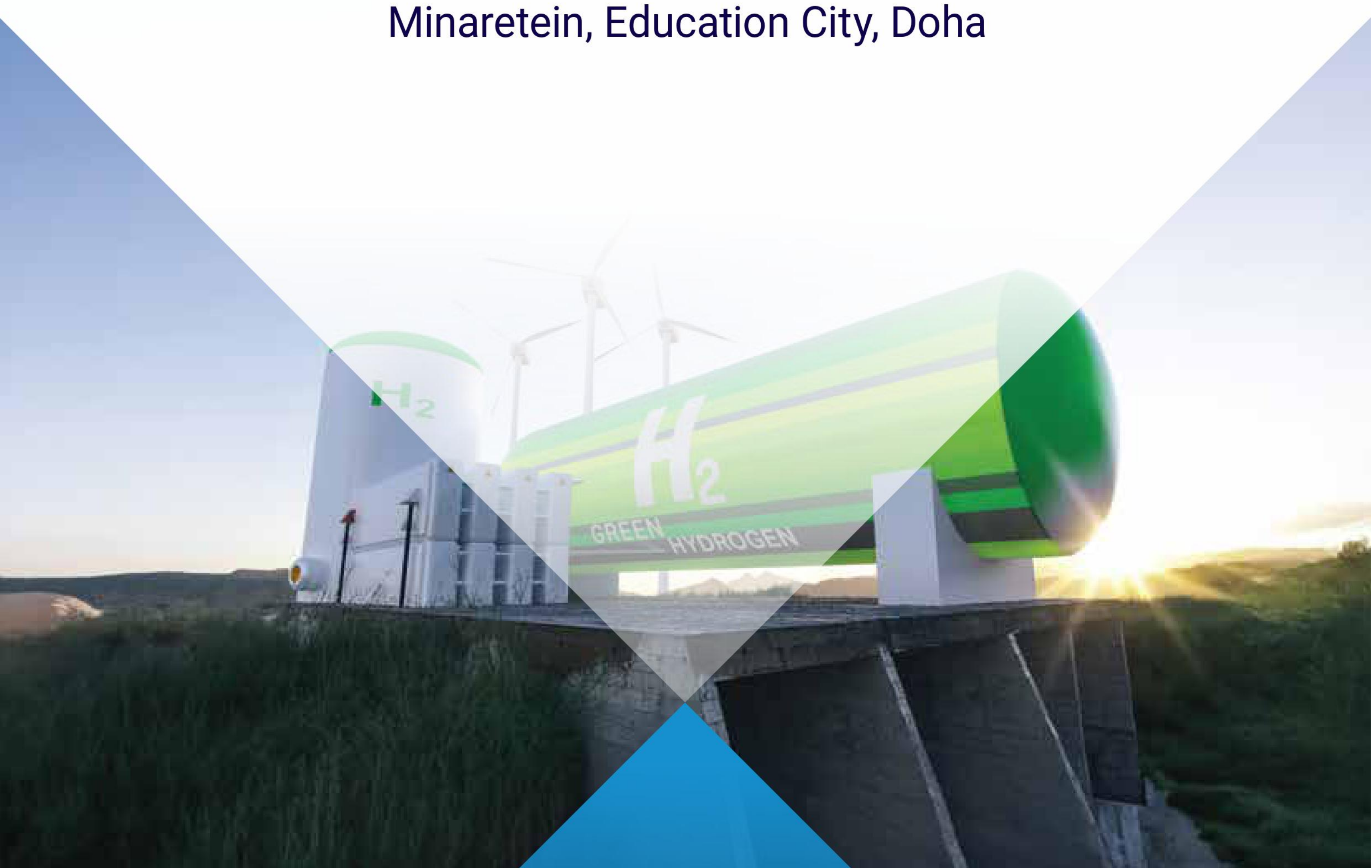
كليّة العلوم والهندسة
College of Science & Engineering
جامعة حمد بن خليفة
HAMAD BIN KHALIFA UNIVERSITY

14TH INTERNATIONAL CONFERENCE ON HYDROGEN PRODUCTION (ICH2P-2023)

DECEMBER 19 - 21, 2023

Minaretein, Education City, Doha



14TH INTERNATIONAL CONFERENCE ON HYDROGEN PRODUCTION (ICH2P-2023)

December 19-21, 2023

Hamad Bin Khalifa University
Doha, Qatar

CONFERENCE PROGRAM

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Program Layout

Day 1 | Tuesday, December 19, 2023		
08:00 am-9:00 am	Conference Registration	Exhibition Hall
09:00 am-10:00 am	**Opening Ceremony (Welcoming Talks)**	**Auditorium**
10:00 am-10:45 am	**Keynote Talks**	**Auditorium**
10:45 am-11:15 am	Coffee Break	Exhibition Hall
11:15 am-12:45 pm	**Keynote Talks**	**Auditorium**
12:45 pm-02:00 pm	Lunch	Exhibition Hall
02:00 pm-03:30 pm	**Industry Panel Session**	**Auditorium**
03:30 pm-04:00 pm	Coffee Break (with Poster Presentations)	Exhibition Hall
04:00 pm-05:30 pm	**Parallel Scientific Sessions**	**Conference Rooms**
Day 2 | Wednesday, December 20, 2023		
09:00 am-10:30 am	**Plenary Sessions**	**Auditorium**
10:30 am-10:45 am	Coffee Break (with Poster Presentations)	Exhibition Hall
10:45 am-12:30 pm	**Parallel Scientific Sessions**	**Conference Rooms**
12:30 pm-02:00 pm	Lunch	Exhibition Hall
02:00 pm-03:30 pm	**Parallel Scientific Sessions**	**Conference Rooms**
03:30 pm-04:00 pm	Coffee Break (with Poster Presentations)	Exhibition Hall
04:00 pm-05:30 pm	**Parallel Scientific Sessions**	**Conference Rooms**
06:30 pm-08:30 pm	Gala Dinner and Awards Ceremony	
Day 3 | Thursday, December 21, 2023		
09:00 am-06:15 pm	**Hydrogen Energy Course**	**Auditorium**
09:00 am-10:30 am	**Parallel Scientific Sessions**	**Conference Rooms**
10:30 am-11:00 am	Coffee Break (with Poster Presentations)	Exhibition Hall
11:00 am-12:30 pm	**Parallel Scientific Sessions**	**Conference Rooms**
12:30 pm-02:00 pm	Lunch	Exhibition Hall
02:00 pm-03:30 pm	**Parallel Scientific Sessions**	**Conference Rooms**
03:30 pm-04:00 pm	Coffee Break (with Poster Presentations)	Exhibition Hall
04:00 pm-05:30 pm	**Parallel Scientific Sessions**	**Conference Rooms**
06:15 pm-06:30 pm	**Closing Ceremony**	**Auditorium**
06:30 pm-09:30 pm	**Optional Social Tour**	

Day 1 | Tuesday, December 19, 2023

Time	Program	Location
08:00 am-09:00 am	**Conference Registration**	**Exhibition Hall**
09:00 am-10:00 am	**OPENING CEREMONY** **Dr. Ala Al-Fuqaha** Associate Provost Hamad Bin Khalifa University **Dr. Yusuf Bicer** Co-Chair of the Conference Hamad Bin Khalifa University **Dr. Tareq Al-Ansari** Co-Chair of the Conference Hamad Bin Khalifa University **Dr. Mounir Hamdi** Dean, College of Science and Engineering Hamad Bin Khalifa University **H.E. Dr. Mohammed Bin Saleh Al-Sada** Former Minister of Energy and Industry in Qatar Chairman of the Joint Advisory Board of Texas A&M University at Qatar Chairman of the Board of Trustees of the Doha University of Science and Technology	**Auditorium**
	Keynote Talks	
10:00 am-10:45 am	**ICH2P14-KN1** New Horizons in Hydrogen Production Technologies **Keynote Speaker - Dr. Ibrahim Dincer** Professor, Ontario Tech University, Canada	**Auditorium**
10:45 am-11:15 am	**Coffee Break**	**Exhibition Hall**

11:15 am-12:00 pm	**ICH2P14-KN2** Development of Manufacturing Techniques for Highly Performing Polymer Electrolyte Membrane Fuel Cells **Keynote Speaker – Dr. Xianguo Li** Professor, University of Waterloo, Canada	**Auditorium**
12:00 pm-12:45 pm	**ICH2P14-KN3** Hydrogen and Fuel Cell Development and the Benefit of Digital Twin and Artificial Intelligence in this field **Keynote Speaker - Dr. Abdul Ghani Olabi** Professor, University of Sharjah, UAE	**Auditorium**
12:45 pm-02:00 pm	Lunch	**Exhibition Hall**
02:00 pm-03:30 pm	**Industry Panel Session** **Moderator:** **Sean van der Post** Global Offshore Business Director, Lloyd's Register	**Auditorium**

Day 1 | Tuesday, December 19, 2023

Poster Number	Poster Presentations 3:30 PM - 4:00 PM Chair: **Dr. Burak Yuzer**	Exhibition Hall
ICH2P14 – PP175	Turquoise Hydrogen Production: Carbon Management and Conversion to Sustainable Energy Carriers ***Aliya Banu*, *Yusuf Bicer***	
ICH2P14 – PP166	Evaluation of Hydrogen Production from Ammonia Reforming on Ni/ZnO Nanowire Catalysts ***Hiroya Tamai*, *Hironori Nakajima***	
ICH2P14 – PP114	Photocatalytic Hydrogen Generation from Seawater Using High Performance Polymeric Materials ***Noora Al-Subaiei*, *Ghalya Abdulla*, *Mohammed Al-Hashimi, Konstantinos E Kakosimos***	
ICH2P14 – PP008	Long-Term Assessment of Hydrogen Technology Deployment for Large Scale Decarbonisation of Power Production ***Kamran Khammadov*, *Damian Flynn, Eoin Syron***	
ICH2P14 – PP 013	Use of Refinery Off Gas (ROG) as CO_2 Emission Reduction and Natural Gas (Ng) Savings in Hydrogen (H_2) Production ***Marcelo Tagliabue***	
ICH2P14 – PP139	Performances of Commercial Zeolites with Different Acidities for Catalytic CO_2 Hydrogenation to Dimethyl Ether Using Copper/Zinc/Alumina Catalyst ***Abdelbaki Benamor, Assem Mohamed, Abdul Hakeem Anwer, Siham AlQaradawi, Mohammed Saad***	
ICH2P14 – PP075	Modeling of Hydrogen Liquifaction Process Parameters Using Advanced Artificial Intelligence Technique ***A. Abdallah El Hadj, Ait yahia, Hamza. K, M. Laidi, S. Hanini***	
ICH2P14 – PP066	Hydrogen Protection of the Mechanical Properties and Electrochemical Effects by Bio-Corrosion Inhibitors on Carbon Steel in the Presence of Aggressive Media ***Mouna Amara, Azedine Belalia, Mohammed HadjMeliani, Hadjer Didouh, Rami K.Suleiman, Guy Pluvinage***	
ICH2P14 - PP192	Hydrogen from Catalytic Steam Reforming of Biomass ***Sergio Rapagnà, Alessandro Antonio Papa, Andrea Di Carlo***	
ICH2P14 - PP161	Textile Wastewater Treatment and Hydrogen Generation with Ion-Exchange Resins on Solar-Assisted Bipolar Membrane Electrolysis Process ***Burak Yuzer, Ragad F. Alshebli, Nadira Salsabila, Yusuf Bicer***	
ICH2P14 - PP170	In-Situ Current Distribution Measurements of a Planar Solid Oxide Fuel Cell for a Three-Dimensional Finite Element Model to Train a Machine-Learning Surrogate Model ***Yutaro Io, Yingtian Chi, Hironori Nakajima***	

Day 1 | Tuesday, December 19, 2023

Parallel Sessions 1			
Time	**Conference Room – A047**	**Conference Room – A048**	**Conference Room – A046**
04:00 pm- 05:30 pm	**Session 1A: Clean Hydrogen Production** Chair: **Dr. Fadwa ElJack** Co-Chair: **Dr. Fares A. Almomani**	**Session 1B: Waste to Hydrogen Energy** Chair: **Dr. Tareq Al-Ansari** Co-Chair: **Dr. Mohammad Alherbawi**	**Session 1C: Hydrogen Production Catalysts** Chair: **Dr. Abdulkarem Amhamed** Co-Chair: **Dr. Ahmed Abdala**
04:00 pm- 04:15 pm	**Invited Talk** **ICH2P14-IT1** Green Hydrogen Production: Solar Chimney Power Plant Integrated with Water Desalination Plant **Dr. Fares A. Almomani** Department of Chemical Engineering, Qatar University	**ICH2P14 - OP010** A Novel Cost-Effective Approach for Production of Hydrogenase Enzymes and Molecular Hydrogen from Whey-Based By-Products ***Anna Poladyan, Meri Iskandaryan, Ofelya Karapetyan, Ela Minasyan, Anait Vassilian, Karen Trchounian, Garabed Anatranikian***	**ICH2P14 - OP037** Synergizing Hydrogen and Chlorine Gas Production for Enhanced Resource Utilization Using Earth-Abundant Electrocatalysts ***Ahmed Badreldin, Ahmed Abdel-Wahab***
04:15 pm- 04:30 pm		**ICH2P14 - OP044** Biotechnological Potential of Spent Coffee Grounds for Large-Scale Hydrogen Production ***Liana Vanyan, Anait Vassilian, Anna Poladyan, Karen Trchounian***	**ICH2P14 - OP171** Ni-Cu Bimetallic Catalysts for Effective Syngas Production via Low-Temperature Methane Steam Reforming ***Martin Khzouz, Babak Fakhim, Saleh Babaa, Mohammad Ghaleeh, Farooq Sher, Evangelos I. Gkanas***
04:30 pm- 04:45 pm	**ICH2P14 – OP095** A Solar Pond Integrated with Bifacial Solar Panels for Power and Hydrogen Generation ***Dogan Erdemir, Ibrahim Dincer***	**ICH2P14 – OP069** Biohydrogen Production from Various Industrial Wastewater of Chalawa, Kano, Nigeria ***Garba Uba, Abdulhadi Yakub, Salisu Ahmed, Ibrahim Abdulganiyyu***	**ICH2P14 - OP017** Kinetic Modelling and Process Optimization for Blue Hydrogen Production Via Ammonia Cracking ***Ragad Aldilaijan, Sai Katikaneni, Osamah Siddiqui, Mohammad Rakib, Bandar Solami***
04:45 pm- 05:00 pm	**ICH2P14 – OP205** PV-AWG-H_2: A Potential Method for Sustainable Hydrogen Production in Qatar ***Aiyad Gannan, Nagi Abdussamie***	**ICH2P14 – OP102** Syngas Production Using Catalyst Based on Local Minerals Extruded as Honeycomb Monolith ***Tarik Chafik***	**ICH2P14 – OP122** Synthesis, Characterization, and Application of Bio-Templated Ni-Ce/Al_2O_3 Catalyst for Clean H_2 Production in the Steam Reforming of Methane Process ***Mohammad Reza Rahimpour, Maryam Koohi-Saadi***
05:00 pm- 05:15 pm	**ICH2P14 - OP083** Design and Performance Analysis of Green Hydrogen Production from Hybrid Solar PV/Wind Turbine Energy System ***Chaouki Ghenai***	**ICH2P14 – OP125** Green Energy from Waste: A Systems Engineering Approach to Bio-Hydrogen Production ***Salman Raza Naqvi, Bilal Kazmi, Syed Ali Ammar Taqvi, Imtiaz Ali, Muhammad Shahbaz***	**ICH2P14 – OP211** Integrated SMR System for Efficient Hydrogen and Power Production ***Abdullah A. AlZahrani, Mansur Aliyu***
05:15 pm-05:30 pm	**ICH2P14 – OP123** Green Hydrogen Based Ammonia Production Process: Insight into Energy and CO_2 Emissions Minimization ***Swaprabha P. Patel, Ashish M. Gujarathi, Piyush Vanzara***	**ICH2P14 – OP113** Development of a Hydrogen Production Model for The Gasification of Municipal Solid Waste and Its Constituents Using Aspen Plus Using Cao for CO_2 Capture ***Muhammad Shahbaz, Prakash Parthasarathy, Mohammad Alherbawi, Gordon McKay, Tareq Al-Ansari***	**ICH2P14 - OP144** Hydrogen Production Via Steam Reforming of Methanol (SRM) Using Cu/ZnO/Al_2O_3 Catalyst ***Masresha Adasho Achomo, P. Muthukumar, Nageswara Rao Peela***
End of the Day			

Day 2 | Wednesday, December 20, 2023

Time	Plenary Session	Location
09:00 am - 09:45 am	**ICH2P14-KN4** Sustainable Feedstocks and Integrated Bioprocess for Biohydrogen Production in Arid and Desert Regions **Keynote Speaker - Dr. Moktar Hamdi** Professor, National Institute of Applied Sciences and Technology, University Carthage, Tunisia	**Auditorium**
09:45 am - 10:30 am	**ICH2P14-KN5** A Framework to Evaluate Economics and CO2 Fixation potential of New Carbon Capture and Utilization (CCU) Reaction Pathways – Towards Golden Hydrogen Production **Keynote Speaker - Dr. Nimir Elbashir** Professor, Chemical Engineering, Director TEES Gas and Fuels Research Center, Texas A&M University at Qatar	**Auditorium**
10:30 am - 10:45 am	**Coffee Break with Poster Presentations**	**Exhibition Hall**

Poster Number	**Poster Presentations** **10:30 am-10:45 am** Chair: **Dr. Burak Yuzer**	**Exhibition Hall**
ICH2P14 – PP117	Redox Regulation of Hydrogen Production in Escherichia Coli During Growth on Byproducts of the Wine Industry ***Lusine Baghdasaryan, Ofelya Karapetyan, Karen Trchounian, Garabed Antranikian, Anna Poladyan***	
ICH2P14 – PP118	Comparative Economic Analysis of Small Modular Reactor Hydrogen Cogeneration and Conventional Gas-Fired Plant for Load Following: A Case Study ***Derrick Whelan, Lixuan Lu***	
ICH2P14 – PP124	Ship Design Adaptations for LNG Propulsion, Carbon Capture Utilization, and Hybrid Technologies ***Aisha Al-Asmakh, Yusuf Bicer, Tareq Alansari***	
ICH2P14 – PP128	Green Hydrogen Production: A Cost Comparison of Different Electrolysis Technologies ***Hafiz Muhammad Uzair Ayub, Sabla Y. Alnouri***	
ICH2P14 – PP012	Comparative Study Between GBO and BES Optimization Algorithms for Optimal PEMFC Parameters Identification ***Ahmed Zouhir Kouache, Ahmed Djafour, Khaled Mohammed Said Benzaoui, Souheil Touili***	
ICH2P14 – PP172	Integrated Hydrogen Production and Purple Phototrophic Bacteria Biomass Recovery via Electrocoagulation ***Ojima Wada, Burak Yuzer, Yusuf Bicer, Gordon McKay, Hamish Mackey***	
ICH2P14 – PP188	Hydrogen Naval Propulsion: Problems and Solutions ***Remili Sadia, Mohamed Chaimaa***	
ICH2P14 - PP186	Study of the Energy and Financial Performance of Hydrogen Production with Solar Energy and Photoelectrolyzer/PEM in the Algerian Desert Region (OUARGLA) ***Madjeda Ramdani, Ahmed Djafour, El Mouatez Billah Messini, Ahmed Zouhir Kouache, Zineb Bensaci***	
ICH2P14 – PP014	Investigating the Effect of Using Hydrogen as a Fuel on Performances of Gas Turbine Operating at Lean Condition in Site of Hassi R'MEL ***Fethia AMROUCHE, Bouziane Mahmah, Lidya Boudjemaa, Oum Keltoum Bari***	

Day 2 | Wednesday, December 20, 2023

Parallel Sessions 2			
Time	**Conference Room – A047**	**Conference Room – A048**	**Conference Room – A046**
10:45 am-12:30 pm	**Session 2A:** **Hydrogen Storage** Chair: **Dr. Fadwa El Mellouhi** Co-Chair: **Dr. Dhabia M. Al-Mohannadi**	**Session 2B:** **Bio-Hydrogen** Chair: **Dr. Ibrahim M. Abu-Reesh** Co-Chair: **Dr. Burak Yuzer**	**Session 2C:** **Low-Carbon Hydrogen with Reforming** Chair: **Dr. Anand Kumar** Co-Chair: **Dr. Mohammad Alherbawi**
10:45 am-11:00 am	**Invited Talk** **ICH2P14-IT2** Iron Based Hydrogen Storage and Transport **Dr. Viktor Hacker** Professor, Graz University of Technology, Institute of Chemical Engineering and Environmental Technology, Austria	**ICH2P14 – OP024** Biogas Dry Reforming to Syngas Using Catalyst Based on Local Minerals Extruded as Honeycomb Monolith ***Tarik Chafik***	**Invited Talk** **ICH2P14-IT3** Analyzing Grey and Blue Hydrogen Production Costs in Steam-Methane, Auto-Thermal, and Non-Catalytic Partial Oxidation Reforming Plants ***Mary Katebah, Ma'moun Al-Rawashdeh, Patrick Linke*** Texas A&M University at Qatar
11:00 am-11:15 am		**ICH2P14 – OP197** A Net-Zero Emission System with Biogas-Fed Solid Oxide Fuel Cell for Hydrogen Production to Advance Sustainability in the Textile Industry ***Baraka Abbas, Hooreen Ansari, Kabsha Zain, Wasifa Umer, Abeeha Fatima, Khurram Kamal, Tahir A.H. Ratlamwala***	
11:15 am-11:30 am	**ICH2P14 – OP133** Graded Gyroid-Enhanced Metal Hydride Container for Efficient Hydrogen Storage Application ***Luthfan Adhy Lesmana, Muhammad Aziz***	**ICH2P14 - OP048** Biogas Production from Date Palm Fruit Waste in Jigawa State Nigeria ***Abdulhadi Yakubu, Garba Uba, Zainab Abbas Abdulhadi, Ahmed Muhammad Gumel***	**ICH2P14 - OP091** Piston Reactor Capabilities to Make Hydrogen from Methane Via Steam and Autothermal Reforming – Modeling Study ***Aya Abousrafa, Patrick Linke, Ma'moun Al-Rawashdeh***
11:30 am-11:45 am	**ICH2P14 - OP027** Transportation and Storage of Hydrogen by LOHC: Design and Simulation of the Dehydrogenation Reactor ***Pietro Delogu, Elena Barbera, Andrea Mio, Alberto Bertucco, Maurizio Fermeglia***	**ICH2P14 – OP049** Production of Bioethanol from Groundnut Shell as a Substrate ***Abdulhadi Yakubu, Garba Uba, Zainab Abbas Abdulhadi***	**ICH2P14 – OP023** Membrane Reformer Technology for Sustainable Hydrogen Production from Hydrocarbon Feedstocks ***Alaa Albasry, Ahmed Naimi, Abdulbari Alqarni, Minseok Bae, Bandar Solami, Stephen Paglieri, Aadesh Harale***
11:45 am-12:00 pm	**ICH2P14 – OP126** Methods of Hydrogen Production, Storage and Transportation ***Sayel M. Fayyad, A.m. Maqableh***	**ICH2P14 - OP165** Hydrogen Gas and Biochar Production from Kitchen Waste Via Dark Fermentation ***Snigdhendubala Pradhan, Burak Yuzer, Yusuf Bicer, Gordon Mckay***	**ICH2P14 – OP057** Catalytic Conversion of CO_2 to CO Via Methane Dry Reforming and Reverse Water Gas Shift Reaction ***Parisa Ebrahimi, Mohammed Al-Marri, Majeda Khraisheh, Anand Kumar***
12:00 pm-12:15 pm	**ICH2P14 – OP109** Multi-Response Optimization of Absorption and Desorption Parameters in a Metal Hydride Based Hydrogen Storage System ***Alok Kumar, Purushothaman Nandagopalan, P. Muthukumar, Ranjith Thangavel***	**ICH2P14 – OP067** An Optimum Approach for Biohydrogen Production Using Poplar ***A. Yagmur Goren, Muratcan Kenez, Ibrahim Dincer, Ali Khalvati***	**ICH2P14 - OP155** Enhancing Ni-Supported Catalysts for Efficient Dry Reforming of Methane: Effects of Halloysite Nanotubular Clay Surface Activation ***Ahmed Abotaleb, Dema Al-Masri, Alaa Alkhateb, Kamal Mroue, Atef Zekri, Yasmin Mashhour, Alessandro Sinopoli***
12:15 pm-12:30 pm	**ICH2P14 - OP031** Experimental Investigation on Novel Multi-Tube Metal Hydride Reactor for Large Capacity Hydrogen Storage Applications ***Shubham Parashar, P. Muthukumar, Atul Kumar Soti***	**ICH2P14 – OP087** Biomethanol and Hydrogen Production from Pinecone Biomass Using Steam Gasification ***Hilal Sayhan Akci Turgut, Ibrahim Dincer***	**ICH2P14 - OP047** The Hydrogen Production Using Steam Methane Reforming Based on Central Receiver ***Ali Alaidaros, Abdullah A. AlZahrani***
12:30 pm-02:00 pm **Lunch** **Exhibition Hall**			

