respectively. The present study provides a theoretical basis for the application and optimal design of porous TPMS methanol reforming catalyst supports.

Submission 9905

Title **Design and thermodynamic analysis of multi-generation system producing Hydrogen, electricity, heating and cooling.**

Abstract A novel system comprising parabolic trough solar collector is proposed along with a concept of thermal storage tank, based upon useful multigenerational purposes and hydrogen production. Also, the problem of unavailability of solar energy during night is solved. This study is based on a comprehensive energy and exergy analysis of concentrated solar power based multigeneration system. A novel and unique system is configured for electric power production from Organic Rankine Cycle, space heating from heat recovery of condenser, space cooling from vapor absorption cycle, fresh water from supercritical ORC run Reverse Osmosis plant, hot water by heat rejected from refrigeration cycle's absorber, dry air from air desiccant dehumidification, hydrogen production from Proton Exchange Membrane Method. The efficiency of system is enhanced by utilization and recovery of waste rejected heat. A well-insulated Thermal Storage Tank is proposed for more sustainable solar energy usage at nighttime. Molten Hitec salt is used as working fluid having high specific heat capacity and capable of delivering heat at night. The overall exergy and energy efficiencies are found to be 40 % and 60 %. The desired outputs achieved are 0.63 MW power, 0.000316 kg/s H2, 138 tons refrigeration, 0.24 kg/s fresh water production, 0.00406 kg/s of dry air, and 1 kg/s of hot water for domestic use. In comparison to the similar systems, the proposed system provides superior and unique features based on its thermal storage concept and waste recovery methods and efficiency.

Submission 3520

Title **Wind powered Multigeneration system with PID controller**

Abstract This paper provides the research on development and analysis of wind turbine multigenerational system. Wind is considered as the renewable source for this study. Energy and exergy analysis are determined. The designed system comprises of using multiple thermodynamic cycles that includes gas turbine cycle containing air and fuel (methane) as its main fluid, organic Rankine cycle with water as its main fluid and vapor absorption cycle containing NH3-H2O. Since the whole physical system to be manufactured is expensive, a mathematical model and simulation is designed along with feasibility regarding heat loss and exergy analysis to study the performance. The gas turbine producing electrical output for multiple plants are considered along with heating and cooling through secondary cycle and lastly tertiary cycle for space heating and electricity. The whole model is designed on EES. MATLAB/SIMULINK 2016 is used to control and stabilize the variation in the mass flow rates through multiple components to keep the efficiency close to a constant value.