Day 2 | Wednesday, December 20, 2023

Parallel Sessions 3			
Time	**Conference Room – A047**	**Conference Room – A048**	**Conference Room – A046**
02:00 pm-03:30 pm	**Session 3A:** **Electrochemical Hydrogen** Chair: **Dr. Ahmed Abdala** Co-Chair: **Dr. Dogan Erdemir**	**Session 3B:** **Decarbonization through Hydrogen** Chair: **Dr. Marcello Contestabile** Co-Chair: **Dr. Luluwah Al-Fagih**	**Session 3C:** **Hydrogen in Transportation Applications** Chair: **Dr. Sertac Bayhan** Co-Chair: **Dr. Abdulla Al Wahedi**
02:00 pm-02:15 pm	**ICH2P14 - OP064** Effect of Volume Concentration and Sonication Time on the Performance of Hybrid Solar Collector Based Hydrogen Production System with Hybrid Nanofluid: An Experimental Investigation ***M.Baskaran, <u>S.Senthilraja</u> R. Gangadevi, Mohamed M. Awad***	**Invited Talk** **ICH2P14-IT4** In the Green Zone: Navigating Carbon Management in the Hydrogen Shift **Dr. Muftah El-Naas** Professor, Chemical Engineering, Qatar University	**ICH2P14 - OP007** Carbon Emission Reductions in the University of Sao Paulo's Transportation Sector Using Hydrogen-Powered Vehicles ***<u>Beethoven Narváez-Romo</u>, Danilo Perecin, Thiago Lopes, Daniel Lopes, Karen Mascarenhas, Suani Coelho, Julio R. Meneghini***
02:15 pm-02:30 pm	**ICH2P14 - OP073** Solar Energy Driven Silicon Photovoltaic Monolithic Electrochemical Cells for Efficient Hydrogen Production from Water ***Mourad Frites, <u>Shahed Khan</u>***		**ICH2P14 – OP020** Experimental Investigation of Diesel Engine in Dual Fuel Mode by Using Hydrogen and Low Carbon Ether Blended Diesel ***Vasanthakumar Ravisankar, <u>Loganathan Marimutthu</u>, Vikneswaran Malaiperumal***
02:30 pm-02:45 pm	**ICH2P14 - OP163** Seawater Desalination and Hydrogen Production Using Monovalent Selective Membranes Assisted with Ion-Exchange Resins for Hydroponic Solution Production ***<u>Ragad F. Alshebli</u>, Nadira Salsabila, Burak Yuzer, Yusuf Bicer***	**ICH2P14 - OP159** Developing A Sustainable Production Framework for Green Hydrogen to Decarbonize Existing Industrial Clusters ***<u>Afreenuzzaman Badruzzaman</u>, Fadwa Eljack, Seckin Karagoz***	**ICH2P14 - OP150** Driving Toward Hydrogen Mobility: A Life Cycle Cost Analysis of Traditional, Electric, And Hydrogen Fuel Cell Vehicles in Qatar ***<u>Carlos Méndez</u>, Marcello Contestabile, Yusuf Biçer***
02:45 pm-03:00 pm	**ICH2P14 - OP085** Design Considerations of Artificial UV Light-Driven Photocatalytic Water Splitting for Production of Hydrogen in a Combined Solar/Artificial Light Reactor ***<u>Ahmed Abbas</u>, Shohda Makki, Konstantinos E. Kakosimos***	**ICH2P14 - OP164** Decarbonizing ASEAN By 2050: From the Lens of a Hydrogen Economy ***<u>Archana Kumaraswamy</u>, Sushant S Garud, <u>Iftekhar A Karimi</u>, Shamsuzzaman Farooq***	**ICH2P14 – OP099** An Adaptation of The Conventional LNG Floating Storage and Regasification Unit to Hydrogen and Ammonia ***<u>Dindha Andriani</u>, Muhammad Usman Sajid, Yusuf Bicer***
03:00 pm-03:15 pm	**ICH2P14 - OP174** Electrochemcial Conversion of Carbon Dioxide into Formic Acid as Hydrogen Carrier: Role of Anolyte ***<u>Muhammad Arsalan</u>, Muftah H. El-Naas***	**ICH2P14 - OP177** Shades Of Sustainability: An In-Depth Analysis of The Direct and Indirect Carbon Footprint in Blue Ammonia Manufacturing ***<u>Hussein Al-Yafei</u>, Ahmed AlNouss, Saleh Aseel***	**ICH2P14 – OP130** Exergetic Analysis of the Process for Hydrogen Rich Syngas Production Through Biomass Gasification and Its Onsite Use in HCCI Engine for Land Transportation ***<u>Tawfiq Al-Mughanam</u>, Abdul Khaliq***
03:15 pm-03:30 pm	**ICH2P14 - OP074** Evaluation of a Novel Hybrid Photoelectrochemical-Conventional Hydrogen Generator ***<u>Mehmet Gursoy</u>, Ibrahim Dincer***	**ICH2P14 – OP190** Feasibility Study of Backing Up Energy Supply For Electric Charging Stations With Hydrogen Integration ***<u>Huseyin Bıyıkcı,</u> Yusuf Bicer***	**ICH2P14 – OP110** Development of a Hybrid Powering System with Ammonia Fuel Cells and Internal Combustion Engine for Submarines ***<u>Ibrahim Akgun</u>, Ibrahim Dincer***
Coffee Break with Poster Presentations **Exhibition Hall**			

Day 2 | Wednesday, December 20, 2023

Poster Number	Poster Presentations 03:30 pm-04:00 pm Chair: **Dr. Burak Yuzer**	Exhibition Hall
ICH2P14 – PP041	Fast Modeling Method of Gas Diffusion Layers of Polymer Electrolyte Membrane Fuel Cells ***Hamid Reza Taheri, Mohsen Shakeri***	
ICH2P14 – PP101	$La_{0.6}Sr_{0.4}Co_{0.2}\ Fe_{0.8}O_{3-\delta}$ (LSCF) Cathode Supported on Gadolinium-Doped Ceria Electrolyte Prepared by Screen-Printing Method and Performances Evaluation as Solid Oxide Fuel Cell at Intermediate Temperature ***Oumaima Ettalibi, Hicham Ben Brahim Sbitri, Abdessamad Samid, Ouafae Achak, Raphael Ihringer, Tarik Chafik***	
ICH2P14 – PP015	Sorption Properties of Ball-Milled Porous Silicon for Hydrogen Storage Up to 80 Bar ***Rama Chandra Muduli, Paresh Kale***	
ICH2P14 – PP016	Evaluation of Synergistic Integration of Nickel, Porous Silicon, and Thermally Reduced Graphene Oxide for Hydrogen Storage ***Rama Chandra Muduli, Neeraj Kumar Nishad, Paresh Kale***	
ICH2P14 – PP108	Hydrogen Adsorption Characteristics of Activated Carbon Derived from Prickly Pear Seed Cake ***Rimene Dhahri, Imen Tlili***	
ICH2P14 – PP154	Facilitating Production of Acetate and Hydrogen Through Enhanced Electron Transfer and Substrate Mass Transfer Using a Multifunctional Photocathode with Nio/G-C_3N_4/Polythiophene ***Abdul Hakeem Anwer, Assem Mohamed, Nafees Ahmed, Abdelbaki Benamor***	
ICH2P14 – PP167	Recovery Of Spent Acidic and Alkaline Liquors Generated in Metal Industry and Hydrogen Production by An Integrated System ***Huseyin Selcuk, Yusuf Gunes, Ayse Elif Ates, Burak Yuzer, Yusuf Bicer***	
ICH2P14 – PP105	Neural network for the prediction of Biohydrogen Production during Dark Waste Organic Biomass Fermentation ***Fares Almomani***	
ICH2P14 – PP201	Recent Technological Development and Advancements in Hydrogen Storage Technologies ***Abhishek Sharma, Mohit Nayal, Siddharth Jain, Varun Pratap Singh***	

Day 2 | Wednesday, December 20, 2023

Parallel Sessions 4

Time	**Conference Room – A047**	**Conference Room – A048**	**Conference Room – A046**
04:00 pm-05:30 pm	**Session 4A:** **Green Hydrogen Production** Chair: **Dr. Hicham Hamoudi** Co-Chair: **Dr. Ahmed AlNouss**	**Session 4B:** **Hydrogen Techno-Economics** Chair: **Dr. Ahmed Khalifa** Co-Chair: **Dr. Ikhlas Ghiat**	**Session 4C:** **Integrated Hydrogen Production Systems** Chair: **Dr. Ahmad K. Sleiti** Co-Chair: **Dr. Abdullah A. AlZahrani**
04:00 pm-04:15 pm	**ICH2P14 – OP082** Green Hydrogen Production and Solar to Hydrogen Ratio Using Bifacial Solar Photovoltaics and High Roof Surface Albedo ***Fahad Ahmad Faraz, Oussama Rejeb, Chaouki Ghenai***	**Invited Talk** **ICH2P14-IT5** Future and Potential of Hydrogen for Qatar Under Its Energy and Economic Transformation Quest **Dr. Muammer Koc** Professor, Division of Sustainable Development, College of Science and Engineering, Hamad Bin Khalifa University	**ICH2P14 - OP094** Innovative Integrated Multigeneration System for Sustainable Power, Hydrogen, and Ammonia Production ***Ahmad K. Sleiti, Wahib A. Al-Ammari, Mohammad Azizur Rahman***
04:15 pm-04:30 pm	**ICH2P14 – OP029** Green Hydrogen Production by Hydrolysis of Aluminum and Waste Recycling ***Pedro Ayala, Edgar Borja, P.J Sebastian***		**ICH2P14 - OP009** Transient Simulation and Comparative Assessment of Two Concentrated-Solar Based Hydrogen Production Systems Integrated with Vanadium-Chlorine Thermochemical Cycle ***Erfan Zand, Mohammadreza Khosravi, Pouria Ahmadi, Mehdi Ashjaee***
04:30 pm-04:45 pm	**ICH2P14 – OP018** Solar Hydrogen Production with Direct and Indirect Design System ***Ilyès Nouicer, Sabah Menia, Fares Meziane, Nourdine Kabouche, Chaouki Ghenai***	**ICH2P14 - OP036** A Techno-Economic Evaluation of the Integration of Direct Air Capture with Hydrogen and Solar Fuel Production ***Enric Prats-Salvado, Nathalie Monnerie, Christian Sattler***	**ICH2P14 – OP104** Green Hydrogen Production via Integrated Triple Technologies: Downdraft Tower, Photovoltaic and Electrolysis ***Emad Abdelsalam, Fares Almomani***
04:45 pm-05:00 pm	**ICH2P14 - OP025** Thermoelectric Condensation of Ambient Humidified Air for Green Hydrogen Production ***Hilal Ahmad, Taqi Ahmad Cheema, Hadeed Ahmed Sher***	**ICH2P14 - OP176** Flowsheet Safety and Techno-Economic Analysis of Optimum Ammonia and Urea Production Route ***Amzan Alsabri, Ahmed AlNouss, Fadwa ElJack***	**ICH2P14 – OP089** Electricity Hydrogen and Heat (EHH) Production in Stand-Alone Renewable Energy System ***El Manaa Barhoumi, Ikram Ben Belgacem, Manaf Zghaibeh, Mohamed Ouda***
05:00 pm-05:15 pm	**ICH2P14 – OP187** Optimum Green Hydrogen Production Through Biomass Feedstock Blending ***Ahmed AlNouss, Gordon Mckay, Tareq Al-Ansari***	**ICH2P14 - OP096** Techno-Economic Evaluation of Various Hydrogen Carriers ***Ahmad K. Sleiti, Laveet Kumar, Wahib A. Al-Ammari***	**ICH2P14 – OP080** A Clean Option for Potential Hydrogen Production Via Nuclear in Canada ***Gorkem Kubilay Karayel, Ibrahim Dincer***
05:15 pm-05:30 pm	**ICH2P14 – OP111** An Integrated Solar-Driven Chlor-Alkali System for Hydrogen and Chlorine Production ***Sümeyya Ayça, Ibrahim Dincer***	**ICH2P14 – OP193** Strategy Of Turkiye on Hydrogen Energy ***Serpil Edebali, Mustafa Ersoz***	**ICH2P14 – OP088** A Study on Nuclear-Based Hydrogen Production System Via Three- and Four-Step Magnesium Chlorine Cycles ***Şulenur Asal, Adem Acır, Ibrahim Dincer***

06:30 pm-08:30 pm
Gala Dinner and Awards Ceremony
Hotel

Day 3 | Thursday, December 21, 2023

Parallel Sessions 5			
Time	**Conference Room – A047**	**Conference Room – A048**	**Conference Room – A046**
09:00 am-10:30 am	**Session 5A:** **Life Cycle Assessment of Hydrogen** Chair: **Dr. Mohamed Haouari** Co-Chair: **Dr. Tareq A. Al-Ansari**	**Session 5B:** **Hydrogen in Grids and Communities** Chair: **Dr. Patrick Linke** Co-Chair: **Dr. Veronica Bermudez**	**Session 5C:** **Hydrogen Effects on Materials** Chair: **Dr. Ibrahim Galal Hassan** Co-Chair: **Dr. Afrooz Barnoush**
09:00 am-09:15 am	**ICH2P14 – OP084** Life Cycle Assessment of Green Hydrogen Supply Network ***Dana Alghoul*, *Mohamed Haouari, Paolo Trucco***	**ICH2P14 - OP056** Multi-Scenario Analysis of Levelized Cost of Hydrogen for Water Electrolysis-Photovoltaic Energy Technology in the Near Future (2025–2050) of Algeria ***Hammou Tebibel*, *Abdelhamid M'raou***	**ICH2P14 – OP134** The Correlation of Porous Material's Properties Between Particle Geometry for Hydrogen Fuel And Electrolysis Cells ***Jaeyeon Kim*, *Luthfan Adhy Lesmana, Muhammad Aziz***
09:15 am-09:30 am	**ICH2P14 – OP180** Life Cycle Assessment of a Direct Air Capture and CO_2 Utilization System ***Aliya Banu, Namra Mir, Muftah H. El-Naas, Ahmed Ali Khalifa, Abdulkarem I. Amhamed, Yusuf Bicer***	**ICH2P14 - OP142** Optimizing Green Hydrogen and Power Generation from Urban Sewage Sludge in the Steel Industry: A Kerman Case Study ***Saeed Edalati*, *Mohammadreza Khosravirad***	**ICH2P14 – OP112** Influence Of Hydrogen Uptake on Additively Manufactured and Conventional Austenitic Stainless Steels 316l ***Qingyang Liu*, *Sumia Manzoor, Mohammad Tariq, Hanan Farhat, Afrooz Barnoush***
09:30 am-09:45 am	**ICH2P14 - OP178** Tank To Tank Life Cycle Assessment of Greenhouse Gas Emission from Methanol Plant ***Hussein Al-Yafei*, *Ahmed AlNouss, Saleh Aseel, Mohannad AlJarrah, Tareq Al-Ansari***	**ICH2P14 - OP097** Maximizing Power Grid Resilience: Rolling Horizon Control for Output Power Smoothing in Islanded Wind-Solar Microgrids with Multiple Hydrogen Storage Tanks ***Muhammad Bakr Abdelghany*, *Ahmed Al-Durra***	**ICH2P14 – OP046** In-House Green Anti-Corrosion Inhibitor to Protect from Hydrogen Embrittlement Effect on the Structural Integrity of Api 5l Steel Pipeline ***Mohammed HadjMeliani*, *Hadjer Didouh, Mouna Amara, Azedine Belalia, Rami K.Suleiman, Guy Pluvinage***
09:45 am-10:00 am	**ICH2P14 – OP106** An Integrated Life Cycle Assessment and Supply Chain Analysis of a Multi-Generation System for Renewable Clean Power and Green Hydrogen Production ***Tahir Abdul Hussain Ratlamwala*, *Sheikh Muhammad Ali Haider, Khurram Kamal***	**ICH2P14 - OP173** Circular Economy of integrating Green Hydrogen Production within an Eco-Industry Park ***Hajer Mkacher, Fadwa ElJack***	**ICH2P14 - OP072** Protection From Hydrogen Embrittlement Using Green Inhibitor on the Welding Joint of Api X65 Pipeline Steel in Dynamic Loading ***Azedine Belalia*, *Mohammed Hadj Meliani, Hadjer Didouh, Mouna Amara, Rami K.Suleiman, Guy Pluvinage***
10:00 am-10:15 am	**ICH2P14 - OP151** Regeneration Energy Optimisation of Post-Combustion CO_2 Capture (PCC) Process Based on Amine Composition Using Artificial Neural Network (ANN) ***Najamus Sahar Riyaz*, *Nancy Khalaf AbuZaid, AlAnkaa Al-Harbi, Abdelbaki Benamor***	**ICH2P14 - OP004** Monte Carlo Simulation Applications for Stakeholder Management on Hydrogen Production Projects: Toward Sustainable Development ***Ayman Mashali***	**ICH2P14 - OP043** Advancing Hydrogen Production: High-Resolution Kinetic Analysis of Photocatalytic Water Splitting Using Covalent Organic Framework Catalyst and Ascorbic Acid ***Suhde Makki*, *Konstantinos E. Kakosimos***
10:15 am-10:30 am	**ICH2P14 – OP120** A Life Cycle Assessment of Hydrogen Production with Catalyst ***Assem Abdurakhmanova*, *Ibrahim Dincer***	**ICH2P14 - OP052** Assessment of Hydrogen Trading Within Blockchain and Artificial Intelligence: A Review ***Sofya Morozova*, *Arif Karabuga, Zafer Utlu***	**ICH2P14 – OP140** A Critical Review of Hydrogen (H_2) Flow Assurance in the Presence of Impurities ***Mohammad Azizur Rahman*, *Ibrahim Hassan, Rashid Hasan, Faisal Khan, Eduardo Gildin, Ahmad Sleiti***

Poster Number	Poster Presentations 10:30 am-11:00 am Session Chair: **Dr. Burak Yuzer**	Exhibition Hall
ICH2P14 – PP005	Efficiency Hydrogen Production Via Water Photoreduction Over Fenps Elaborated Via Green Way ***Meriem Guouasmi, Amel Boudjema, Chahrazed Benhamidech, Khaldoun Bachari***	
ICH2P14 – PP011	Field Investigation of Green Hydrogen Production Through the Pem Electrolyzer in Ouargla City ***Ahmed Zouhir Kouache, Ahmed Djafour, Khaled Mohammed Said Benzaoui, Madjida Ramdani***	
ICH2P14 – PP028	Recent advances in Green Synthesis of Cu_2O as a Photocatalyst for Conversion of Solar Energy into H_2 ***S. Torres-Arellano, P.J. Sebastian***	
ICH2P14 – PP030	Effect of Scale-Up in Membraneless Microbial Electrolysis Cells on Hydrogen Production ***M. Mejía-López, O. Lastres, J.L. Alemán-Ramirez, L. Verea, P.J. Sebastian***	
ICH2P14 – PP153	Synthesis and Evaluation of Cu-Based Catalytic Materials for CO_2 Hydrogenation to Value-Added Products ***Rim Ismail, Assem Mohamed, Mohamed Ali H. Saad, Abdelbaki Benamor***	
ICH2P14 – PP168	Current and Temperature Distributions in a Planar Solid Oxide Electrolysis Cell In-situ Assessed with Segmented Electrodes ***Kentaro Yokoo, Hironori Nakajima, Kohei Ito***	
ICH2P14 – PP181	Underground Gas Storage Systems: Natural Gas, Hydrogen, And Carbon Sequestration ***Manal Al-Shafi, Yusuf Bicer, Ahmad Abushaikha***	
ICH2P14 – PP055	Forced Convection in Porous Medium Using Triply Periodical Minimum Surfaces: Experimental and Numerical Approach ***M. Ziad Saghir***	

Day 3 | Thursday, December 21, 2023

Parallel Sessions 6			
Time	**Conference Room – A047**	**Conference Room – A048**	**Conference Room – A046**
11:00 am-12:30 pm	**Session 6A:** **Bio-Hydrogen-2** Chair: **Dr. Mohammad Alherbawi** Co-Chair: **Dr. Farhat Mahmood**	**Session 6B:** **Hydrogen Storage and Carriers** Chair: **Dr. Majeda Khraisheh** Co-Chair: **Dr. Alessandro Sinopoli**	**Session 6C:** **Electrolyzers** Chair: **Dr. Muhammed Iberia Aydin** Co-Chair: **Dr. Nurettin Sezer**
11:00 am-11:15 am	**ICH2P14 - OP157** Potential Evaluation and Optimization of Exoelectrogenic Activity of Rhodobacter Capsulatus: A Sustainable Strategy for Bioelectricity Production ***Saima Mirza, Junaid Mahmood, Arjumand Shah Bano, Mohammad Morowvat, Mudassar Ali, Obaid ur-Rehman***	**ICH2P14 - OP145** Heat Transfer Optimization of a Metal Hydride Tank Targeted to Improve Hydrogen Storage Performance ***Nadhir Lebaal, Djafar Chabane, Alaeddine Zereg, Nouredine Fenineche***	**ICH2P14 - OP156** An Electrolyser Design for Membraneless Electrolysis by Using 3D Printing ***Muhammed Iberia Aydin, Ibrahim Dincer***
11:15 am-11:30 am	**ICH2P14 – OP135** Predictive Modeling of Biogas and Methane Production from Cow and Chicken Manure Using a Modified Gompertz Model Optimized by Particle Swarm Optimization ***Nadjiba Sophy, Nour Elislam Mougari, Nabil Himrane, Luis Le Moyne***	**ICH2P14 – OP137** Sodium Bicarbonates Production Through Carbon Mineralization for Hydrogen Storage: A Techno-Economic Assessment ***Dina Ewis, Zeyad Moustafa Ghazi, Sabla Y. Alnouri, Abdelbaki Benamor, Muftah H. El-Naas***	**ICH2P14 – OP179** Modeling For Multi-Mechanisms Permeability of Hydrogen Using a Membrane Process ***Hamid Zentou, Mahmoud M. Abdelnaby, Abdullah A. AlZahrani***
11:30 am-11:45 am	**ICH2P14 - OP079** Optimizing Hydrogen Production and Anaerobic Biodegradability in Pharmaceutical Industry Wastewaters Through Photocatalytic Oxidation ***Ayşe Elif Ateş, Burak Yüzer, Adem Yurtsever, Sinan Ates***	**ICH2P14 - OP146** Assessing the Potential and Viability of Renewable Methane and Hydrogen as Sustainable Energy Carriers ***Mohammed Al-Breiki, Yusuf Bicer***	**ICH2P14 - OP033** Degradation Modelling of Water Electrolysers Using Hidden State Estimation and Deep Learning ***Frank Hilden, Pourya Azadi, Stéphane Haag, Giuseppe Cusati, Vanessa Gepert***
11:45 am-12:00 pm	**ICH2P14 – OP189** Biocatalytic Conversion of Lignocellulosic Biomass into Biohydrogen Via Photofermentation Route ***Saima Mirza, Javed Iqbal Qazi, Shulin Chen***	**ICH2P14 – OP184** Flexible Natural Gas Allocation to Blue-Hydrogen Monetised Products: An Agent-Based Modelling Approach ***Noor Yusuf, Ahmed AlNouss, Tareq Al-Ansari***	**ICH2P14 - OP141** Experimental And Numerical Analyses of A Cathode-Supported Monolithic Solid Oxide Electrolysis Cell ***Hironori Nakajima, Yoshihiro Iwanaga, Kohei Ito***
12:00 pm- 12:15 pm	**ICH2P14 – OP196** Mathematical Modeling of A Sustainable Energy System For Restaurant Communities: Waste-To-H2 Conversion, CO2 Mitigation, Clean Fuel Production, And Power Generation ***Syed Muhammad Aun Rizvi, Khurram Kamal, Tahir A.H. Ratlamwala***	**ICH2P14 – OP035** Power-To-Gas Process in the Upgrading of The CO_2 Extracted from the Unprocessed Algerian Natural Gas ***Rafika Boudries, Nourdine Kabouche, Rafik Medjebour, Brahim Laoun, A. Khellaf***	**ICH2P14 – OP065** Solar Hydrogen and Methanol Production with CSP/PV Driven Electrolyser ***Nathalie Monnerie, Andreas Rosenstiel, Christian Sattler***
12:15 pm-12:30 pm	**ICH2P14 - OP092** An Approach in Treating Biomass and Plastic Waste for Production of Hydrogen and Ethanol ***Muhammad Ishaq, Ibrahim Dincer***	**ICH2P14 – OP183** Comparative Thermodynamic Analysis of Two Green Fuel Production and Power Generation Pathways ***Amira Chebbi, Yusuf Bicer***	**ICH2P14 - OP090** An Investigation of Metal Coated 3D-Printed Electrodes for Hydrogen Production ***Muarij Khalil, Ibrahim Dincer***
12:30 pm-02:00 pm **Lunch** **Exhibition Hall**			

Day 3 | Thursday, December 21, 2023

Parallel Sessions 7			
Time	**Conference Room – A047**	**Conference Room – A048**	**Conference Room – A046**
02:00 pm-03:30 pm	**Session 7A:** **Thermodynamic Analysis of Hydrogen Systems** Chair: **Dr. Nader Javani** Co-Chair: **Dr. Shoukat Alim Khan**	**Session 7B:** **Fuel Cells and Combustion** Chair: **Dr. Mohd Zamri Che Wanik** Co-Chair: **Dr. Tahir A.H. Ratlamwala**	**Session 7C:** **Photo-Electro-Catalytic Hydrogen Production** Chair: **Dr. Rima Isaifan** Co-Chair: **Dr. Khaled Abedrabboh**
02:00 pm-02:15 pm	**ICH2P14 - OP152** Design, development and investigation of solar-integrated co-electrolysis for methanol production ***Muhammad Sajid Khan, Muhammad Abid, Chen Chen, Juliana Hj Zaini, Tahir Ratlamwala***	**ICH2P14 - OP042** Feasibility Study of a Molten Carbonate Fuel Cell as a CO_2 Separator for Various Industrial Exhaust Emissions ***Arkadiusz Szczęśniak, Aliaksandr Martsinchyk, Olaf Dybinski, Katsiaryna Martsinchyk, Kamil Futyma, Łukasz Szabłowski, Jarosław Milewski, Małgorzata Dembowska***	**ICH2P14 - OP034** Synthesis and Application of Pd/Sr-NPs@TiO_2 for Photocatalytic H_2 Generation from Water Splitting Reactions ***Ejaz Hussain, Khezina Rafiq***
02:15 pm-02:30 pm	**ICH2P14 – OP160** Energy And Exergy Analysis of A Four-Step Copper Chlorine Cycle For Enhanced Efficiency And Performance ***Satyasekhar Bhogilla, Aman Pandoh, Uday Raj Singh***	**ICH2P14 - OP149** Sustainable Proton-Exchange-Membrane Fuel Cell (PEMFC) System Exergoeconomic Analysis ***Rodrigo Raimundo, Carlos Matiolo, Rhayssa Ribas, Lauber Martins, André Mariano, Stephan Och, Vanessa Kava, José Vargas***	**ICH2P14 – OP127** Dye-Sensitized Photocatalytic Hydrogen Production by Sepiolite Clay ***Yigit Osman Akyildiz, Emre Aslan, Mahmut Kus, Imren Hatay Patir, Mustafa Ersoz***
02:30 pm-02:45 pm	**ICH2P14 – OP054** Performance Evaluation of Different Working Fluids In S-ORC Based Hydrogen Production System ***Arif Karabuga, Zafer Utlu, Melik Ziya Yakut***	**ICH2P14 – OP136** 3e Analysis and Multi-Objective Optimization of Solar-Thermal-Assisted Energy System: Supercritical CO_2 Brayton Cycle and Solid Oxide Electrolysis/Fuel Cells ***Zhicong Fang, Zhichao Liu, Shuhao Zhang, Zekun Yang***	**ICH2P14 - OP032** Synthesis of Au–Bao@TiO_2/Cds Catalysts: H_2 Generation from Water Splitting Reactions ***Khezina Rafiq, Ejaz Hussain***
02:45 pm-03:00 pm	**ICH2P14 - OP162** Thermodynamic Evaluation of a Renewable Energy Storage Concept Incorporating a Solid Oxide Electrolyzer and Metal Hydride Compressor ***Uday Raj Singh, Satyasekhar Bhogilla***	**ICH2P14 – OP203** A Review of The Feasibility of Utilising Hydrogen as a Marine Fuel in Australia ***Hongjun Fan, Nagi Abdussamie, Andrew Harris, Peggy Shu-Ling Chen, Irene Penesis***	**ICH2P14 – OP115** Photocatalytic Hydrogen Generation from Seawater Using High-Performance Polymeric Materials ***Noora Al-Subaiei, Ghalya Abdulla, Mohammed Al-Hashimi, Konstantinos E Kakosimos***
03:00 pm-03:15 pm	**ICH2P14 - OP053** Thermodynamic Analysis of PTC-Based Hydrogen Production System ***Arif Karabuga, Zafer Utlu, Hasan Ayarturk***	**ICH2P14 - OP143** Study Of Laminar Burning Speed Correlation' For Ammonia-Hydrogen Fueled Mixture ***Anas Rao, Muhammad Ihsan Shahid, Muhammad Farhan, Yongzheng Liu, Fanhua Ma***	**ICH2P14 - OP021** Efficient and Stable Seawater Electrolysis Over a Binder-Free Nio-Nanosheet Array Bifunctional Catalyst ***Khadijeh Hemmati***
03:15 pm-03:30 pm	**ICH2P14 – OP093** A Unique System for Hydrogen, Methanol, Fresh Water and Electricity Production with Carbon Capturing and Storage ***Mitra Ghannadi, Ibrahim Dincer***	**ICH2P14 – OP194** Proton Exchange Membrane based Fuel Cell Generation System Modeling for Power System Studies ***Mohd Zamri, Che Wanik***	**ICH2P14 – OP121** Piezocatalytic Hydrogen Evolution Activity of Seleno-Chevrel Phases ***Talha Kuru, Emre Aslan, Faruk Ozel, Imren Hatay Patir, Mustafa Ersoz***
03:30 pm-04:00 pm **Coffee Break with Poster Presentations** **Exhibition Hall**			

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Poster Number	Poster Presentations 03:30 pm-04:00 pm Chair: **Dr. Burak Yuzer**	Exhibition Hall
ICH2P14 – PP132	Modeling Of Supercritical Hydrogen Storage System Parameters Using Artificial Intelligence Technique ***A. Abdallah El Hadj*, Ait Yahia, Smain Sabour, Mohammed R Zahi, Maamar Laidi, S.Hanini**	
ICH2P14 – PP147	Photo-Electro-Electrolysis System Utilizing TiO_2-Coated Stainless Steel and FTO as Photoelectrodes for Enhanced Dye Removal in Wastewater and Hydrogen Production ***Nadira Salsabila*, Ragad F. Alshebli, Burak Yuzer, Yusuf Bicer**	
ICH2P14 – PP169	Dynamic Modelling Approach for Understanding the Influence of Carbon Policies on Electrofuels Utilisation Within the Aviation Sector ***Ridab Khalifa*, Yusuf Bicer, Tareq Al-Ansari**	
ICH2P14 – PP185	Multi-Purpose Charging Station for Electric and Hydrogen Vehicles Enabling Sustainable Transportation ***Marawan Hussein*, *Sara Mohamed*, *Amira Chebbi*, Luluwah Al-Fagih, Tareq Al-Ansari, Yusuf Bicer**	
ICH2P14 – PP068	Hydrogen Sulfide H_2S – for the Service of Humanity! ***Anatolii Startsev***	

Time	Conference Room – A048	Conference Room – A046
04:00 pm-05:00 pm	**Session 8A:** **Other Hydrogen Applications** Chair: **Dr. Dogan Erdemir** Co-Chair: **Dr. Hanadi G. Al-Thani**	**Session 8B:** **Hydrogen Utilization and Production** Chair: **Dr. Muhammed Iberia Aydin** Co-Chair: **Dr. Burak Yuzer**
04:00 pm-04:15 pm	**ICH2P14 - OP051** Enhancing Hydrogen Gas Production in Escherichia Coli Through a Crispr-Based Approach ***Salisu Ahmed*, Musa Abdullahi, Abubakar Ahmad**	**ICH2P14 – OP182** A Techno-Economic Analysis of Hybrid Solar-Wind Energy Systems with Hydrogen Storage for Residential Communities ***Sara Mohamed*, Yusuf Bicer, Luluwah Al-Fagih**
04:15 pm-04:30 pm	**ICH2P14 – OP119** Low Price Photo and Thermal Production of Hydrogen Fuel from Hydrogen Sulfide Extracted from Petroleum Natural Gas ***Salah Naman***	**ICH2P14 – OP138** Design And Performance Analysis of Ammonia-Based Power Generation ***Kazuki Ohira*, Rahmat Waluyo, Muhammad Aziz**
04:30 pm-04:45 pm	**ICH2P14 - OP148** State-Flow Based Energy Management System in Micro-Grid Including Fuel Cell ***Hamid Bentarzi*, Abderrahmane Ouadi, Abdelkader Zitouni, Abdelkader Abdelmoumene**	**ICH2P14 – OP071** Investigation of a New Energy System with Recycled Aluminum-Water Hydrogen Production ***Andre Bolt*, Ibrahim Dincer, Martin Agelin-Chaab**
04:45 pm-05:00 pm	**ICH2P14 – OP070** Bio-Inspired Optimization of Hydrogen Production Plants: Harnessing the Pollutants for Enhanced Efficiency of Fuel Cell ***Khaled Abu Alfoul*, Anaam Abu Foul**	**ICH2P14 – OP195** Optimizing Green Hydrogen Production in the GCC: A Pilot Study of Capacity Factor Enhancement via Trans-Continental Energy Imports ***Moiz Ali*, Yusuf Bicer, Tareq Al-Ansari**
05:00 pm-05:15 pm	**ICH2P14 – OP191** Wind Power's Evolution: Unveiling Advances and Challenges in the Quest for Sustainable Energy ***Abdelkader Abdelmoumene*, Hamid Bentarzi**	**ICH2P14 - OP098** Electro-Biomembrane Reactor for Concurrent Hydrogen Production and Desalination ***Ahmet Faruk Kilicaslan*, A. Yagmur Goren, Ibrahim Dincer, Ali Khalvati**
05:15 pm-05:30 pm	**ICH2P14 – OP213** An Investigation on the Magnetic Cooling Systems in Electric Vehicle **Nader Javani, *Hadi Genceli***	**ICH2P14 - OP078** A Community Energy System Designed to Cover the Needs Including Hydrogen ***Moslem Sharifishourabi*, Ibrahim Dincer, Atef Mohany**
06:30 pm-09:30 pm **Optional Social Tour**		

Hydrogen Energy Course

Time	Hydrogen Energy Course (with registration)	Auditorium
09:00 am-09:15 am	Opening Talks	
09:15 am-11:15 am	**Introduction to Hydrogen: H2-101** **Professor Dr. Ibrahim Dincer**, Ontario Tech University, Canada	
11:15 am-11:30 am	Break	
11:30 am-01:30 pm	**Hydrogen Production: Electrolyzes, Methods and Processes** **Professor Dr. Fares Almomani,** Qatar University, Qatar	
1:30 pm-02:00 pm	Lunch Break	
2:00 pm-04:00 pm	**Hydrogen Storage and Transportation** **Dr. Yusuf Bicer,** Hamad Bin Khalifa University, Qatar	
04:00 pm-04:15 pm	Break	
04:15 pm-06:15 pm	**Hydrogen Utilization and Fuel Cells** **Professor Dr. Xianguo Li**, University of Waterloo, Canada	
06:15 pm-06:30 pm	**Certification Ceremony**	

14TH INTERNATIONAL CONFERENCE ON HYDROGEN PRODUCTION (ICH2P-2023)

December 19-21, 2023

Hamad Bin Khalifa University
Doha, Qatar

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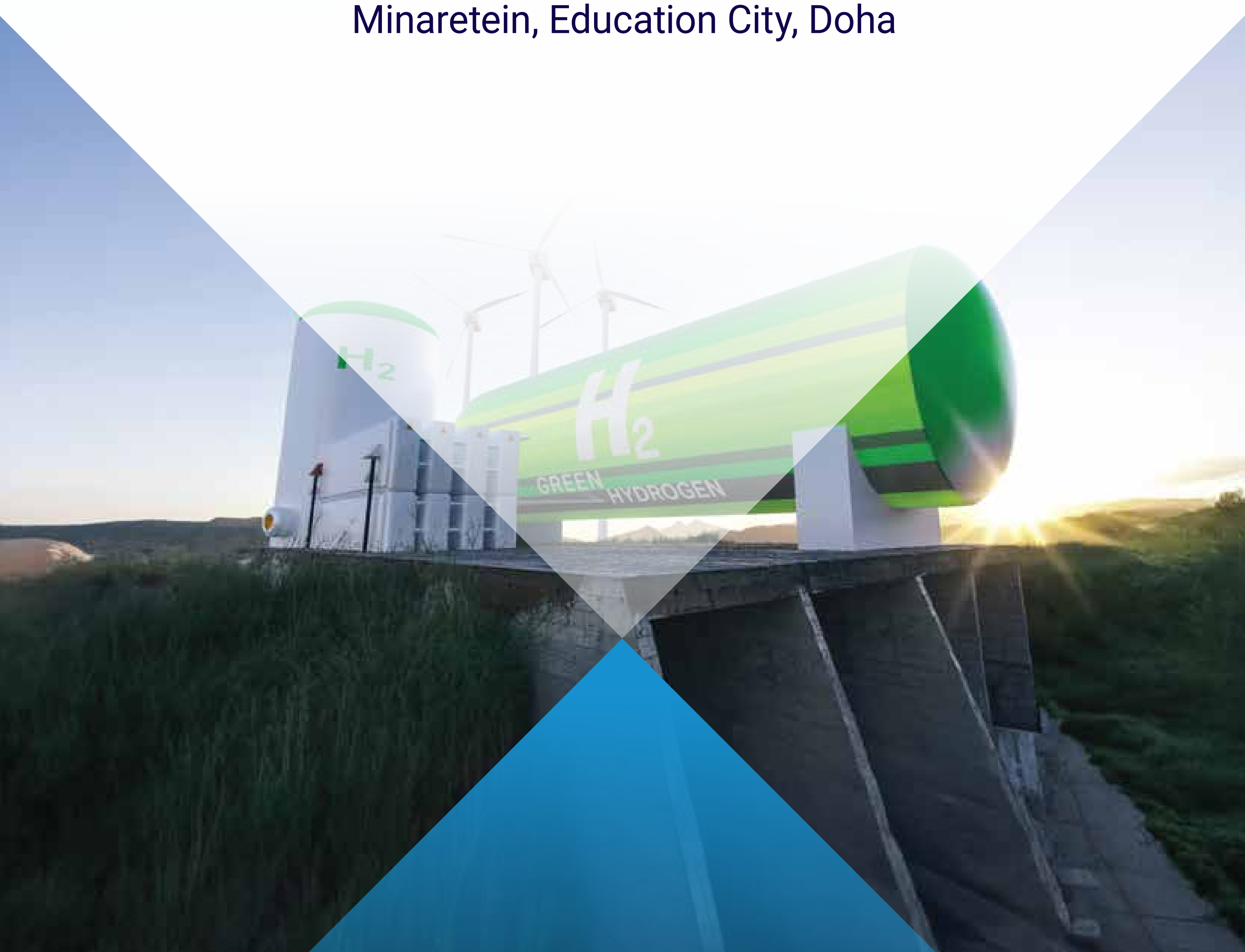

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ABSTRACTS BOOK

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ABOUT HAMAD BIN KHALIFA UNIVERSITY

Hamad Bin Khalifa University (HBKU), a member of Qatar Foundation for Education, Science, and Community Development (QF), was founded in 2010 to continue fulfilling QF's vision of unlocking human potential.
HBKU is a homegrown research and graduate studies University that acts as a catalyst for positive transformation in Qatar and the region while having a global impact.

Located within Education City, HBKU seeks to provide unparalleled opportunities where inquiry and discovery are integral to teaching and learning at all levels utilizing a multidisciplinary approach across all focus areas.

HBKU is committed to actively contribute to achieving the Qatar National Vision 2030 by building and cultivating human capacity through an enriching academic experience and an innovative research ecosystem. Through applying creativity to knowledge, students will have the opportunity to discover innovative solutions that are locally relevant and have a global impact.

At Hamad Bin Khalifa University – our students, faculty, staff, partners, and leadership – all share a common belief in the power of higher education and research to make a positive impact in the development of nations.

FOREWORDS

Dean’s Welcoming Message

On behalf of the College of Science and Engineering (CSE) at Hamad Bin Khalifa University, it is our honor to host and organize this prestigious international event, the 14th International Conference on Hydrogen Production (ICH2P-2023). I would like to extend my warmest greetings to all the attendees of this promising event.

The College of Science and Engineering aims to be a world-class multidisciplinary college with significant positive impact on the region and the world, in the fields of science, engineering, and technology. One of our key divisions is the Division of Sustainable Development with its mission of educating future leaders on Sustainable Energy and Sustainable Environment and all associated areas.

We look forward to contributing to the high-quality research results that will be presented during the symposium, which will help develop new policies and scientific progress towards achieving sustainable development, and be of great value to positioning our college in the midst of these extremely important fields of hydrogen research.

We look forward to welcoming you.

Dr. Mounir Hamdi
Dean of the College of Science and Engineering
Hamad Bin Khalifa University

FOREWORDS

Co-Chair's Welcoming Message

As Co-Chair of the Organizing Committee for the International Conference on Hydrogen Production (ICH2P-2023), I am honored to welcome you to this esteemed gathering held at Hamad Bin Khalifa University, Education City, in Qatar from December 19-21, 2023. Your presence here signifies a shared commitment to addressing the challenges of our time through innovative solutions in hydrogen production, storage, transportation, delivery, and utilization.

The scientific part of ICH2P-2023 will include talks by keynote speakers, invited speakers, and industry experts, as well as oral and poster presentations from academic participants. Conference proceedings will be published on the website after reviewing the submitted manuscripts. High-quality papers will be considered, in expanded form, for possible publication in specific reputable international journals mentioned on the conference website.

Throughout the conference days, we invite you to immerse yourself in the diverse discussions, presentations, and collaborative opportunities that this conference offers. The insights and knowledge shared here have the power to shape the future of sustainable energy.

We extend our deepest appreciation to the speakers, sponsors, and the dedicated organizing committee for their tireless efforts in making this event possible. Together, let us embark on a journey of discovery, collaboration, and progress towards a more sustainable and hydrogen-powered world.

Thank you for being part of this transformative experience.

Yusuf Bicer
Conference Co-Chair
Associate Professor, Division of Sustainable Development
College of Science and Engineering
Hamad Bin Khalifa University

FOREWORDS

Co-Chair’s Welcoming Message

On behalf of the Division of Sustainable Development, it is my distinct pleasure to welcome you to the International Conference on Hydrogen Production (ICH2P-2023) at Hamad Bin Khalifa University. This gathering is a testament to our collective commitment to advancing sustainable solutions, and your presence amplifies the impact we can make together.

Hydrogen, as a clean and versatile energy source, is at the forefront of our shared vision for a more sustainable future. We encourage you to actively participate in the sessions, engage in discussions, and forge connections that transcend borders and disciplines. The interdisciplinary collaboration fostered during this conference has the potential to drive innovation and pave the way for a greener world.

We also plan to include a social program covering a welcome reception, lunches, coffee breaks, a gala dinner, and social tours in Doha. You will have the opportunity to experience and observe the distinctive Qatari culture, and the hospitality and beauty of Doha.

A heartfelt thank you to the organizers, speakers, and sponsors for their dedication to making this event a success. Together, let us explore the frontiers of hydrogen production and contribute to building a more sustainable and resilient world.

We endeavor to ensure that ICH2P-2023 will be a valuable, impactful, and enjoyable event.

Dr. Tareq Al-Ansari
Conference Co-Chair
Associate Professor, Head of the Division of Sustainable Development
College of Science and Engineering
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KEYNOTE SPEAKERS

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ICH2P14-KN1

NEW HORIZONS IN HYDROGEN PRODUCTION TECHNOLOGIES

Ibrahim Dincer

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Energy is recognized by many as a key element of the interactions among the nature, society and human activities where it appears to be critically important for the environment and sustainable development. Many environmental issues have been caused directly or indirectly by and/or related to the production, transportation, conversion, storage and consumption of fossil fuels-based energy, for example, acid rain, stratospheric ozone depletion and global warming/climate change. Recently, a variety of potential solutions to the current environmental problems, particularly associated with the greenhouse gas emissions, has evolved, including renewable energies and carbon free fuels where hydrogen comes into the picture as a unique solution. In this regard, energy systems appear to be one of the most effective solutions to the current energy, environment and sustainability issues and can play a significant role in providing better performance, better environment and better sustainability. As Professor Dincer stated previously back in early 2020 that the COVID-19 pandemic hit the humanity and their future in a way became a turning point by closing the carbon age but opening the hydrogen age. The European Community and many other countries in almost every continent started developing their clean energy strategic plans and road maps with hydrogen. This has made it clear globally that we have gone into the hydrogen age where hydrogen will play critical roles as a fuel, an energy carrier and more importantly as a feedstock. It is now globally clear that every country needs to develop their hydrogen energy ecosystem and prepare their sectors by overcoming challenges, benefiting from the opportunities and preparing their human capital to manage the transition to hydrogen age accordingly. That's why Professor Dincer introduced this hydrogen age as "Hydrogen 1.0" and explained that the requirements in achieving this hydrogen era critically requires three players as technology, innovation and digitalization where there is a strong need to couple and synchronize them in a right way. Furthermore, there are challenges and opportunities simultaneously available for the humanity to tackle with and build a global hydrogen society. So, this is something remarkable, and the history will, in the future, praise those who will make contributions to this hydrogen society building process. The hydrogen age requires hydrogen production systems designed and developed for production of hydrogen from hydrogen containing resources, particularly water, where hydrogen production methods may be classified either based on the type of material which hydrogen is produced from, or the type of the process driving energy source. In addition, the production of hydrogen is a critical target to make it green (clean) for the environment and societal adaption to deploy in every sector of economies. The talk introduces the hydrogen production methods, including electrolysis, thermochemical and hydrid cycles, photonic processes, microwave techniques, ultrasonic (so-called: sonic hydrogen production) techniques, material processes, etc. and compare them by considering the operational and performance related criteria as well as cost. It also discusses how renewables and nuclear become green enough together to manage the hydrogen ecosystem and addresses the environmental and sustainability concerns through the assessment study results.

ICH2P14-KN2

DEVELOPMENT OF MANUFACTURING TECHNIQUES FOR HIGHLY-PERFORMING POLYMER ELECTROLYTE MEMBRANE FUEL CELLS

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Polymer electrolyte membrane (PEM) fuel cell technology is maturing for commercial applications with challenges on methods and techniques for their volume production with low cost, consistency, reliability and repetitiveness among the same batch and different batches of manufacturing processes, within a specified quantifiable tolerance range. Three low-cost manufacturing techniques with volume capability have been evaluated: catalyst-coated substrate (CCS), catalyst-coated membrane (CCM) and decal-transfer method (DTM). For each method, systematic and consistent investigations have been conducted for various sub-processes and conditioning parameters, such as DTM with different operation temperatures, and additional layers of Nafion and carbon at different locations and orders. The sensitivity of the different manufacturing techniques with different platinum loadings on the MEA performance has also been investigated. It is observed that at the high Pt loading of 0.3-0.5 mg/cm^2, excellent MEA performance is achieved for all the three methods with almost identical results. When the Pt loading is reduced to 0.125 mg/cm^2 (a low Pt loading targeted for cost-effective practical applications), the performance of MEAs made by the different methods changes substantially, indicating significant sensitivity of the fuel cell to the manufacturing methods for different Pt loadings.

ICH2P14-KN3

HYDROGEN AND FUEL CELL DEVELOPMENT AND THE BENEFIT OF DIGITAL TWIN AND ARTIFICIAL INTELLIGENCE IN THIS FIELD

Abdul Ghani Olabi

Director
Sustainable Energy and Power Systems Research Centre
University of Sharjah

Green hydrogen is considered one of the most important sources of clean energy, and the expansion of its use will preserve the environment and reduce the problems of heat emission. Green hydrogen is more expensive compared to blue and grey hydrogen due to the higher cost of renewable energy. However, recent developments in the production of renewable energy have significantly reduced these costs. The cost of green hydrogen varies between $3 - 6.5 per kilogram compared to $2.4 and $1.8 per kilogram for blue and grey hydrogen products, respectively. Renewable energy costs and consequently the cost of green hydrogen are expected to fall to the grey hydrogen scale by 2025, and lower by 2040. This presentation will present the latest developments on green hydrogen developments including; production, storage and transportation. Also the presentation will show the state of art of fuel cell developments.

ICH2P14-KN4

SUSTAINABLE FEEDSTOCKS AND INTEGRATED BIOPROCESS FOR BIOHYDROGEN PRODUCTION IN ARID AND DESERT REGIONS

Moktar Hamdi

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National Institute of Applied Sciences and Technology
University of Carthage

In the coming years, the production of hydrogen with high energy content per unit mass (34 Kcal/g-H_2) will increase and provide the possibilities to decarbonize industry and transport. In addition to its environmental benefits and contribution in circular economy, biohydrogen can be obtained through non food feedstocks bioconversion at a lower production cost than other types of green hydrogen.

Fruits and vegetable waste, food waste, sewage sludges, animal manure and date palm waste are potential feedstocks for biohydrogen production in arid and semi-arid regions. Algae, Opuntia, Salicornia and Agave have also a potential renewable feedstocks for biohydrogen production and can be cultivated on the non-arable land to fix carbon dioxide and reuse treated wastewaters. The feedstocks composition and pretreatment are practical challenges of conversion of biomass into biohydrogen.

In arid and semi-arid regions, food wastes (one-third of produced food) are the most sustainable feedstocks due to its abundant availability, the established collecting system, low pretreatment cost, high conversion efficiency, and the possibility of storage. Moreover, the coproducts of biohydrogen production from food waste like biofertilizer and biochar (immobllizing carbon, nitrogen and others important elements) can be used as sustainable soil amendments to improve soil fertility and quality for non-edible plant culture in marginal areas.

The main technologies converting feedstoks to biohydrogen are dark fermentation, photofermentation and microbial electrolysis cell. The bioprocess optimization of biohydrogen production are crutial and decisive because this minimizes downstream processing and enhances biohydrogen and productivity (yield and growth rate). Biomimetic approaches in synthetic biology that are developed to resolve the biological problems should contribute in the control of microbiome structure and metabolic pathways (microbial cell factory, Lactate-barrier…) invoved in the biohydrogen production. Lessons could be learned from digesters and photobioreactors design and operation experiences to innovate in bioreactors dedicated for biohydrogen production. The variability of feedstocks (food waste, microalgae, non-edible plants) requires flexible and integrated biorefinery process that converts biomass into biohydrogen and value-added products.

The integrated bioprocess with optimization of pretreatment of substrate, bioreactor design and monitoring, synthetic microbiome, electrofermentation, bioaugmentation and membrane technology are the most promising ways for biohydrogen production. The developed technologies are still immature, require comprehensive approach to sustainable product development assessment and need innovative design and scale-up to be experimented in industrial scale.

Keywords: feedstocks, biohydrogen, microbiome, integrated bioprocess.

ICH2P14-KN5

A FRAMEWORK TO EVALUATE ECONOMICS AND CO_2 FIXATION POTENTIAL OF NEW CARBON CAPTURE AND UTILIZATION (CCU) REACTION PATHWAYS – TOWARDS GOLDEN HYDROGEN PRODUCTION

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Efforts to mitigate climate change globally involve significant reductions in greenhouse gas (GHG) emissions. The industrial sector, responsible for nearly 24% of the world's anthropogenic emissions (8.5 $GtCO_2$ in 2020), presents a crucial opportunity for GHG abatement. Carbon capture and utilization (CCU) is a key strategy in this context, especially in sectors like natural gas, cement, and steel manufacturing. CCU involves the conversion of CO_2 to products, but its economic and environmental sustainability is only sometimes guaranteed. To evaluate the effectiveness of CCU in terms of CO_2 fixation, life cycle assessments (LCA) and techno-economic assessments (TEA) are typically employed. These comprehensive analyses demand extensive data and are best conducted in the later stages of CCU technology development.

In this work, a novel approach for evaluating CCU technologies is discussed to integrate two metrics: the Metric for inspecting sales and reactants (MISR) and CO2Fix. MISR evaluates the economic viability of reactions, while CO2Fix measures CO_2 fixation potential or abatement potential of CCU technologies, considering both Scope 1 and Scope 2 emissions. The developed framework utilizes readily available data such as reaction stoichiometry, conversion, and heat of reaction. The methodology categorizes CCU technologies into four types based on economic feasibility and CO_2 fixation capability. Furthermore, the developed approach estimates the minimum subsidy for economically unviable but environmentally beneficial technologies, and the maximum CO_2 capture cost for maintaining economic viability while achieving CO_2 fixation. The concept is illustrated using two CCU reactions: CO_2 hydrogenation to methanol and dry methane reforming (DRM). The results suggest that the DRM process is economically viable but has very low CO_2 fixation potential. However, DRM could transition to a better CO_2 fixation potential by combination with CO_2 capture process while incurring a CO_2 capture cost of approx. \$0.115/kg-CO_2. In contrast, the CO_2 hydrogenation to methanol process is evaluated to provide great CO2 fixation potential but suffers from economics. Our assessments show that if the CO_2 hydrogenation process is provided a \$ 0.064/kgCO2 subsidy, the process could become economically competitive with conventional routes.

This presentation will highlight the unique journey of developing the CO2Fix metric and its evolution to a combined economics-sustainable metric to provide a simplistic and robust technique for rapidly screening new CCU technologies. Also, we will present how such an assessment helped identify the potential of golden-hydrogen production from methane and CO_2.

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ICH2P14-IT1

GREEN HYDROGEN PRODUCTION: SOLAR CHIMNEY POWER PLANT INTEGRATED WITH WATER DESALINATION PLANT

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Modeling of a Solar Chimney Power Plant (SCPP) integrated with a water desalination power plant (WDPP) for synchronous electricity production, clean water, and hydrogen has been investigated for the Doha-Qatar climate. This study focuses on the performance of the SCPP when operating in standalone mode and when integrated with a WDPP. The SCPP produces electricity through a wind turbine, clean water through an evaporative process, and hydrogen using electrolysis. The excess heat from the WDPP boosts the temperature profile of the SCPP and results in continuous electrolysis to produce hydrogen. Results indicate that the combined SCPP and WDPP system enhanced the temperature and air velocity profiles, resulting in the maximum hydrogen production exceeding 39,018 kg annually compared to 13,351 kg for a standalone SCPP. Furthermore, electricity and clean water from the proposed system were 2.9 times and 1.6 times, respectively, greater than the standalone SCPP.

Keywords: Green hydrogen, sustainability, solar energy, power plants.

ICH2P14-IT2

IRON BASED HYDROGEN STORAGE AND TRANSPORT

[*]Viktor Hacker, Fabio Blaschke, Michael Lammer, Magdalena Pauritsch

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The transport and provision of green energy in the form of high-purity green hydrogen on an industrial scale requires new energy carriers that are economically available in large quantities, ideally non-toxic, non-flammable and non-gaseous. When metals are used for this purpose, the energy introduced in the form of the reduction process can be easily transported and recovered. At TU Graz, we have extensive experience in the development of fixed-bed chemical looping processes with highly stable oxygen carriers (OC) for hydrogen production. Iron-based oxides are used for redox cycles with reducing gases (e.g., syngas, hydrogen or biogas) and steam as oxidant, to release pure hydrogen. Even with biogenic trace compounds in the reduction gas, a hydrogen purity of 99.998% is achieved without gas purification. To maintain the operability of the oxygen carrier for more than 100 cycles, novel materials based on structured ceramic supports with mixed ionic and electronic conductivity (MIEC materials) have been developed. The results of this innovative materials research are the key to developing this future energy carrier and significantly reducing the production and transport costs of green hydrogen. The contribution highlights advantages and challenges of using iron and other metals for energy transport.

Keywords: Chemical looping, contact mass, reformer steam iron cycle, oxygen carrier.

ICH2P14-IT3

ANALYZING GREY AND BLUE HYDROGEN PRODUCTION COSTS IN STEAM-METHANE, AUTO-THERMAL, AND NON-CATALYTIC PARTIAL OXIDATION REFORMING PLANTS

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Global hydrogen demand is seeing significant growth. Most of the hydrogen production is by natural gas (NG) reforming. The main production routes are steam-methane reforming (SMR), auto-thermal reforming (ATR), and partial oxidation (POX). Hydrogen plants are associated with substantial amounts of emissions, and reducing their carbon intensity is essential in the clean energy transition. Blue hydrogen production, where CO_2 emissions are captured and stored (CCS), is currently the most promising solution for carbon reduction. While the SMR route is widely studied, limited techno-economic analyses exist for ATR and POX. This study presents a comparative assessment on the three main routes. Given the substantial amount of excess heat, emissions reduction is investigated by two pathways: i) integration with an electrolyzer to produce more H_2, and ii) coupling with CCS where energy systems are designed to integrate heat and power across the hydrogen/CCS plants. Results show that integration with CCS is more economically and environmentally advantageous. SMR outperformed ATR and POX for both grey and blue hydrogen production. Outside the boundaries of the plants, life-cycle emissions are quantified and compared with electrolysis. Emissions from blue hydrogen production can compete with electrolysis for current electricity mixes, with green hydrogen costs being around 4-6 times higher than blue hydrogen.

Keywords: Hydrogen, techno-economic analysis, CCS, heat integration.

ICH2P14-IT4

IN THE GREEN ZONE: NAVIGATING CARBON MANAGEMENT IN THE HYDROGEN SHIFT

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The move towards sustainable hydrogen energy is imperative for a lasting future, and effective carbon management serves as a key element in facilitating this transition. Mineral Carbonation (MC) emerges as a promising tool for sustainable carbon management. The process of CO_2 sequestration through mineral carbonation involves the reaction of CO_2 with alkaline compounds, such as calcium and magnesium oxides, showing significant potential for sequestering considerable amounts of CO_2. The MC technique can sequester CO_2 through natural weathering or accelerated carbonation, offering a scalable solution to match CO_2 emissions from various industries.

The MC process encompasses both direct and indirect carbonation techniques, with control exerted by parameters like alkalinity, pretreatment method, particle size, solid-to-liquid ratio, temperature, and pressure. These parameters directly impact CO_2 uptake capacity by influencing kinetics and mass transfer within the process. different process parameters and feedstock contribute to a wide range of uptake capacities. Utilizing alkaline solid wastes such as steel dust, slag, cement and construction materials waste, fly ash, and red mud for mineral carbonation presents an opportunity to permanently sequester CO_2, stabilize solid wastes, and generate valuable products. Estimates suggest that substantial amounts of CO_2 (4.02 Gt per year) could be directly fixed and indirectly avoided through CO_2 mineralization and utilization, resulting in a notable reduction of 12.5% in global anthropogenic CO_2 emissions.

ICH2P14-IT5

FUTURE AND POTENTIAL OF H_2 FOR QATAR UNDER ITS ENERGY AND ECONOMIC TRANSFORMATION QUEST

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In this research, the potential of hydrogen (H_2) as an energy resource for Qatar's future economic and energy transformation was explored. Using situation analysis as the primary method, we examined Qatar's strengths, weaknesses, opportunities, and threats (SWOT) pertaining to the adoption and integration of hydrogen in its energy matrix. Additionally, Porter's Five Forces analysis was utilized to understand the competitive landscape and potential barriers for the hydrogen market in the country. Our results indicate that Qatar possesses significant strengths and opportunities, such as its vast energy infrastructure and global market position, which could facilitate its transition to a hydrogen economy. However, certain challenges, including potential market competition and technological barriers, must be addressed. Based on our findings, we provide strategic recommendations for Qatar to harness the benefits of hydrogen effectively, ensuring a sustainable and economically prosperous future.

Keywords: Hydrogen economy, Qatar, energy transformation, situation analysis, SWOT, Porter's five forces.

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ICH2P14-OP004

MONTE CARLO SIMULATION APPLICATIONS FOR STAKEHOLDER MANAGEMENT ON HYDROGEN PRODUCTION PROJECTS: TOWARD SUSTAINABLE DEVELOPMENT

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This paper seeks to explore, investigate, and assess an innovative approach by implementing Monte Carlo Simulation applications for stakeholder management practices (MC-SMP) in Hydrogen Production projects (H2PPs) toward achieving sustainable development. The methodology/approach included a literature review, Stakeholder identification, Identification of stakeholder attributes and their importance level, and Validation and verification based on Monte-Carlo simulation analysis, "1000 iterations were run" to provide reliable results with affordable computational cost, and A 90% confidence interval was defined. The findings showed that the (MC-SMP) allowed the determination of the degree of uncertainty in achieving the stakeholder performance indicators. The developed approach is more appropriate for dealing with Stakeholder Management in (H2PP), giving the project manager a clear vision and a statistical indicator and predictor of stakeholder performance. The Practical implications lie in that it is the first research to study the synergy of "Monte Carlo simulation application and stakeholder management practice" (MC-SMP) that supports a theory with real-world data. It makes this research a starting point for other researchers. The Originality and value of this study lie in that it has produced valuable insights into a novel approach to synergy between (MC-SMP) that can reinforce SM practices in (H2PPs).

Keywords: Monte Carlo, stakeholder, management, hydrogen.

ICH2P14-OP007

CARBON EMISSION REDUCTIONS IN THE UNIVERSITY OF SAO PAULO'S TRANSPORTATION SECTOR USING HYDROGEN-POWERED VEHICLES

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The energy-intensive transportation sector faces significant challenges in achieving decarbonization goals. According to the System Gas Emissions Estimation platform, the subset of this sector, specifically buses powered by internal combustion engines utilizing diesel fuel in Brazil, accounted for emissions equivalent to 19.76 million tonnes CO_{2eq}. Therefore, this work aims to estimate and compare emission reductions achievable through the implementation of renewable hydrogen vehicles in the transport sector at the University of São Paulo. As a methodological approach, carbon-neutral hydrogen production using the ethanol steam reforming route is considered, wherein energy and mass balances are carried out throughout the hydrogen chain. A baseline scenario for CO_2 emissions is defined, taking into account the transport specifics: routines, frequencies, distances, and embedded technologies, along with their respective consumption coefficients. Subsequently, a comparative assessment is performed between renewable hydrogen technologies and the established baseline scenario. Results showed that replacing the current fleet of conventional internal combustion engine buses with hydrogen-based options leads to a significant reduction in CO_2 emissions per year, decreasing from 3185 to 528 tonnes CO_{2eq}. Consequently, per capita CO_{2eq} emissions could potentially reach 0.42 $mgCO_{2eq}$/km, meaning an approximately 83% reduction as compared to the internal combustion-based operation. Furthermore, energy and mass balance calculations showed that the total energy conversion efficiency achieved 42%, considering a fuel cell efficiency of 60%.

Keywords: Carbon-neutral hydrogen, ethanol, fuel cell, decarbonization, transport.

ICH2P14-OP009

TRANSIENT SIMULATION AND COMPARATIVE ASSESSMENT OF TWO CONCENTRATED-SOLAR BASED HYDROGEN PRODUCTION SYSTEMS INTEGRATED WITH VANADIUM-CHLORINE THERMOCHEMICAL CYCLE

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This research investigates the transient performance of two concentrated solar-based systems, namely E-1 and E-2, under various Middle Eastern climate conditions, both systems are capable of simultaneous production of Hydrogen and power along with other useful services such as fresh water, heating, and cooling. E-1 utilizes a solar power tower configuration with Thermal Energy Storage (TES) to provide heat to a Brayton power cycle. The exhaust gases of the turbine act as the heat source for a three-step V-Cl thermochemical cycle and a Rankine cycle which in turn powers a water production unit. Additionally, a portion of the generated power is allocated to an Alkaline electrolyzer unit for additional Hydrogen production. The generated Hydrogen is compressed to 700 bar in a 3-step Hydrogen compression process, facilitating storage and transportation. E-2 configuration combines Parabolic Trough Collector (PTC) with TES to supply heat to a Rankine and a V-Cl thermochemical cycle, while the other components remain similar to E-1. These setups showcase multigeneration adaptability with different solar concentrating technologies. The main objective of this study is to introduce and compare the performance of the two CSP-based systems, providing insights to help establish and enhance Hydrogen production and integration into the emerging Middle Eastern Hydrogen economy. Transient simulation and modeling are conducted using a coupling of TRNSYS and EES software. Key parameters affecting the system's performance such as solar irradiation and plant area, are identified and investigated. the results demonstrate that Hydrogen production is significantly influenced by seasonal climate changes furthermore, the study presents the produced Hydrogen and power for different cities, highlighting the superior CSP system for each city considering the available area.

Keywords: Hydrogen production, concentrated solar energy, thermochemical water splitting cycle, transient simulation.

ICH2P14-OP010

A NOVEL COST-EFFECTIVE APPROACH FOR PRODUCTION OF HYDROGENASE ENZYMES AND MOLECULAR HYDROGEN FROM WHEY-BASED BY-PRODUCTS

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Heterotrophic *Escherichia coli* and chemolithoautotroph *Ralstonia eutropha* have significant implications in biotechnology. *R. eutropha* H16 is a pivotal model organism in the generation of O_2-tolerant [NiFe]-hydrogenases (Hyds), crucial biocatalyst for biological fuel cells (BFCs). *E. coli* is known for its ability to produce molecular hydrogen (H_2) through sugars and glycerol mixed acid fermentation. In this study, side streams from the dairy industry, a mixture of curd and cheese whey (CW), were explored for the two-phase growth of *R. eutropha* H16 and *E. coli* BW25113. Diverse parameters, including cell mass (OD), pH, oxidation-reduction potential (ORP) kinetics, H_2 production, and H_2-oxidizing Hyd activity, were examined. For *R. eutropha* H16, growth was observed in 4-fold diluted whey (15 g/L) under microaerophilic conditions over 7 days, both with and without glycerol supplementation. The maximum growth was achieved within 5 days across all samples. Notably, the most remarkable growth and Hyd activity enhancement were observed in the whey mixture supplemented with glycerol. The maximal H_2-oxidizing Hyd activity was measured on the 2nd day of *R. eutropha* H16 cultivation, reaching its maximum (~0.433 ± 0.05 U/min/mg CDW) in glycerol-added CW. The increase in Hyd activity correlated with a decline in pH and ORP. Interestingly, *R. eutropha* H16 could not utilize lactose, which is abundant in whey. High-performance liquid chromatography (HPLC) confirmed lactose presence in CW post *R. eutropha* growth. Consequently, wild-type *E. coli* BW25113 was introduced following *R. eutropha* cell removal. *E. coli* reached maximum growth after 72 hours, with the highest H_2 yields (~5.2 mmol/L/g dry whey) attained within 48 hours across all samples. This study's outcomes offer insights into the economically viable production of bacterial biomass, H_2, and Hyd enzymes using dairy industry by-products, opening new avenues for biotechnological advancement.

Keywords: Biohydrogen, hydrogenases, dairy industry side-streams.

ICH2P14-OP017

KINETIC MODELLING AND PROCESS OPTIMIZATION FOR BLUE HYDROGEN PRODUCTION VIA AMMONIA CRACKING

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Ammonia is considered to be a promising hydrogen carrier as it comprises of 17.8 wt% of hydrogen and enables its transfer over long distances at lower costs. In efforts of optimizing the process of back-cracking ammonia to hydrogen, this study focuses on reactor optimization and energy sources analysis for blue ammonia cracking plants. An industrial scale ammonia cracking plant is modelled using Aspen Plus. A multi-tubular packed bed reactor utilizes a Co-Ba/CeO_2 catalyst to crack the ammonia to hydrogen and nitrogen using in-house developed kinetics. A sensitivity analysis is conducted to investigate the effects of changing reactor temperatures, reactor dimensions and number of tubes on the conversion of ammonia to aid in the optimization of the reactor dimensions and operating conditions. For example, with 30 tubes, a 72% decrease in the reactor length is observed as the temperature increases from 550°C to 600°C at 30 bars. The overall plant energy efficiency is obtained as 76%. In efforts of further optimizing the overall process, different case studies are investigated for providing the required energy for the endothermic reaction of ammonia cracking. For the cases of providing the heat requirement using ammonia, hydrogen, or a mixture of hydrogen and ammonia (40 %mol H_2 and 60 %mol NH_3) as the fuel, efficiencies of 63%, 58% and 59% respectively were estimated. An in-depth analysis is further conducted including the NOx emissions for each case.

Keywords: Ammonia cracking, blue hydrogen, kinetic modelling, process optimization.

ICH2P14-OP018

SOLAR HYDROGEN PRODUCTION WITH DIRECT AND INDIRECT DESIGN SYSTEM

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This research paper introduces a novel approach for optimizing the green hydrogen production system by employing energy performance assessment. The system consists of solar PV panels (PV), lithium batteries (BT) to support a customized daily load, and a polymer electrolyte membrane water electrolyzer (PEMWE) for hydrogen production. The designed system introduces an innovative hourly energy management system (EMS) designed for an independent hybrid renewable energy system (HRES). Initially, a comprehensive model is developed to simulate the electrical energy performance of each component. The EMS utilizes a personalized analytical method (PAM) control strategy to fulfil the energy requirements of the load, uphold the state-of-charge (SOC) within specified target ranges for both the battery and hydrogen tank, all while aiming to enhance overall energy efficiency. The performance criteria used in our study are the loss of power supply probability (LPSP), relative excess power generated (EPG), and global annual loss (GAL). The optimization strategy adopted focuses on maximizing the hydrogen production rate while minimizing GAL through the direct coupling of PV panels with PEMWE. Our findings indicate that our optimization approach enables us to generate an excess of 54% to 77% useful electrical energy, which can be utilized for industrial hydrogen production via PEMWE. The optimal combination allows us to produce an annual hydrogen production AHP = 40290,13 m^3 and 20567,73 m^3 for Constantine and Sharjah cities respectively.

Keywords: Green electricity, green hydrogen, surplus electricity, PEMWE, energy efficiency, stationary industrial applications.

ICH2P14-OP020

EXPERIMENTAL INVESTIGATION OF DIESEL ENGINE IN DUAL FUEL MODE BY USING HYDROGEN AND LOW CARBON ETHER BLENDED DIESEL

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Carbon dioxide is the most significant greenhouse gas responsible for trapping heat in the Earth's atmosphere, contributing to the greenhouse effect and global warming. As a result, reducing CO_2 emissions is crucial for limiting global temperature increases and avoiding the worst consequences of climate change. The transport sector is a significant contributor to global CO_2 emissions. The combustion of fossil fuels, such as gasoline and diesel, in vehicles and vessels,is the primary source of carbon dioxide emissions.Shifting from conventional fuels to low- or no-carbon fuels like hydrogen cansignificantly reduce carbon emissionsin the transport sector. Keeping this in mind, this study tested the combination of different proportions of diethyl ether (5, 10, & 15% by volume) blended diesel and hydrogen in dual fuel mode as an alternative to neat diesel in asingle-cylinderdiesel engineoperating at a constant speed of 1500 rpm under different load conditions.The hydrogen was inducted at the intake manifold at a flow rate of 9 lpm throughout the testing. The engine characteristics like performance, emission, and combustion were studied in dual fuel mode and compared withthe neat diesel operation.The study found that the engine brake thermal efficiency was improved in dual fuel mode, while the brake-specific energy consumption was comparatively lesser thanneat diesel. However, the brake-specific energy consumption increased as the proportion of ether in the blend increased due to a decrease in the calorific value of the blend. The 10% ether blended diesel showed the least HC and CO emissions. The CO_2 emission was lesser in dual fuel mode than in neat diesel operation. In contrast, the NO_x was higher in dual fuel mode than in single fuel (diesel) mode. Finally, it can be concluded from the study that the use of diethyl ether and hydrogen can reduce CO_2 emissions and improve diesel engine performance.

Keywords: Diesel engine, dual fuel, diethyl ether, hydrogen, CO_2.

ICH2P14-OP021

EFFICIENT AND STABLE SEAWATER ELECTROLYSIS OVER A BINDER-FREE NiO-NANOSHEET ARRAY BIFUNCTIONAL CATALYST

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As an eco-friendly and sustainable approach to overcoming the energy crisis, water electrolysis is promising for H_2 production; however, the reliance on freshwater would be detrimental to a sustainable environment. Our planet's freshwater supply has become scarce because of the rapid growth of the world's population and pollution. However, seawater is an inexhaustible water source on the planet, accounting for roughly 96.5% of all water in the world. However, the lack of active and robust HER/OER catalysts severely hinders the progress of direct seawater electrolysis, resulting in the technology remaining in its infancy and far from commercialization. Thus, it is extremely interesting to explore catalysts with high efficiency and robustness, which could produce high-purity O_2 and H_2 from direct splits of seawater without generating any toxins. Herein we developed a bifunctional catalyst designed by morphology engineering to form NiO-Nanosheet Arrays as a 3D oxide/hydroxide material, by utilizing a simple hydrothermal method which provided a large surface area with abundant active sites for both HER and OER in mimic seawater (1M KOH+0.5M NaCl), resulting in high catalytic activity. Impressively, the NiO-Nanosheet Arrays displayed bifunctional HER and OER behavior for selective and stable mimic seawater splitting under alkaline conditions. It achieves a current density of 100 mA cm^{-2} in 1 M KOH mimic seawater with only overpotentials of 300 and 296 mV for OER and HER, respectively, at room temperature, which is superior to those for many recently reported bifunctional electrocatalysts. Importantly, this device demonstrates specific stability for 168 continuous electrolysis. This discovery highlights a new paradigm to construct high-efficiency, corrosion-resistive, and bifunctional electrocatalysts for real potential large-scale green hydrogen technology via direct seawater electrolysis via ingenious morphology engineering.

Keywords: Nickel oxide, nanosheet array, bifunctional electrocatalyst, electrocatalytic seawater splitting.

ICH2P14-OP023

MEMBRANE REFORMER TECHNOLOGY FOR SUSTAINABLE HYDROGEN PRODUCTION FROM HYDROCARBON FEEDSTOCKS

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Hydrogen (H_2) is receiving a growing interest as a clean energy carrier as the world's energy system transitions towards net zero. The International Energy Agency estimates the current global H_2 consumption to increase by > 200% to reach over 200 MMt by 2030. This increase will be accompanied by a significant rise in the demand for low-carbon H_2 from 10% in 2020 to 70% by 2030, and around half of this low-carbon H_2 will be derived from fossil fuels. Today, H_2 is primarily produced from hydrocarbons using the steam methane reforming (SMR) process. This well-established method converts methane-rich gas into syngas, which is further treated with steam to increase H_2 yield via the water-gas-shift (WGS) process. However, this conventional route results in high carbon intensity of 10 tons CO_2 /ton of H_2. Therefore, there is a growing need for sustainable H_2 production technologies that utilize existing fossil energy sources and infrastructure while minimizing carbon emissions and costs. This paper gives an overview of the work conducted by Saudi Aramco's Research and Development Center to develop membrane reactor (MR) technology as a promising method for sustainable H_2 production from hydrocarbons. H_2-selective palladium alloy membrane is integrated within the catalyst bed, creating a system where H_2 production and separation occur simultaneously in a single unit. This integration offers several advantages over the conventional system. Process intensification allows overcoming thermodynamic equilibrium conversion limitations while producing high purity (>99%) H_2 at milder operating temperatures of ~ 550°C compared to 850°C in conventional packed bed reactors. Downstream processes such as WGS reactors and pressure swing adsorption are eliminated, resulting in reduced capital and operating costs. Moreover, the by-product stream is pressurized at 25-40 bar and rich with CO_2 at concentrations above 60%, enabling CO_2 capture at reduced costs by as much as $15 per ton.

Keywords: Hydrogen production, steam methane reforming, palladium alloy membrane, membrane reactor.

ICH2P14-OP024

BIOGAS DRY REFORMING TO SYNGAS USING CATALYST BASED ON LOCAL MINERALS EXTRUDED AS HONEYCOMB MONOLITH

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Wastewater sludge is regarded as an interesting source of biogas resulting from anaerobic treatment. The biogas composition, particularly, with respect to CH_4 and CO_2, depends on the sludge variability regarding several parameters such moisture content, especially, temperature and alkalinity. Thus, biogas is mainly used for onsite production of heat and electricity needed for operating the waste water plan, because of the significant costs associated with transporting and incinerating of wastewater sludge offsite. However, in the actual context of global warming there is an important need for innovation in technology solutions promoting low carbon emissions. This paves the way to new research area with cross-cutting applicability relevant to chemical-to-chemical reactions and chemical to-power processes. Of interest, the syngas production from biogas through methane reforming with CO_2 and further transformation to valuable chemicals and cleaner energy precursors. At this regard the presentation reviews an engineering journey concerning development of non-noble metal catalysts material based on available local minerals containing significant amount of naturally occurring transition metals such as iron and some elements considered as promoters in the clay were proposed to account for the catalytic properties. A systematic investigation for tuning catalytic performance of the clay through incorporation of appropriate active phase and promoters such as Nickel and Magnesium regarding dry reforming for syngas production. So far, the catalytic performances were significantly enhanced by adding 8 wt.%Ni and 3 wt.%Mg to the clay, yielding to CH_4 and CO_2 conversions around 80% at 800 °C for H2/CO ratio around 1. The catalytic behavior was attributed to the stabilization of smaller Ni particles associated with the formation of NiO-MgO solid solution alleviating particle sintering as result beneficial synergy effects due to different types of nickel-support interactions in addition to improved basic properties induced by Magnesium addition. Of interest also the innovation aspect regarding easy extrusion of the clay based catalyst as honeycomb monolith as well as related advantages concerning transformation of syngas to valuable chemicals and/or cleaner energy conversion.

Keywords: Syngas, dry reforming, biogas, catalysis, honeycomb monolith.

ICH2P14-OP25

THERMOELECTRIC CONDENSATION OF AMBIENT HUMIDIFIED AIR FOR GREEN HYDROGEN PRODUCTION

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As the world moves towards decarbonization, green hydrogen produced using solar energy for alkaline electrolysis offers immense potential as a clean and green fuel. An innovative approach for green hydrogen production is condensing water vapor from moist air using thermoelectric coolers (TECs). The present study presents numerical modelling of a novel TEC-based condensation system, designed specifically for water production in remote locations with limited water resources. The system could facilitate solar-powered water generation for subsequent alkaline electrolysis to produce hydrogen under challenging environmental conditions, such as deserts, remote and arid regions, or hot and humid environments. Computational modelling reveals that parameter like air humidity, temperature difference, and flow rate impact important outcomes such as water condensation rate, efficiency, and energy needs. Moreover, the study explores the right balance between efficiently condensing a large volume of vapors using solar-powered TECs and minimizing electricity consumption to yield an optimal quantity of hydrogen through alkaline electrolysis. By optimizing carefully, the thermoelectric condensers seem to be a feasible alternative to move closer to cleaner fuel through a unique solar-powered process that turns humid air into hydrogen through efficient alkaline electrolysis, which is in line with global efforts to make the world more sustainable. The detailed and thoughtful modelling approach sets the groundwork for evaluating this new practical system designed for solar-powered water and hydrogen production using alkaline electrolysis in water-scarce regions.

Keywords: Green hydrogen, alkaline electrolysis, thermoelectric cooler, numerical modelling, ambient humidified air.

ICH2P14-OP027

TRANSPORTATION AND STORAGE OF HYDROGEN BY LOHC: DESIGN AND SIMULATION OF THE DEHYDROGENATION REACTOR

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Long-distance transport and long-term storage of hydrogen can be realized with Liquid Organic Hydrogen Carriers (LOHC) based on a two-step cycle: (1) hydrogenation of the LOHC molecule (i.e., hydrogen is covalently bound to the LOHC) and (2) dehydrogenation after transport and/or storage. Since the (optimal) LOHC is liquid at ambient conditions and shows similar properties to crude oil-based liquids (e.g. diesel and gasoline), its handling and storage is realized by well-known processes; thus, a stepwise adaptation of the existing crude oil-based infrastructure is technically possible. LOHC show economic advantages compared to compressed hydrogen (CGH) and liquid hydrogen (LH) for long-term storage/long distance transport applications. The energetic efficiency of the systems mainly depends on the dehydrogenation step. In this paper we will consider the details of thermodynamic and kinetic fundamentals of hydrogenation and dehydrogenation of a typical LOHC, namely Perhydro-Dibenzyl-Toluene. The fundamental chemical equilibrium expressions as a function of temperature and the catalytic kinetic expression for the reaction speed at different conditions are evaluated for the design of a dehydrogenation Continuous Stirred Tank Reactor (CSTR). A process simulator (Aspen Plus) is used to simulate the reactor at different operating conditions, focusing on the dynamic response of the reactor to any change in temperature, pressure, and inlet flow rate. The results obtained from the simulation show a good agreement with experimental literature data. And the dynamic simulation show that the time response of the reactor is compatible with the hydrogen production variations needed by fuel cells to be used for transportation.

Keywords: LOHC, dehydrogenation, CSTR, dynamics.

ICH2P14-OP029

GREEN HYDROGEN PRODUCTION BY HYDROLYSIS OF ALUMINUM AND WASTE RECYCLING

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Producing hydrogen on site for energy purposes defeats the purpose of hydrogen as an energy carrier, and therefore, hydrogen storage is an important part of an efficient hydrogen-based economy. Aluminum hydrolysis can introduce a new way of powering hydrogen-based applications due to the instant production of hydrogen in enough large quantities. Due to the ease of storage and recycling of the reactants (recycled aluminum waste, such as soda and beer cans, water and an alkaline catalyst) and the by-products (aluminum and sodium hydroxides), a whole system that stores the reactants, carry out the reaction and recover the byproducts using renewable energy can replace a hydrogen storage system of equivalent capacity reducing the space requirements. The reaction is carried in a pressurized vessel designed to deliver the gas at 1 MPa with a volumetric purity of 96%. Although not explored, the temperatures registered during hydrogen production are high enough to produce steam that can be used in low heat processes. During the recovery process, which involves electrolysis and heat treatment to obtain the reactants, hydrogen is also produced. The process of hydrogen production has been tested with a maximum efficiency of 96% for a given time of one hour.

Keywords: Storage, conversion, waste, hydrogen.

ICH2P14-OP031

EXPERIMENTAL INVESTIGATION ON NOVEL MULTI-TUBE METAL HYDRIDE REACTOR FOR LARGE CAPACITY HYDROGEN STORAGE APPLICATIONS

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As the transition from conventional to renewable power generation gains momentum, the demand for energy storage has emerged. However, hydrogen and fuel cells demonstrate significant promise in this regard. The effective reactor design stores and releases the hydrogen in a faster way, as well as fulfilling the role of providing a steady supply of hydrogen to run the fuel cells. In the present experimental investigations on the absorption and desorption characteristics of a multi-tube finned metal hydride reactor filled with 12 kg of newly developed $(TiZr)Mn_{1.36}(VFe)_{0.54}$ powder are presented. During the activation cycles, the alloy absorbed 199.4 g (1.67 wt.%) of hydrogen in the fifth cycle under a supply pressure of 70 bar. After completing 16 cycles, the absorption outcomes indicated that the alloy absorbed 161.47 g (1.34 wt.%) in 1315 s, under a supply pressure of 20 bar and a heat transfer fluid temperature of 25 ˚C. Conversely, the desorption behavior demonstrated that the alloy released 147.4 g (1.22 wt.%) of hydrogen in 2752 s, under a heating fluid temperature of 40 ˚C. The results revealed that the absorption process is 2.1 times faster than the desorption process under the given operating conditions.

Keywords: Metal hydride, fuel cell, hydrogen storage, finned reactor design.

ICH2P14-OP032

SYNTHESIS OF Au–Bao@TiO_2/CDS CATALYSTS: H_2 GENERATION FROM WATER SPLITTING REACTIONS

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Hydrogen is looking most sustainable source of green energy that can be successively generated from water splitting reactions. Herein we work demonstrate an effective, and compatible approach to enhance the efficiency of hydrogen generation from water splitting. For the purpose CdS/TiO_2 hybrid semiconductor support were synthesized and Au-BaO cocatalysts were deposited via chemical reduction and hydrothermal approach. The optical characteristics and morphology of catalysts were obtain via UV–Vis/DRS, PL, XRD, SEM, TEM, AFM, EDX and XPS analytical instruments. All photoreactions were done on quarts reactor (150 mL) using 100W mercury Lamp. The hydrogen generation experiments were run on GC-TCD (Shimadzu-2010/Japan). Higher hydrogen activities were attributed to the presence of surface plasmon electrons over the CdS/TiO_2 hybrid catalyst's surfaces. Gold generate Surface plosmon electrons whereas BaO act as electron promoters to the active sites. The results depict that, Au-BaO@TiO_2/CdS deliver higher hydrogen (15.55 mmolg-1h-1) relative to the CdS/TiO_2, BaO@TiO_2/CdS and Au@TiO_2/CdS catalysts. It has been found that, cocatalysts assists the higher electron transfer on TiO_2/CdS system and enhance water reduction at active sites. (i.e. Au cocatalysts). Various factors affecting the rates of H_2 evolution (i.e. pH, temperature, catalyst dose and effect of light intensity) have been evaluated and discussed. On the basis of results, it could be concluded that higher hydrogen generation on Au-BaO@TiO_2/CdS was attributed to the co-existence of BaO and Au-NPs. This study hold promises a potential to replace the costly and conventional hydrogen generation technologies.

Keywords: Hydrogen evolution, water splitting, Au–BaO@TiO_2/CdS.

ICH2P14-OP033

DEGRADATION MODELLING OF WATER ELECTROLYSERS USING HIDDEN STATE ESTIMATION AND DEEP LEARNING

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In the paradigm of energy transition, water electrolysis (WE) is a predominant route for the production of green hydrogen. Due to large capital costs, lifetime management is critical during operation. The main degradation phenomena in WE are related to the catalyst and membrane. In large-scale electrolysers, monitoring degradation is challenging due to lack of suitable measurement techniques. The current industrial practice takes an increase in the cell voltage as the only indicator for degradation, which is not sufficient. This paper proposes an approach for the estimation of non-measurable degradation indices in WE using particle filters for a nonlinear state-space system. A similar approach has been successfully applied in fuel cells. The WE is conceptualised as a Markov model, with the degradation parameters as stochastic variables that are unobservable. The static equations of these degradation parameters are transformed into state transition equations. By using observable measurements, the likelihood for each particle (possible system state at a given point in time) is determined. A neural network is trained based on the hidden state estimations to handle measurement uncertainties and to forecast the changing rate of the considered parameters, using operating conditions. This approach is validated by generated data.

Keywords: Water electrolysis, degradation modelling, machine learning, neural networks, sequential Monte Carlo methods.

ICH2P14-OP034

SYNTHESIS AND APPLICATION OF Pd/Sr-NPs@TiO_2 FOR PHOTOCATALYTIC H_2 GENERATION FROM WATER SPLITTING REACTIONS

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We demonstrate lost-cost and extremely effective approach to enhance the efficiency of photocatalytic hydrogen generation via water splitting reactions. The Pd/Sr-NPs are in-situ developed and deposited at TiO_2 surfaces hydrothermal and chemical reduction approach. The structural and morphological characterizations of as-synthesized catalysts are carried out on UV–Vis/DRS, XRD, PL, SEM, TEM, EDX and XPS techniques. Hydrogen generation was monitored on GC-TCD (Shimadzu-2014/Japan) Photoreaction were done on 100W/Hg Lamp (Spectroline series). On basis of activities and results, mechanistic insights are justified and addressed. The catalytic impact of Pd and Sr metals on photocatalytic reactions are further revealed. Sr in the form of strontium oxide promotes electron transfer from the semiconductor surface to palladium active sites by increasing the fermi level of the titania-support.

Keywords: Water splitting, hydrogen production, Pd/Sr-NPs@TiO_2.

ICH2P14-OP035

POWER-TO-GAS PROCESS IN THE UPGRADING OF THE CO_2 EXTRACTED FROM THE UNPROCESSED ALGERIAN NATURAL GAS

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At first, hydrogen was considered as a promising energy vector and an alternative fuel to replace the depleting and polluting conventional energy. With the energy transition advent, the scope of hydrogen applications has broadened. Indeed with the massive introduction into the energy mix of renewable energies, particularly intermittent energies such as solar and wind power, hydrogen has emerged as the leading medium in energy storage and management and in process decarbonation. In this sense, the power-to-gas concept offers a powerful solution for energy management and hydrogen use for divers' applications such as dioxide carbon upgrading. On the other hand, CO_2 content of the Algerian unprocessed natural gas is in the range of 3 % to 10 %. This is way above market specification. Carbon capture and sequestration is among the first solution proposed to deal with the CO_2 extracted from the unprocessed natural gas. Unfortunately, this solution fell short of expectation. Another solution is then necessary. In the present work, we propose a solution to avoid CO_2 emission in the atmosphere, and so protect the environment, by reacting the extracted CO_2 with green hydrogen. Here, CO_2 is no more considered as a polluting element that should be gotten rid of, but rather as a valuable and useful commodity that could be used, in the Power-to-gas process case, to generate highly valuable fuels; in the present case natural gas that is going to increase the gas production. The objective of the present study is to estimate the potential of upgrading the CO_2 extracted from the unprocessed Algerian natural gas. To this end, a feasibility study is carried out. First, taking into account the Algerian natural gas resources and their characteristics, the potential of CO_2 resources available for methanation is estimated. The renewable potential is evaluated based on the local conditions data. A study and analysis of the different power-to-gas system units (CO_2 extraction, renewable conversion, hydrogen production and methanation) are carried out. Emphasis is put on solar photovoltaic fields as the renewable conversion process and electrolytic hydrogen production as the process for hydrogen production. Taking into account the different mature or near mature technologies, the focus is on the sizing of the hydrogen production unit. Finally the results are analyzed and discussed and a conclusion is drawn on the suitability of this technique for the upgrading of the CO_2 extracted from the unprocessed Algerian natural gas.

Keywords: Power-to-gas, green hydrogen, dioxide carbon, methanation, natural gas.

ICH2P14-OP036

A TECHNO-ECONOMIC EVALUATION OF THE INTEGRATION OF DIRECT AIR CAPTURE WITH HYDROGEN AND SOLAR FUEL PRODUCTION

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Producing fuels, including hydrogen, with a neutral carbon footprint is a critical step toward decarbonizing our economy. One promising route is to use solar thermochemical cycles to split water and carbon dioxide to produce hydrogen and carbon monoxide (which together form synthesis gas). The required carbon dioxide is captured from the atmosphere to close the carbon cycle. Subsequently, the synthesis gas can be easily processed into liquid fuels such as methanol. However, both direct air capture and the production of synthesis gas are energy-intensive processes. In this study, we identify and evaluate the impact of different synergies between direct air capture technologies and solar thermochemical cycles. To this end, we build a comprehensive model in Aspen Plus® that includes three parts of the process: direct air capture, solar thermochemical cycle, and methanol production. We also paid special attention to the energy required to generate the low oxygen partial pressures needed for the reduction step of the thermochemical cycle. The results show that, thanks to the synergies studied, lower Levelized Cost of Fuel (LCOF) is obtained for all configurations compared to a system without integration, although the large-scale system combined with the low-temperature direct air separation is the most cost-effective configuration.

Keywords: Thermochemical cycle, direct air capture, solar fuels, methanol, techno-economic assessment.

ICH2P14-OP037

SYNERGIZING HYDROGEN AND CHLORINE GAS PRODUCTION FOR ENHANCED RESOURCE UTILIZATION USING EARTH-ABUNDANT ELECTROCATALYSTS

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Addressing pending predicaments of modern electrochemistry entails devising robust electrocatalysts that remain active in corrosive surroundings. Acidic oxygen evolution reaction (OER) and chlorine evolution reaction (CER) anodes fall under this overarching umbrella of electroactive, stable, and product selective electrocatalysts under highly oxidative low-pH electrolytes. The conventional solution relies on dimensionally stable anodes (DSA), which includes noble metal oxides. However, the scarcity of these materials can impede scalability and escalate operational expenses in emerging decentralized electrochemical processes. To that end, identification of transition metal (TM)-based nitrides that are active, stable, and selective at relevant high current densities (> 100 mA cm^{-2}) is highly desired. We synthesized, characterized, and electrochemically tested an array of Ti-doped TM-based nitrides, wherein the Ti acts as a so-called valve metal for stability. Surface metals (Ti and W, V, Mo, or Fe) were hydrothermally grown atop Ti-felt followed by a nitridation step. TiFeN was found to be a promising alternative to DSA, wherein under an acidic brine electrolyte the overpotential required to reach 100 mA cm^{-2} were 800 and 613 mV for the in-house developed catalyst and the DSA, respectively. The corrosion-resilience of the nitride character motivated the removal of the Ti valve metal to further increase the availability of FeN active sites. In doing so, FeN grown atop Ti felt required a mere 77 mV of additional overpotential relative to DSA at current density of 100 mA cm^{-2}. Product Cl_2, versus O_2, selectivity and stability were examined using an on-line GC connected to the electrochemical cell. Chronoamperometric testing for FeN (performed for 100 hours at 100 mA cm^{-2}) showed good and stable performance, comparable to DSA performance. The same FeN electrocatalyst was investigated towards bifunctional cathodic hydrogen production with promising results.

Keywords: Chlorine evolution reaction, hydrogen evolution reaction, metal nitrides.

ICH2P14-OP042

FEASIBILITY STUDY OF A MOLTEN CARBONATE FUEL CELL AS A CO_2 SEPARATOR FOR VARIOUS INDUSTRIAL EXHAUST EMISSIONS

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The paper presents an overview of various flue gas compositions with a view to assessing the possible use of an MCFC as a CO_2 separator. This solution has certain limitations related to the requirement to maintain an appropriate ratio of CO_2 to O_2 in the flue gas. Thus, close attention is paid to the composition of these flue gases in terms of CO_2, O_2 and N_2 content and the corresponding values of the voltages the MCFCs achieve. The possible intake points for the flue gases are also discussed. Research indicates that flue gases from gas turbines yield a significantly lower operating voltage of the MCFC, which translates into a smaller amount of electricity generated. One solution here could be to modify the electrolyte of these fuel cells so as to increase the conductivity of oxygen ions, in which case higher electrical efficiency could be achieved while separating CO_2 from the exhaust gas.

Keywords: CCS, flue gas composition, molten carbonate fuel cells, CO_2 separation.

ICH2P14-OP043

ADVANCING HYDROGEN PRODUCTION: HIGH-RESOLUTION KINETIC ANALYSIS OF PHOTOCATALYTIC WATER SPLITTING USING COVALENT ORGANIC FRAMEWORK CATALYST AND ASCORBIC ACID

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Photocatalytic water splitting offers a sustainable method for hydrogen production but faces hurdles due to low efficiencies and complex scale-up procedures. Limited kinetic data hampers replication and validation. We present an extensive dataset utilizing a covalent organic framework catalyst and ascorbic acid as the sacrificial agent. The study covers various factors affecting kinetics, including temperature, photocatalyst loading, sacrificial agent loading, illumination duration, and intensity. We thoroughly examine phenomena like photodeposition of co-catalyst, sorption and desorption of reactants and products, and catalyst deactivation. Our study's strength lies in high-resolution temporal hydrogen evolution measurements via a lab-scale photoreactor cell, coupled with a Residual Gas Analyzer for precise mass spectrograph collection of evolved gases. Additionally, we use high-resolution scanning field emission scanning electron microscopy to characterize the spent photocatalyst. In parallel, we investigate the oxidation kinetics of ascorbic acid both with and without the photocatalyst using light spectrometry. The collected data are integrated into a three-step apparent kinetic model, accurately describing experimental data with an R^2 value exceeding 0.75 in most cases. Preliminary findings show a first-order reaction for ascorbic acid degradation to by-products, with the photocatalytic reaction rate increasing with temperature, photocatalyst loading, and sacrificial agent dosages. This model provides valuable insights into the complex mechanisms of photocatalytic water splitting for enhanced hydrogen production using the covalent organic framework catalyst and ascorbic acid. The study's findings hold promise for advancing sustainable hydrogen generation and pave the way for further optimizations in photocatalytic systems.

Keywords: Green hydrogen, kinetic modelling, photocatalysis.

ICH2P14-OP044

BIOTECHNOLOGICAL POTENTIAL OF SPENT COFFEE GROUNDS FOR LARGE-SCALE HYDROGEN PRODUCTION

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Currently hydrogen (H_2) has emphasized as a clean and versatile solution for sustainable development. This study aims to investigate the large-scale production of hydrogen to assess the biotechnological potential of coffee waste utilization. *Escherichia coli* wild-type and septuple mutant (*ΔhyaB ΔhybC ΔhycA ΔfdoG ΔldhA ΔfrdC ΔaceE*) were used. Bacteria were grown in coffee waste processing solution (65 g L^{-1} SCG hydrolyzed with diluted sulpuric acid) at pH 7 in 5 L reactor, additional glycerol at a concentration of 10 mL L^{-1}, was added. In wild type without the presence of glycerol, the cumulative hydrogen yield was ~4 L (0.13 L Day^{-1}), and in the mutant, the production of ~5.3 L lasted for a month, accumulating ~0.4 L of hydrogen per day. During glycerol co-fermentation, the cumulative amount of hydrogen in the wild type was ~5.2 L, accumulating 0.2 L of hydrogen per day, while the septuple mutant produced 15 L of hydrogen, accumulating 0.5 L of hydrogen per day, and the maximum hydrogen was produced in the 24th hour. Thus, hydrogen equal to 33 Kwh of energy was possible to produce during batch culturing of 200 g SCG and glycerol, which can be used in large semi-technological productions.

Keywords: Renewable energy, spent coffee grounds, *E. coli*.

ICH2P14-OP046

IN-HOUSE GREEN ANTI-CORROSION INHIBITOR TO PROTECT FROM HYDROGEN EMBRITTLEMENT EFFECT ON THE STRUCTURAL INTEGRITY OF API 5L STEEL PIPELINE

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Hydrogen plays a decisive role in many future energy systems. For this reason, much research has been performed to see the effect of hydrogen on network canalizations using anti-corrosion inhibitors. In this paper, the effect of hydrogen embrittlement (HE) on the mechanical properties of pipe steels was examined in the presence of aggressive media and green inhibitors. It appeared that the yield stress and ultimate strength were few sensitive to HE. However, fracture toughness and elongation at failure exhibited a severe decrease. Failure pressure established by different codes involved a flow stress which is a combination of yield stress and flow stress. Pipe defect assessment involved fracture toughness and flow stress upon using Failure Assessment Diagram (FAD) or Crack Driving Force (CDF) methods. In this paper, the consequence of hydrogen embrittlement on the failure and critical pressures of a pipe with a semi-elliptical defect was examined. The influence of the assessment method, relative defect depth and working pressure were examined through the comparison of respective safety factors.

Keywords: Integrity of structure, hydrogen embrittlement, FAD, CDF, failure pressure codes, FEM.

ICH2P14-OP047

THE HYDROGEN PRODUCTION USING STEAM METHANE REFORMING BASED ON CENTRAL RECIEVER

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In pursuing sustainable and efficient energy solutions, integrating renewable technologies has emerged as a promising option. The primary source of industrial hydrogen is steam methane reforming (SMR); however, this process is usually based on fossil fuels. The solar tower appears to be a suitable renewable source for providing the required high temperature heat to drive the process reactions. This approach aims to harness the abundance of solar energy while utilizing methane as a feedstock for hydrogen production. This study establishes the viability of combining external central receiver concentrated solar power with steam methane reforming, revealing informative insights into the system's energy and exergy performance. The analysis of the current system is performed using thermodynamic heat transfer, and thermochemical approaches to produce a detailed parametric study. The process model is developed and solved using Engineering Equation Solver (EES). The subsystem models are individually validated, and integrated for optimized exergy performance. The solar tower technology utilizes molten salt as a heat transfer fluid, achieving energy and exergy efficiencies of about 46% and 35%, respectively. This indicates the conversion from solar power to heat delivered to the SMR process. Moreover, the SMR exhibits a performance of 86% and 88% for energy and exergy efficiencies. The peak efficiency is achieved at 790°C when the methane conversion factor hits 100%. The overall conversion from solar to hydrogen production in terms of energy and exergy efficiencies are 68% and 67%, respectively. The hydrogen produced at the central receiver scale of 220 MW (absorbed heat) is about 7.3 kg/s at 2.1 steam-to-carbon ratio.

Keywords: Steam methane reforming, central receiver, energy and exergy analysis, hydrogen production.

ICH2P14-OP048

BIOGAS PRODUCTION FROM DATE PALM FRUIT WASTE IN JIGAWA STATE NIGERIA

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A research was conducted with aimed of producing biogas from Date Palm fruit waste which is abundant in the study area. The Date Palm fruit waste which act as substrate was collected from Nigerian Institutes for Oil Palm Research (NIFOR) Dutse substation Jigawa State Nigeria. Three different anaerobic digesters with their corresponding control digesters were set up for forty-two (42) days. For anaerobic digestion process, cylinder of 15 litre working volume equipped with air-tight lids and provision for collection of gas was used. The digesters were fabricated in Federal University, Dutse Research centre and were maintained at 37°C in the Botanical garden. They were shaken manually to about 2-3 times every day to keep the contents homogenized. The result shows a highest biogas concentration in the 0.5w/w (2000g/ml) of 10.5g while the lowest biogas concentration (3.4g) was recorded in an aerobic digester containing 2:1 waste-water ratio with 200ml cow dung as slurry. On the other hand, the control anaerobic digester produced a very small amount of biogas from the respective digester which contains only slurry and water. It is therefore recommended that Date Palm fruit waste can be utilized for production of biogas as a substitute for fossil fuel.

Keywords: Biogas, date-palm, digester, slurry.

ICH2P14-OP049

PRODUCTION OF BIOETHANOL FROM GROUNDNUT SHELL AS A SUBSTRATE

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This research was aimed at bioethanol production from cow dung and groundnut shell for co-digestion process. A laboratory digester was constructed in the form of modular digester. The pressure reading indicates the presence of gas which confirms that it is possible to produce useful gas from slurry and groundnut shell mixed together. The research was conducted simultaneously with control digester where groundnut shell was absent. Although this was done in a small scale because of research purposes, it was able to produce a maximum of 0.025L of bioethanol. The production was carried out with a pressure gauge during the construction of the digester. This serves as an alternative for gas collection in a tyre tube which is a more efficient way of detecting the presence of produced gas in the system. For faster yield of gas, the production was done in a thermophilic condition, at higher temperature range. It is recommended that the process may be an alternative to fossil fuel if large quantity of substrates were used.

Keywords: Bioethanol, groundnut shell, substrate, fossil fuel.

ICH2P14-OP051

ENHANCING HYDROGEN GAS PRODUCTION IN *ESCHERICHIA COLI* THROUGH A CRISPR-BASED APPROACH

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The journey for viable and clean energy sources has driven intensive research into novel approaches for hydrogen gas production. This research is aim to precisely manipulate the gene (hya gene) responsible for hydrogen production in Escherichia coli fine-tuning its metabolic processes for sensitive hydrogen gas production. In this study genetic engineering approaches particularly the CRISPR-cas technology to modified the Escherichia coli for the production of hydrogen gas production in this approach the Escherichia coli was isolated and grown Natural agar media in the petridish. The CRISPR – cas9 complexes were prepared after checking the integrity of the synthesized the guide RNA. The complexes of CRISPR was delivered to the E.coli after 24 hrs incubation. The modified E.coli was rescued and test the hydrogen gas production when compared with the wild type E.coli. From the result the maximal hydrogen gas produced by mutant E.coli was 4,6 fold from glucose and increased the hydrogen yield 2 fold from 0.85 to 1.6 mol H_2/mol glucose (maximum 2 mol H_2/mol glucose) While incorporating the current information and know-how, much future development and progress is to be done before H_2 is accepted as a viable primary energy source.

Keywords: CRISPR, *Escherichia coli*, glucose, hydrogen, mutant.

ICH2P14-OP052

ASSESSMENT OF HYDROGEN TRADING WITHIN BLOCKCHAIN AND ARTIFICIAL INTELLIGENCE: A REVIEW

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This paper showcases the idea of using blockchain technology and subfields of Artificial Intelligence (AI) to establish an efficient hydrogen trading mechanism. A review literature study was conducted in order to understand the abilities of the blockchain to run hydrogen trading contracts. Furthermore, to establish and characterize an example of a smart contract that would cover needed aspects of the hydrogen trading mechanism. As a key outcome, blockchain technology with AI-based predictions can organize the hydrogen trading market under one decentralized network, where all traders are connected and transaction costs and risks associated with intermediaries are decreased. Subfields of AI are able to provide accurate and efficient hydrogen predictions by using train models that collect historical and real-time data. Results given by AI algorithms should help participants to determine future demand for hydrogen credits, leading to more accurate pricing and distribution on the market. Also it was found that for the implementation of prediction model to the blockchain a special structure like oracle, service that enables predicted data to flow from the off-chain environment to on-chain, needs to be used. As a result, hybrid smart contract structure with AI-based predictions suitable for hydrogen trading were described.

Keywords: hydrogen trading, blockchain, artificial intelligence.

ICH2P14-OP053

THERMODYNAMIC ANALYSIS OF PTC-BASED HYDROGEN PRODUCTION SYSTEM

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In this study, hydrogen production at low temperatures is experimentally investigated. The presented study consists of three main stages. The first of these is thermal energy production, the second is electricity generation, and the third is hydrogen production. Parabolic trough collector (PTC) is used for thermal energy generation, organic Rankine cycle (ORC) is used for electricity generation, and proton exchange membrane (PEM) electrolyzer is used for hydrogen production. All of the electricity obtained from the ORC system, which has a unique design, is used for hydrogen production. In the presented study, the turbine output power is calculated as 2.02 kW and the net power of the ORC system is calculated as 1.26 kW.

Keywords: PTC, hydrogen production, green hydrogen, energy efficiency.

ICH2P14-OP054

PERFORMANCE EVALUATION OF DIFFERENT WORKING FLUIDS IN S-ORC BASED HYDROGEN PRODUCTION SYSTEM

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In this study, the hydrogen production system integrated into the solar-organic Rankine cycle (S-ORC) system is discussed. An evacuated tube solar collector (ETSC) is used to benefit from solar energy. The thermal energy obtained from the collector is produced in the integrated ORC system. Different fluids are examined comparatively in the S-ORC system. As a result of the study, the energy efficiency of the whole system for hydrogen production was calculated as 41.2%, 44%, 59.1% and 46.9% by using R134a, R1234yf, R410a and R32 fluids in the ORC system.

Keywords: Solar-ORC, hydrogen production, green hydrogen, energy efficiency.

ICH2P14-OP056

MULTI-SCENARIO ANALYSIS OF LEVELIZED COST OF HYDROGEN FOR WATER ELECTROLYSIS-PHOTOVOLTAIC ENERGY TECHNOLOGY IN THE NEAR FUTURE (2025–2050) OF ALGERIA

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The Algerian government's efforts to reduce future emissions include widespread adoption of the green Hydrogen (H_2) economy. However, inherent uncertainties in decision support endeavours drive the strategic vision of H_2 development. Algerian government planned to install a demonstration plan of 100-130 MW Electrolyzer for investigating the technological viability and economic profitability. The choice of electrolysis technology and the renewable source that will be used remain a challenging issue. The treatment of this issue can be done using a model-based decision support including costs assessment. In this context, prediction of the levelized cost of hydrogen (LCOH) produced from clean energies in the near future is of utmost importance. To that end we focused on the Algiers potential to generate green H_2 using multi-megascale off-grid PV-H_2 system. Alkaline water electrolyzer is one of the easiest and mature technologies with more than hundred years of experience and thousands of installed plants and capable of producing H_2 with high efficiency. To find the lowest LCOH, the system is optimized utilizing a dual-objective approach including total hydrogen deficit. A dynamic energy and hydrogen management strategy is utilized. We analysed three scenarios during the period 2025-2050, considering whether the operational performance and capital costs of the system components are improved.

Keywords: Hydrogen economy, photovoltaic energy, alkaline water electrolyzer, multi-scenario analysis, LCOH.

ICH2P14-OP057

CATALYTIC CONVERSION OF CO_2 TO CO VIA METHANE DRY REFORMING AND REVERSE WATER GAS SHIFT REACTION

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Global industrialization has increased atmospheric CO_2 levels by 60% over the past century. In addition to being a major greenhouse gas, CO_2 is also a cheap and abundant source of carbon, and its chemical conversion into value-added chemicals and fuels not only lowers CO_2 emissions but also has significant economic advantages. Methane dry reforming (MDR) and reverse water gas shift (RWGS) reaction are among the most attractive ways to convert CO_2 into CO, and by combining it with H_2 (syngas), it can be used to produce the desired fuels and chemicals in the well-known Fischer-Tropsch process. More recently, MDR has re-emerged as the most interesting technique for syngas production due to its intriguing economic and environmental advantages. However, due to rapid catalyst deactivation and carbon species deposition on catalysts, these reactions have yet to be commercialized. Therefore, developing highly stable catalysts that ultimately result in efficient CO production is important and challenging since catalyst selection can have a significant impact on reaction performance. This study aims to examine the efficiency of transition metals (such as Ni, Co, and Cu) supported on widely used oxides (CeO_2, SiO_2, ZrO_2) for their performance in RWGS and MDR reactions. Our results (to be presented), do indicate the selective nature of Cu metal on CeO_2 support for high activity, CO selectivity and coke tolerance resulting in a stable performance for long-time on-stream hours.

Keywords: CO_2 conversion, transition metals, reverse water gas shift reaction, methane dry reformation.

ICH2P14-OP064

EFFECT OF VOLUME CONCENTRATION AND SONICATION TIME ON THE PERFORMANCE OF HYBRID SOLAR COLLECTOR BASED HYDROGEN PRODUCTION SYSTEM WITH HYBRID NANOFLUID: AN EXPERIMENTAL INVESTIGATION

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Because of clean in nature and more energy efficient than fossil fuel, hydrogen has attracted the researchers over the past few decades. Though many techniques available, water electrolysis technique is one of the simple and cost-effective method and can be used in many applications. In this context, a novel solar powered hydrogen production system was developed, and the energy analysis also performed based on PVT module efficiency and hydrogen yield rate. This system comprises, Photovoltaic (PV) module, Spiral flow thermal collector, Nanofluid storage tank, Hoffman's Electrolyzer, Heat exchanger unit and hydrogen storage unit. In this research, hybrid nanofluid was prepared by dispersing different quantities of CuO and Al2O3 with less than 50nm are dispersed in water and circulated in the spiral flow thermal collector. This study results indicated that the hybrid nanofluid with 0.2% volume fraction with 4 Hrs sonication time shows the best impact on the electrical efficiency and hydrogen yield rate. At 12.00 noon, the value of electrical efficiency of PVT solar collector with 0.05%, 0.1 %, 0.2% volume concertation with 4 Hrs sonication time and conventional PV module were 7.1%, 7.7%, 8.3% and 5.3% respectively. The highest and lowest hydrogen yield rate of 16.87 ml/min and 15.97 ml/min were obtained for Hybrid nanofluid with 0.2% volume fraction with 4 Hrs sonication time and 0.05% volume friction with 2 Hrs sonication time. The results indicated that the hydrogen yield rate showed increasing trend as the volume fraction and sonication time increased in all operating conditions.

Keywords: Hybrid nanofluid, photovoltaic – thermal solar collector, sonication time, hydrogen production system.

ICH2P14-OP065

SOLAR HYDROGEN AND METHANOL PRODUCTION WITH CSP/PV DRIVEN ELECTROLYSER

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Hydrogen produced using renewable energy and its derivatives play a significant role in cutting greenhouse gas emissions. If produced with green hydrogen and CO_2 from a sustainable source, these fuels like e.g. Methanol have the potential to assist the chemical sector in moving away from fossil feedstocks. The combination of a concentrated solar power plant (CSP) including a thermal storage with a photovoltaic power plant (PV) to drive an electrolyser that produces hydrogen appears to be a good solution to ensure longer full-load times of the electrolyser and is analysed in this study. It is thus possible to achieve a relatively continuous power supply for the electrolysis and other process units. This hybrid concept can be also coupled with a methanol production process. Both concepts have been investigated in details. Dynamic annual simulations have been carried out. The full solar hydrogen and methanol production process chain has been evaluated and techno-economic analyses have been realized. In the case of solar hydrogen, production cost of 3.09 USD/kg has been calculated considering the anticipated cost reduction in the next years. In case of Methanol, a production cost of 726 €/t is expected, which demonstrate the attractive potential of this hybrid technology.

Keywords: Hydrogen, methanol, solar fuels, concentrated solar energy, techno-economic assessment.

ICH2P14-OP067

AN OPTIMUM APPROACH FOR BIOHYDROGEN PRODUCTION USING POPLAR

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Biohydrogen (Bio-H_2), a sustainable and environmentally friendly energy alternative, is critical in transitioning towards a more energy-efficient future. This research investigated the potential of utilizing poplar leaves as a substrate for bio-H_2 production with dark fermentation process, an underexplored area. Through a series of fifty-eight experimental runs according to the Box-Behnken Design (BBD), insightful findings were obtained about the bio-H_2 production process. The ideal maximum bio-H_2 production rate was estimated at approximately 0.2 mL/h, with an optimal time constant of about one hour. This study also identified optimal operational conditions for maximizing bio-H_2 production using Design-Expert statistical software with the BBD tool: an acid concentration of 10 %, a biomass quantity of 2.009 g, an initial pH of 7.65, a temperature of 39.9 °C, and a mixing ratio of 325.66 rpm. These conditions were projected to produce a maximum bio-H_2 production of 0.76 mL/g.

Keywords: Biohydrogen, poplar leaves, dark fermentation, box-behnken design, optimization.

ICH2P14-OP069

BIOHYDROGEN PRODUCTION FROM VARIOUS INDUSTRIAL WASTEWATER OF CHALAWA, KANO, NIGERIA

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Hydrogen energy is an alternative energy resource because it is clean and environmentally safe, it can be produced from different materials by chemical, o-cultures, and photo-fermentation using soluble metabolites from dark fermentation were applied to ephysical, and biological processes. In this study, different strategies such as pre-treatment of substrates, cnhance biohydrogen production. Sewage sludge was found to be better by producing a hydrogen yield of 5±0.2 mol/kg with glucose and 3.3±0.21 mol/kg using starch industrial effluent as substrate through a dark fermentation process. The combination of sewage sludge and tannery sludge showed better yields of hydrogen (6.1±0.2 mol/kg) from starch effluent with a simultaneous increase in acetate levels. Using anaerobic sewage sludge as inocula, starch industrial effluent with added crude amylase showed increased levels of hydrogen (11.1±0.2 mol/ kg), and treated distillery spent wash effluent as substrate showed the maximum hydrogen yield of 5.8±0.2mol/kg and 0.8±0.2mol/kg and 0.94±0.2mol/kg from treated and untreated distillery spent wash effluent respectively. Acetate production predominantly occurs, and hence, higher hydrogen yields. The microbial consortia from agricultural soil showed the hydrogen production of 2.15±0.2 mol/mol glucose, 3.34±0.2 mol/kg with acetate, 4.8±0.2 mol/kg of dark fermentation effluent of dairy effluent, and 5.6±0.2 mol/kg with dark fermentation effluent of starch effluent. Plantation soil microbial consortia showed the hydrogen production of 3.2±0.2 mol/mol glucose, 1.7±0.2 mol/kg with acetate, 4.7±0.2 mol/kg with dark fermentation effluent of brewery effluent, and 6.1±0.2 mol/kg with dark fermentation effluent of starch effluent at optimum conditions of 7.0 pH, temperature of 40°C and light intensity of 4000lux.

Keywords: Fermentation, sludge, bio-hydrogen, methanogens.

ICH2P14-OP070

BIO-INSPIRED OPTIMIZATION OF HYDROGEN PRODUCTION PLANTS: HARNESSING THE POLLUTANTS FOR ENHACED EFFICIENCY OF FUEL CELL

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This research explores the utilization of pollutants generated by hydrogen production plants to enhance efficiency while reducing environmental impact. The introduction traces the history of fuel cell development and highlights the environmental concerns associated with hydrogen production, emphasizing the increasing demand for this versatile energy carrier. To achieve the objectives of the study, the quantitative and qualitative analytical approach use, as it is considered the most appropriate for this study. It is interview based a approach on a set of research procedures that depend on the collection, classification, processing and analysis of facts and data completely and accurately to describe, analyze and interpret the results of the study members' responses and access to results and generalizations about the phenomenon of the study. The research hypothesis posits a positive relationship between emissions utilization and reduced environmental impact, as well as increased fuel cell efficiency. The methodology employed for this study combines quantitative and qualitative approaches, including interviews and data analysis. In conclusion, this research seeks to address pressing environmental concerns related to hydrogen production .Also, benefit from emissions from hydrogen production, the study aims to reduce environmental impact, increase fuel cell efficiency, and enhance global energy security. by reducing 60% of emissions, especially with regard to sulfur, nitrogen and carbon emissions, it will be used and exploited to generate a new type of energy.

Keywords: Hydrogen, energy, fuel cell, pollution, renewable.

ICH2P14-OP071

INVESTIGATION OF A NEW ENERGY SYSTEM WITH RECYCLED ALUMINUM-WATER HYDROGEN PRODUCTION

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The presented study illustrates the design and investigation of a new renewable multigeneration system capable of hydrogen production through the aluminium water chemical reaction and electrolysis. The system can also produce other useful outputs such as electrical power, space heating and space cooling. The system achieved hydrogen production rates of 0.01277 kgs^{-1} and 0.02299 kgs^{-1}, respectively, for the electrolysis system and from the aluminium-water reaction. Additionally, the system achieved an electrical energy output, heating load, and cooling load of 2571 kW, 2576 kW, and 344.7 kW, respectively.

Keywords: Hydrogen, aluminium-water, electrolysis, solar power, wind power, energy.

ICH2P14-OP072

PROTECTION FROM HYDROGEN EMBRITTLEMENT USING GREEN INHIBITOR ON THE WELDING JOINT OF API X65 PIPELINE STEEL IN DYNAMIC LOADING

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Pipelines face a real complex issue due to defects and cracks occurring in their structural body. The world economy lost trillions of dollars due to corrosion phenomenon. The objective of this work report is to investigate the degradation of the mechanical properties according to corrosion problem on pipelines specimens for different aggressive milieu and test them by different mechanical analysis in the presence of hydrogen. Protection from hydrogen by the green inhibitors were presented and prepared to use them as a solution for corrosion field and to increase the lifetime of pipelines. Tensile exam, Charpy impact test, weight loss and CCD Camera investigation are methods to explore the fact of the problem. Pipeline specimens were removed from DIN 17175 (ST 35.8) carbon steel and API X65 steel. Significant results were obtained for mechanical properties in the presence of inhibitor.

Keywords: Hydrogen, corrosion, green inhibitor, HCl, mechanical properties, Charpy.

ICH2P14-OP073

SOLAR ENERGY DRIVEN SILICON PHOTOVOLTIAC MONOLITHIC ELECTROCHEMICAL CELLS FOR EFFICIENT HYDROGEN PRODUCTION FROM WATER

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A novel bench-top solar energy driven silicon photovoltaic electrochemical cell (Si-PV-EC) has been meticulously designed for the purpose of generating hydrogen from water. The primary objectives of this project were to achieve high efficiency and long-term stability. The design incorporates a Si-PV cell sealed within an evacuated transparent glass capsule. The front and back surface of the capsule was coated with spray pyrolytically deposited thin layer electrodes of earth abundant transition metal oxides. In the initial, Si-PV-EC-I, a thin layer semi-transparent Co-oxide anode was deposited onto the front window of the glass capsule, which was pre-coated with conducting fluorine doped tin oxide (FTO). Under these conditions Si-PV-EC-I exhibited a percent solar to hydrogen efficiency (% STHE) of 5.42 %. In the second design, Si-PV-EC-II (A), the anode consisted of a thin layer of opaque mixed Co-Ni-oxide deposited onto the back window of the glass capsule, also precoated with conducting FTO. This configuration yielded a % solar to hydrogen efficiency of 8.67 %. In second design, Si-PV-EC II (B), the anode was similarly composed of an opaque layer of mixed Co-Ni-oxide, but it was deposited onto the back window formerly coated with a conducting graphite layer. In this case, the % STHE increased to 8.82 %. This enhanced efficiency was anticipated due to the superior conductivity of the graphite layer compared to the FTO coating. All efficiencies were calculated using the volumes of actual hydrogen gas collected under the light illumination intensity of 0.1Watt cm^{-2} (1 sun) from a solar simulator equipped with an AM 1.5 G filter. These high values of % STHEs were attributed to the photovoltage of 3.6 V generated by the Si-PV used and as well as to enhanced electrocatalytic activity of the transition metal oxide anodes. No degradation of these Si-PV-ECs was observed even for continuous run during hydrogen gas collection.

Keywords: Photovoltaic, hydrogen, monolithic, electrochemical, cell.

ICH2P14-OP074

EVALUATION OF A NOVEL HYBRID PHOTOELECTROCHEMICAL-CONVENTIONAL HYDROGEN GENERATOR

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The main aim of this study is to investigate the integrated power process that utilizes solar power for various multigeneration applications, such as electricity generation, freshwater output, production of hydrogen, heating, and cooling. The research being suggested involves the integration of many components, including a solar power tower system, a combination Brayton-Rankine cycle, a multi-effect desalination (MED) unit, a unique hybrid electrolyzer system, an absorption cooling cycle, and a hydrogen storage and refuelling station. The power generated served a dual purpose, both as an input for hydrogen synthesis and as meeting the electrical needs of the local population. The thermodynamic assessment is used to assess the efficiency of the system being studied. The investigation focused on analysing the variation in hydrogen generation inside a combined photoelectrochemical (PEC) and conventional hybrid electrolyzer, with respect to solar irradiation levels, under ambient conditions. Based on the study conducted, it is seen that the hydrogen production rate is 1823.4 mL/h under conditions of no sun irradiation. However, this value increases to 1905.3 mL/h when subjected to a solar intensity of 1200 W/m^2.

Keywords: Solar energy, hydrogen production, hybrid water electrolysis.

ICH2P14-OP078

A COMMUNITY ENERGY SYSTEM DESIGNED TO COVER THE NEEDS INCLUDING HYDROGEN

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This article introduces a new multigeneration system designed to address the pressing demand of energy. Harnessing the power of solar and biomass energy sources, this system is designed to meet a diverse range of energy demands. Its capabilities extend beyond conventional systems, generating not only hydrogen but also providing hot water, heating, cooling, fresh water, and electricity. To comprehensively assess the system's performance and sustainability, this study conducts an analysis covering energy, exergy, and environmental impact assessments. By taking this holistic approach, valuable insights can be gained into the system's operation and its impact on the environment. The engineering equation solver is used for the analysis and the results of this investigation show that the overall energy and exergy efficiencies of the system are found to be 55.46 % and 49.34 %, respectively. In addition, the energy and exergy coefficients of performance (COPs) of the absorption system are found to be 1.67 and 0.64, respectively. These findings signify the system's efficiency and potential to significantly contribute to a cleaner and more sustainable energy future.

Keywords: Biomass, solar, multigeneration, water treatment, hydrogen production.

ICH2P14-OP079

OPTIMIZING HYDROGEN PRODUCTION AND ANAEROBIC BIODEGRADABILITY IN PHARMACEUTICAL INDUSTRY WASTEWATERS THROUGH PHOTOCATALYTIC OXIDATION

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The pharmaceutical industry generates significant amounts of wastewater containing high concentrations of various toxic, biodegradable, nonbiodegradable organic and inorganic compounds, including pharmaceutical residues. Due to the complex structure of pharmaceutical industry wastewaters, combined biological and advanced oxidation processes are frequently used to treat these wastewaters effectively. Pharmaceutical wastewater treatment by photocatalytic oxidation is an emerging approach for the removal of organic pollutants from industrial waste. Photocatalytic degradation involves the use of photocatalysts such as titanium dioxide (TiO_2) to initiate chemical reactions under light irradiation, leading to the breakdown of organic compounds. In addition, the treatment of wastewater by advanced oxidation increases its biological treatability. The main purpose of the study is to increase the treatability of the pharmaceutical industry wastewater containing high resistant organic matter and to determine the energy requirement of treatment process that simultaneously produce hydrogen gas. In the study, hydrogen production potential from pharmaceutical industry wastewater was explored using integrated photocatalytic oxidation and anaerobic processes. Pretreated wastewater underwent batch anaerobic treatment in a multi-reactor system to assess its biodegradability. Photoelectrocatalytic oxidation employed TiO_2-coated titanium electrodes in the anode chamber and 316 stainless steel electrodes in the cathode chamber. A cation exchange membrane facilitated to separate photo-anode and cathode compartments, while solar light was applied by using the Atlas Suntest solar simulator. The integrated system's efficiency was assessed by comparing the organic matter content in pre-treated and untreated wastewater per produced hydrogen gas. Subsequently, sewage sludge from the anaerobic treatment underwent gasification to explore its hydrogen production potential.

Keywords: Hydrogen, photocatalytic oxidation, anaerobic process, titanium dioxide, pharmaceutical wastewater.

ICH2P14-OP080

A CLEAN OPTION FOR POTENTIAL HYDROGEN PRODUCTION VIA NUCLEAR IN CANADA

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The current study investigates clean hydrogen production using nuclear energy in various power plants located in Canada. Currently active Canadian Deuterium-Uranium (CANDU) reactors and small modular reactors considered in the calculations. The total clean hydrogen production is 2.014 Mt using electricity generated from nuclear energy. 1.84 Mt hydrogen can be produced using currently active nuclear power plants and 166.74 kt can be produced from small modular reactors. It shows promising potential for Canada to be on the list of hydrogen-producing countries.

Keywords: Clean hydrogen, electrolyser, nuclear energy, small modular reactor, Canada.

ICH2P14-OP082

GREEN HYDROGEN PRODUCTION AND SOLAR TO HYDROGEN RATIO USING BIFACIAL SOLAR PHOTOVOLTAICS AND HIGH ROOF SURFACE ALBEDO

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Green hydrogen is a key factor for the decarbonization of the energy sector and to foster the clean energy transition but has the highest cost when compared to grey and blue hydrogen. This is due to the high cost of the generation of energy from renewable sources and the efficiency of the water electrolyzer. Future innovative energy technologies are needed to boost the power production from solar PV systems, reduce the cost of renewable electricity and enhance hydrogen production from electrolyzers. The main objective of this study is to investigate green hydrogen production enhancement using a bifacial solar PV system integrated with cool roof technology (high-albedo roof coatings). The best operating conditions of the bifacial solar PV (albedo, height from the ground, tilt angle, and distance between the solar panels) need to be determined to maximize the power output from the bifacial solar PV system and the green hydrogen production. The originality and novelty of this study lie in the fact that it integrates innovative technologies such as bifacial solar PV and building cool roofs to boost the power generation output and green hydrogen production. The experimental set-up is composed of bifacial solar PV, a building roof with high solar reflective material, microinverter, electrolyzer, metal hydride hydrogen tank, and an integrated data acquisition system. The results will show the daily performance of the bifacial solar PV and the green hydrogen production with different building roof coatings (green, grey, and white). The percentage changes in renewable energy production (kWh), green hydrogen production (L/hr), and solar-to-hydrogen conversion ratio using bifacial solar PV with cool roof technology compared to mono-facial solar PV system will be presented in this study.

Keywords: Green hydrogen, bifacial solar PV, cool roof technology, albedo, performance analysis.

ICH2P14-OP083

DESIGN AND PERFORMANCE ANALYSIS OF GREEN HYDROGEN PRODUCTION FROM HYBRID SOLAR PV/WIND TURBINE ENERGY SYSTEM

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The primary objective of this techno-economic analysis is to look at the viability of producing environmentally friendly hydrogen from a water electrolyzer using a power system that combines solar photovoltaic cells and wind turbines. Modelling and simulation analysis was used in this study to test the performance of renewable power systems and green hydrogen production. To evaluate the efficiency and dependability of the proposed system, the city of Adrar, Algeria, which is located in the middle of the Sahara Desert, was chosen as the testing ground. Wind and solar resources are abundant in this oasis city. Solar photovoltaic, wind turbine, and PEM fuel cell systems are all capable of producing sufficient energy to meet the daily electrical loads of thousands of houses (15,000 kWh). Green hydrogen for PEM fuel cells and other hydrogen-based technologies (50 kg/day for industrial/transportation applications) was generated using surplus energy from renewable sources like solar panels and wind turbines. The results show the system's performance on a daily, monthly, and annual basis as well as the price of producing hydrogen and electricity. The potential and challenges for green hydrogen production and utilization in the Algerian desert for clean energy transition will be presented.

Keywords: Green hydrogen, solar PV, wind turbine, desert climate, energy transition.

ICH2P14-OP084

LIFE CYCLE ASSESSMENT OF GREEN HYDROGEN SUPPLY NETWORK

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Green hydrogen has garnered significant attention from numerous countries as a promising energy source to replace traditional fossil fuels, dramatically reduce greenhouse gas emissions, and foster the transition toward net-zero energy systems. Green hydrogen can be produced in various ways (i.e., coupling standard PV panels, PV-T collectors, or CPV-T collectors with electrolyzer), conditioned to different states or carriers (i.e., liquefied hydrogen, compressed hydrogen, ammonia, and methanol), stored in various methods, transported by different means according to its state, and reconditioned to its original state at end-customers. In other words, hydrogen can go through various pathways (i.e., different processes and stages) in the hydrogen supply network (HSN), resulting in different greenhouse gas emission levels. This paper reports on a life cycle assessment (LCA) study of twelve different green hydrogen pathways for analyzing and comparing their emission profiles. The paper uses GaBi software for this purpose. The results indicate that the pathway with the lowest emissions, measuring just 2.67 $kgCO_{2equ}/kgH_2$, involves coupling CPV-T collectors with an electrolyzer for hydrogen production. Hydrogen is subsequently compressed in a compression process, stored, transported in a compressed hydrogen container, and eventually delivered as compressed hydrogen to end-customers.

Keywords: Life cycle assessment, green hydrogen, hydrogen supply network, CO_2 emissions.

ICH2P14-OP085

DESIGN CONSIDERATIONS OF ARTIFICAL UV LIGHT-DRIVEN PHOTOCATALYTIC WATER SPLITTING FOR PRODUCTION OF HYDROGEN IN A COMBINED SOLAR/ARTIFICIAL LIGHT REACTOR

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Utilizing solar power in photocatalytic water-splitting for the production of hydrogen offers a promising avenue towards its sustainable production, although it suffers from the intermittent nature of sunlight and its low efficiency, particularly when compared to more developed methods like water electrolysis, or larger/industrial scale processes like steam methane reforming. In this work, a novel process is introduced, that combines natural and artificial light to power a continuously running photocatalytic water-splitting process. The process is based on an in-house developed low-cost organic catalyst, and uses non-potable water sources, to enhance the environmental savings achieved. In this study, the design of the artificial light source is investigated. A solar simulator is used to mimic natural sunlight, which is then used in a purpose-built lab-scale photoreactor. For the artificial light, ultraviolet (UV) high power LEDs are used. A 10-string configuration of 3W LEDs, lying on the UV-A spectrum of wavelengths from 365nm to 430nm, are used at various power levels in order to find the optimal hydrogen production point. Additionally, the design of LED strips was explored for use in a pilot plant, where the goals of continuous production, high power density and compact space were taken into account. Preliminary results indicate that UV-A light at 380nm was optimal for hydrogen production for the Covalent Organic Framework (COF) photocatalyst used, with 395nm not far behind. In addition, driving the LEDs at lower currents was beneficial for hydrogen production, as the effect of increased heat negatively affected the LED brightness, which is the main indicator of water-splitting rates. Nevertheless, increased temperatures were also found to positively correlate to hydrogen production, hence, a more comprehensive design could incorporate waste heat of LEDs into the reactor mixture while cooling the LEDs down.

Keywords: Solar, green hydrogen, LED, photocatalysis.

ICH2P14-OP087

BIOMETHANOL AND HYDROGEN PRODUCTION FROM PINECONE BIOMASS USING STEAM GASIFICATION

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The integrated system is designed to simulate the production of biomethanol and hydrogen, aiming to mitigate the pine beetle problem in British Columbia. The model incorporates robotic harvesting and steam gasification of woody bioresources derived from pinecones. Aspen Plus and MATLAB software are used to run the simulation. Gasification, syngas post-treatment, and methanol synthesis are the three primary stages of the procedure. The analysis of the system is conducted based on thermodynamic evaluations. The present system produces 0.17 kg/s of methanol and 0.025 kg/s of hydrogen, respectively.

Keywords: Methanol, hydrogen, biomass, gasification.

ICH2P14-OP088

A STUDY ON NUCLEAR-BASED HYDROGEN PRODUCTION SYSTEM VIA THREE- AND FOUR-STEP MAGNESIUM CHLORINE CYCLES

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This study presents a nuclear-based hydrogen production system where a high-temperature gas-cooled reactor (pebble bed module) is used to meet the required energy demand of a hydrogen production facility. The 3-step and 4-step magnesium-chlorine (Mg-Cl) cycles are considered to examine hydrogen production capacities. The studies are carried out by comparing different reaction conversion ratios for both cycles. Also, the 3-step Mg-Cl cycle is found to be more efficient for hydrogen production compared to the 4-step Mg-Cl cycle. Moreover, the hydrogen production rate decreases a decrease in the conversion ratio.

Keywords: Nuclear hydrogen production, HTR-PM, magnesium-chlorine cycles.

ICH2P14-OP089

ELECTRICITY HYDROGEN AND HEAT (EHH) PRODUCTION IN STAND-ALONE RENEWABLE ENERGY SYSTEM

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Fuel cells, electrolyzers, and hydrogen reformers will play interesting role in the development of energy sector in rural areas around the word. These generators permit to increase the efficiency of systems producing electricity, heat and hydrogen gas for rural areas. This paper presents a depth analysis and optimal design of a system producing heat, electricity and hydrogen in an off grid photovoltoltaic (PV) power station. This system is composed of electrolyzers, fuel cells, boiler, diesel generator and reformer. The hybrid renewable energy system provides electricity, heat and green hydrogen according to the load requirements. The optimization of the system's size and cost shows that the optimal alternative is composed of 6.9 MWp of PV panels, 80 kW Fuel Cell capacity, 100 kg/hr reformer, 100 kW diesel generator, and 3500 kW Electrolyzer. The system operating in stand-alone mode generates 13457127 kWh of electricity, 257858 kWh of heat, and 307832 kg of hydrogen, yearly. The reformer generates 73398 kg of grey hydrogen per year. The Net Project Cost is 16710114 € for a project lifetime of 25 years. The levelized cost of hydrogen is 4.2 euro/kg. The reformer permitted to increase the system efficiency by providing required hydrogen from natural gas.

Keywords: Optimization, green hydrogen, grey hydrogen, heat, photovoltaic.

ICH2P14-OP090

AN INVESTIGATION OF METAL COATED 3D-PRINTED ELECTRODES FOR HYDROGEN PRODUCTION

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In the presented paper, a new approach where the electrolysis cathodes are 3D-printed and coated for alkaline water electrolysis is investigated. Alloys including copper and iron are considered with nickel as coatings using electrodeposition. A new flow-through electrode design is compared with the traditionally designed electrodes. The flow-through electrodes were shown to have 70% higher efficiency than the coated 3D-printed electrode of the conventional design. 3D printing provides a safe design place for exploring unconventional electrode designs for improving electrolysis performance and efficiency.

Keywords: Hydrogen production, electrolysis, cathodes, energy, efficiency.

ICH2P14-OP091

PISTON REACTOR CAPABILITIES TO MAKE HYDROGEN FROM METHANE VIA STEAM AND AUTOTHERMAL REFORMING – MODELING STUDY

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The piston-reactor is a novel concept that converts electrical-energy into mechanical-work, and subsequently to chemical products. It offers a simple and compact technology to carry out chemical reactions within a unique operating window at very high temperatures around 1500K, and pressures up to hundreds of bars within milliseconds. The rapid gas expansion leads to quenching of the reacting mixture which hinders secondary reactions of metastable species toward undesired by-products. To date, the applications studied for the piston reactor have been limited to a few reaction routes with limited experimental work. To enable an early-stage screening of the reaction before intensive experimental validation, a model-based approach is proposed to explore the piston reactor operating conditions for a given reaction. The developed piston reactor model is based on coupling a zero-dimensional thermodynamic model with kinetics from the literature. The application of the modelling approach is illustrated for methane conversion to hydrogen via different chemical conversion routes including Steam-Reforming, and Autothermal-Reforming. The model-based screening of the SMR route revealed poor performance while the ATR route showed superior performance (conversions > 90%). The proposed early-stage, high-level screening quickly identified the ATR reaction as a promising route on which to focus future experimental investigations.

Keywords: Piston reactor, sustainability, hydrogen, electrification.

ICH2P14-OP092

AN APPROACH IN TREATING BIOMASS AND PLASTIC WASTE FOR PRODUCTION OF HYDROGEN AND ETHANOL

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A novel configuration of using plastic waste and biomass-based energy to produce liquid fuel, hydrogen, thermal heat, and condensable gases is proposed in this study. The system aims to take advantage of key features of co-pyrolysis and gasification of plastic waste and biomass. The ASPEN pus V14.0 is employed to predict the efficiency of the process. The proposed waste processing energy system generates 658 kg/h of liquid fuel and 639 kg/h of hydrogen. The sensitivity analysis demonstrates that maximum hydrogen production mass flow rate is achieved at steam to carbon (S/C) ratio of 4.0 and gasification temperature of 700°C. A considerable trend in liquid fuel production rate is obtained at S/C of 0.4, 0.8, 1.2, and a temperature range of 200-800°C.

Keywords: Co-pyrolysis, gasification, biomass, plastic waste, steam to carbon ratio.

ICH2P14-OP093

A UNIQUE SYSTEM FOR HYDROGEN, METHANOL, FRESH WATER AND ELECTRICITY PRODUCTION WITH CARBON CAPTURING AND STORAGE

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This study aims to investigate an innovative, multifunctional system designed to achieve dual hydrogen generation via Fe-based chemical looping and electrolysis. This system also encompasses capturing carbon dioxide emissions from a steel production facility and subsequent methanol production through the reaction of hydrogen and carbon dioxide. The system integrates three interconnected cycles, Brayton, Rankine, and Organic Rankine, to meet the electrical demands. Furthermore, the system features the production of an auxiliary resource in freshwater, obtained through seawater desalination and subsequently stored for future utilization. The findings reveal that when utilizing 1.5 kg/s of flue gas at a temperature of 1400℃, the system achieves a carbon dioxide capture efficiency of 92.5% using an amine-based solution, yielding a total of 0.0027 kg/s of hydrogen and 0.0042 kg/s of methanol with the overall energy and exergy efficiencies of 48.6% and 42.5%, respectively.

Keywords: Hydrogen, methanol, carbon capturing.

ICH2P14-OP094

INNOVATIVE INTEGRATED MULTIGENERATION SYSTEM FOR SUSTAINABLE POWER, HYDROGEN, AND AMMONIA PRODUCTION

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Renewable energy-based multigeneration systems face challenges related to intermittency and high production costs, while conventional fossil-fuel-based systems contribute to high CO_2 emissions. This study introduces an advanced, efficient, compact, and interactive solution to address these issues. Our innovative multigeneration system combines power, hydrogen (H_2), and ammonia (NH_3) production integrated with a breakthrough liquid hydrogen (LH_2) production system that uses dual mixed refrigerant (DMR)-based cryogenic process. The H_2 production system integrates a direct oxy-combustion supercritical carbon dioxide (DOC-sCO_2) power plant with water electrolysis (WE) and the Haber-Bosch process for power, H_2, and NH_3 co-generation. To optimize the efficiency, the oxygen produced by the WE system is strategically used to significantly reduce the power consumption of the air separation unit (ASU), while the ASU's nitrogen gas is used for ammonia production, which results in minimizing the costs. Moreover, the WE system's feedwater is internally sourced from the DOC-sCO_2 power block, and the CO_2 is effectively captured, achieving near-zero emissions. In the liquefaction process, our proposed DMR H_2 liquefaction cycle exhibits superior energy efficiency and flexibility compared to existing methods (with energy consumption of 3.73 kWh/kg_{LH2}) and eliminates the freezing problems. Comprehensive 4E analyses are performed for the integrated system. These analyses demonstrate impressive results: a levelized cost of electricity of 3.22¢/kWh, a levelized cost of LH_2 production of 1.22 \$/kg_{LH2}, and NH_3 levelized production cost of 0.28\$/kg_{NH3}, all with overall energy and exergy efficiencies of 43.78% and 62.32%, respectively. Our system reduces CO_2 emissions by 49.6% for H_2 production and 9.6% for NH_3 production compared to conventional methods. Additionally, this study provides guidelines for future research to improve the technical and economic feasibility of LH_2 production.

Keywords: Hydrogen, ammonia production, water electrolyzer, liquid hydrogen, dual mixed refrigerants, near-zero CO_2 emissions.

ICH2P14-OP095

A SOLAR POND INTEGRATED WITH BIFACIAL SOLAR PANELS FOR POWER AND HYDROGEN GENERATION

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This study develops a unique integrated system which combines bifacial solar panels and solar pond. These technologies are integrated to create a synergistic system capable of supplying electricity, hydrogen, and heating for community use. The performance of the system is rigorously evaluated using thermodynamic assessments based on energy and exergy efficiencies. Hourly solar data for Antalya, Turkey, sourced from the Photovoltaic Geographical Information System (PVGIS), is utilized for calculations. The results demonstrate the potential to produce electricity, hydrogen, and recover heat energy efficiently, showcasing the viability of integrating bifacial solar panels with solar ponds. The overall energy and exergy efficiencies are calculated as 28.33% and 23.67%, respectively. This integrated approach presents a promising solution for meeting the multifaceted energy demands of a community while utilizing solar energy effectively.

Keywords: Solar energy, solar pond, bifacial solar panel, hydrogen, energy storage.

ICH2P14-OP096

TECHNO-ECONOMIC EVALUATION OF VARIOUS HYDROGEN CARRIERS

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The shift from a fossil fuel-based economy to one focused on low-carbon pathways is fundamentally dependent on the mode of energy transportation. Hydrogen can play a pivotal role in the future global energy landscape, facilitating the achievement of carbon-neutral goals by 2050. Nevertheless, the large-scale transportation of hydrogen presents significant challenges, encompassing both technological and economic aspects, which need to be addressed within existing energy infrastructures. This paper investigates and compares the four different modes of hydrogen energy carrier as liquid hydrogen (LH_2), Ammonia (NH_3), methanol (MeOH) and dimethyl ether (DME) transportation. A comprehensive study on the techno-economic assessments of these hydrogen transportation pathways is analytically investigated to promote the economical and large-scale hydrogen energy carrier development. This study concluded that NH_3 followed by LH_2 are suitable options. The total SEC of NH_3 is 15.04 kWh/kg-H_2 which is lower than all other pathways. This indicates that the overall OPEX of other pathways especially NH_3 will be much lesser than that of LH_2 process. The least cost is of NH_3 pathway which is 4.76 \$/kg-H_2 because the main cost in LCOH for MeOH and DME is conditioning and reconditioning which is higher than all other pathways. It is recommended to consider LOHC pathways as a promising alternative for efficient and sustainable energy transportation, thereby contributing to the establishment of an environmentally friendly hydrogen economy. However, it is crucial to emphasize that substantial research efforts are required to make this approach both technologically and economically viable.

Keywords: Hydrogen transportation, techno-economic, liquid hydrogen, ammonia, liquid organic hydrogen carrier.

ICH2P14-OP97

MAXIMIZING POWER GRID RESILIENCE: ROLLING HORIZON CONTROL FOR OUTPUT POWER SMOOTHING IN ISLANDED WIND-SOLAR MICROGRIDS WITH MULTIPLE HYDROGEN STORAGE TANKS

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This paper introduces a strategic framework based on hierarchical rolling horizon control, also called model predictive control, for efficiently operating a hydrogen-energy storage system (HESS) within a self-contained wind-solar microgrid. The HESS employs an electrolyser to convert renewable-generated electricity into clean hydrogen, subsequently re-electrified using a fuel cell to meet the microgrid's energy demands. A significant innovation lies in incorporating multiple hydrogen storage tanks within the HESS, setting it apart from prior research that typically focused on a single tank. This multi-tank configuration allows for the long-term storage of significant hydrogen volumes, enabling the microgrid to function independently, isolated from the main grid. Optimal device selection at each time-step is crucial to guarantee peak performance. The proposed control strategy considers economic and operational expenses, degradation factors, and physical constraints of the HESS, while concurrently ensuring adherence to reference load demands and the prioritized smoothing of renewable energy fluctuations. Numerical simulations employing actual wind and solar generation profiles demonstrate that the proposed controller adeptly administers the HESS, even when disparities exist between projected and real-time scenarios. This ensures economic efficiency and device cost optimization.

Keywords: Hydrogen-based energy storage systems, energy management, model predictive control.

ICH2P14-OP098

ELECTRO-BIOMEMBRANE REACTOR FOR CONCURRENT HYDROGEN PRODUCTION AND DESALINATION

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This study has presented a novel reactor for producing both renewable bio-H_2 using poplar leaves and hydrogen from water electrolysis and water desalination simultaneously. The effects of voltage and CO_2 gas on hydrogen production rates were investigated, and the maximum hydrogen production rates were 18.86 mg/min for the dark fermentation chamber and 78.53 mg/min for the electrolysis chamber at an operating voltage of 8V with a total production rate of 97.39 mg/min in the electro-biomembrane reactor. The hydrogen production in the dark fermentation chamber was increased 1.2 times in the presence of CO_2 gas due to its positive effect on the growth of anaerobic microorganisms.

Keywords: Biohydrogen, biomass, electrolysis, dark fermentation, desalination.

ICH2P14-OP099

AN ADAPTATION OF THE CONVENTIONAL LNG FLOATING STORAGE AND REGASIFICATION UNIT TO HYDROGEN AND AMMONIA

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Floating Storage and Regasification Unit (FSRU) is an offshore repository alternative and is considered a practical fuel receiving terminal when the onshore-based receiving terminal is more challenging to build in a particular area due to a lack of land, cost, and time constraints. Since FSRU is constructed primarily for the regasification of Liquefied Natural Gas (LNG), the current regasification methods and the infrastructures on an FSRU could not be directly applicable to facilitate other liquefied energy carriers. Hence, this paper aims to develop adaptation and modification technologies to regasify the prominent renewable energy carriers, such as liquid hydrogen and liquid ammonia. By employing adaptable techniques such as vaporizer/heat exchanger and cryogenic expansion, these methods are tailored to the particular characteristics and needs of liquid hydrogen and liquid ammonia for regasification and storage, resulting in safe and effective renewable multi-gas FSRU operations. Incorporating these specialized and customized technologies on the FSRU necessitates careful consideration of several elements, including the vessel's design, storage tanks, safety issues, thermal management, and system compatibility to meet these renewable energy carriers' unique requirements. Moreover, a conventional FSRU needs excessive electricity; thus, in compliance with clean energy transition purposes, integrating renewable energy sources such as Concentrated Solar Power (CSP) and Ocean Thermal Energy Conversion (OTEC) is another fundamental goal. Furthermore, to further minimize environmental impacts, especially on marine life, the two significant barriers in developing an FSRU, such as the discharging of brine during the regasification process and appropriate Boil-Off Gas (BOG) management within the whole FSRU operations, are thoughtfully considered and provided practical solutions as well.

Keywords: BOG management, energy transition, offshore repository, renewable integration.

ICH2P14-OP102

SYNGAS PRODUCTION USING CATALYST BASED ON LOCAL MINERALS EXTRUDED AS HONEYCOMB MONOLITH

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CH_4 and CO_2 contained in biogas are of interest with respect to syngas production through auto-thermal dry reforming reactions. At this regard the presentation reviews an engineering journey concerning development of non-noble metal catalysts material based on available local minerals containing significant amount of naturally occurring transition metals such as iron and some elements considered as promoters in the clay were proposed to account for the catalytic properties. A systematic investigation for tuning catalytic performance of the clay through incorporation of appropriate active phase and promoters such as Nickel and Magnesium regarding dry reforming for syngas production. The catalytic performances were significantly enhanced by adding 8 wt.%Ni and 3 wt.%Mg to the clay, yielding to CH_4 and CO_2 conversions around 80% at 800 °C for H_2/CO ratio around 1. So far, a Hydrogen yield of about 60% was obtained through reproducible experiments carried out at 800°C with a model biogas with respect to CH_4/CO_2 mixture containing respectively 50 and 40 vol.% to which 10% O_2 were added using a GHSV= 8000 ml h^{-1} g^{-1}. Note that blank tests yield, only, to maximum CH_4 and CO_2 conversion values about 15% and 6% respectively as result of the intrinsic catalytic activity of the unmodified clay. The improved catalytic performances were attributed to the stabilization of smaller Ni particles associated with the formation of NiO-MgO solid solution alleviating particle sintering as result beneficial synergy effects due to different types of nickel-support interactions in addition to improved basic properties induced by Magnesium addition. Of interest also the innovation aspect regarding easy extrusion of the clay-based catalyst as honeycomb monolith and related further advantages regarding syngas transformation into valuable chemicals due to the obtained CH_4/CO_2 ratio.

Keywords: Biogas, syngas, dry reforming, honeycomb monolith, clay catalyst.

ICH2P14-OP104

GREEN HYDROGEN PRODUCTION VIA INTEGRATED TRIPLE TECHNOLOGIES: DOWNDRAFT TOWER, PHOTOVOLTAIC AND ELECTROLYSIS

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This work proposes an integrated structure consisting of three types of technologies to produce green hydrogen. The technologies include a downdraft tower, photovoltaic panels, and an electrolysis station. The downdraft tower is at the center of the integrated structure. The bottom of the tower is surrounded by rows of photovoltaic panels that fan out from the tower, row by row. At the base of the tower, a water pool is installed. The water pool is integrated with an electrolysis station with two pipes extending from the station to hydrogen and oxygen storage tanks outside the tower. The downdraft tower provides a jet of cool air that travels downwards from the top. The cool air interacts with a turbine located at the bottom of the tower, generating electricity that powers up the electrolysis station, producing hydrogen. Similarly, the photovoltaic panels produce electricity from solar irradiance during the daytime, combined with the electricity from the downdraft tower to power up the electrolysis station. Hence, the combined produced energy improves the production of hydrogen. The downdraft cool air helps to cool the photovoltaic panels, improving their efficiency by about 5%. Hence, improving the efficiency of the photovoltaic panels improves hydrogen production efficiency. In addition, the downdraft tower could work during the day and at night to produce electricity, depending on the weather conditions. Hence, the photovoltaic panels and the downdraft tower allow the integrated structure to produce hydrogen around the clock. The results show that the photovoltaic panels produced 463.984 MWh, and the downdraft tower produced 636.011 MWh of energy annually. The results also showed that the total energy from the system was used to produce 37161 kg of hydrogen.

ICH2P14-OP106

AN INTEGRATED LIFE CYCLE ASSESSMENT AND SUPPLY CHAIN ANALYSIS OF A MULTI-GENERATION SYSTEM FOR RENEWABLE CLEAN POWER AND GREEN HYDROGEN PRODUCTION

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Energy crisis across the globe is leading towards an unstable future where the scarcity of energy shall create huge problems at domestic and commercial levels. The need of the hour is to develop and implement sustainable energy production methods which can overcome the crisis. With the depletion of fossil fuels, conventional power production methods are becoming outdated. Environmental crises such as carbon footprints and global warming pose a serious threat to the existence of mankind as well. In this alarming situation, renewable energy sources like biomass, solar, geothermal and wind energy can prove to be sustainable and reliable sources of energy generation with aided advantage of least carbon emissions. This research presents a biomass sourced multigeneration system which produces power and hydrogen as main outputs and cooling, heating, fresh water, and hot water as its by-products. The system consists of a Cogeneration Cycle, a Triple Effect Vapor Absorption Cycle, and a Double Flash Desalination Cycle. The thermal efficiency of the system is 33.36% while the energetic and exergetic efficiencies are 64.82% and 80.99%, respectively. The system produces 33 MW of power, 0.04037 kg of hydrogen per second, 4960 kW of cooling, 37274 kJ/s of space heating, and 34.99 kg/s of freshwater, respectively. Engineering Equation Solver (EES) is used to perform energy and exergy analyses. Multi-objective optimization of the system has also been carried out.

Keywords: Green hydrogen, clean power, renewable energy, multigeneration systems, sustainable energy.

ICH2P14-OP109

MULTI-RESPONSE OPTIMIZATION OF ABSORPTION AND DESORPTION PARAMETERS IN A METAL HYDRIDE BASED HYDROGEN STORAGE SYSTEM

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Considering hydrogen storage challenges in compressed and cryogenic methods, metal hydride (MH) has emerged as a safer hydrogen storage solution. However, performing rigorous experiments to obtain optimum operating parameters for MH reactors may not be a feasible solution. The present study demonstrates a series of multi-response optimisation techniques implemented on MH based hydrogen storage reactors for obtaining optimum working parameters for absorption and desorption, minimising the number of experiments performed. The approach uses Taguchi-MOORA method (TM), Grey Relational Analysis (GRA) and Response Surface Methodology (RSM) to correlate the experimental data to test reliability of the optimisation. The experimental data used in the optimisation of absorption parameter was hydrogen supply pressure (2,5,10,15 and 20 bar) and absorption temperature (10, 15, 20 and 30°C). For optimising desorption parameter, experimental results of temperature variation from 60 to 90°C (in step of 10°C) was considered. It was observed that the optimum hydrogen desorption temperature was found to be 90°C for all the three optimisation techniques. However, for the absorption, optimum pressure lies in the range of 15-20 bar with reduction in absorption time (240 s - 330 s) of almost 50% as compared to experiments. The present work gives new insights for development of new optimization techniques for efficient H_2 storage in MH systems.

Keywords: Grey relational analysis, hydrogen, metal hydride, response surface methodology, Taguchi-MOORA.

ICH2P14-OP110

DEVELOPMENT OF A HYBRID POWERING SYSTEM WITH AMMONIA FUEL CELLS AND INTERNAL COMBUSTION ENGINE FOR SUBMARINES

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To overcome the limitations of current hydrogen storage technologies in submarines, this paper proposes a novel, integrated system that utilizes ammonia as a fuel source. The system combines Direct Ammonia Fuel Cell (DAFC) and Internal Combustion Engine (ICE) technology to generate power, freshwater, and cooling. The system is designed to recover waste heat and utilize it efficiently to produce power, freshwater, and cooling. The study aims to evaluate the performance of the system using thermodynamic energy and exergy analysis tools and conduct a parametric study to investigate the impact of varying system parameters and operating conditions on system efficiency. The proposed integrated system can produce 4,069 kW of net power, provide 5.895 kW of cooling, and generate 1.269 kg/s of freshwater under specified conditions. The energy and exergy efficiencies of the system are 33.96% and 39.39%, respectively.

Keywords: Ammonia, hydrogen, submarine, exergy, direct ammonia fuel cell.

ICH2P14-OP111

AN INTEGRATED SOLAR-DRIVEN CHLOR-ALKALI SYSTEM FOR HYDROGEN AND CHLORINE PRODUCTION

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This paper deals with a review of the chlor-alkali process, an industrial application with significant promise for hydrogen production. In this process, the 2.6 MWh of power required for the operation of the system is met by an ingenious approach using a photovoltaic-based energy system. The research includes a comprehensive simulation of a chlor-alkali production system with the operating temperature set to 88°C using the Aspen Plus. The results demonstrate the remarkable potential of this system with a hydrogen production rate of 82.5 kg/h.

Keywords: Hydrogen, hydrogen production, chlor-alkali process, photovoltaic-based energy system.

ICH2P14-OP112

INFLUENCE OF HYDROGEN UPTAKE ON ADDITIVELY MANUFACTURED AND CONVENTIONAL AUSTENITIC STAINLESS STEELS 316L

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With increased energy demand in the present-day world, a strong driving force prevails in the transition from existing fossil fuel-based economy to a circular and sustainable renewable energy-based economy. In this context, hydrogen is regarded to play one of the most significant roles in achieving a carbon-neutral society. However, this also poses several major challenges raised by hydrogen-induced metal/alloy degradation during the generation, transportation, and storage of hydrogen. Additive manufacturing is a promising means of production of austenitic stainless-steel parts for hydrogen service. The hydrogen embrittlement resistance of SS 316L parts by conventionally manufactured and directed energy deposition was examined using tensile testing. For this study, an attempt is made to understand the effect of hydrogen on additively manufactured 316L SS and compare it with conventionally manufactured 316L samples. Therefore, electrochemical hydrogen charging was performed on both AM and CM 316L samples to achieve a comparable hydrogen content in the samples, which were further measured by Thermal Desorption Spectroscopy and Glow Discharge Optical Emission Spectroscopy. A combination of surface characterization techniques; SEM, EDX, XRD, and EBSD are deployed to accurately characterize and gain an improved understanding of the hydrogen embrittlement mechanism in CM and AM stainless steel. The higher presence of hydrogen reduced ductility in the as-built AM sample but did not significantly influence the response in CM materials. Hydrogen-charged samples exhibited a large area of brittle fracture mode, while hydrogen-free samples showed ductile fracture morphology.

Keywords: Addictive manufacturing, hydrogen uptake, hydrogen embrittlement.

ICH2P14-OP113

DEVELOPMENT OF A HYDROGEN PRODUCTION MODEL FOR THE GASIFICATION OF MUNICIPAL SOLID WASTE AND ITS CONSTITUENTS USING ASPEN PLUS USING CAO FOR CO_2 CAPTURE

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The hydrogen (H_2) economy is gaining significant importance due to its applications in the synthesis of various chemicals and its potential as a high-energy source. Currently, H_2 is primarily obtained from fossil fuel-based resources. However, over the past decade, there has been an increase in H_2 production from renewable resources. One notable method that has emerged in renewable sources is the conversion of carbonaceous materials into H_2 through gasification. In this study, a process simulation model is developed for the gasification of municipal solid waste (MSW) and its major constituents, including food, plastic, paper, and textile wastes to produce H_2. The study also investigates the influence of CaO (for CO_2 capture) on the H_2 yield in syngas. The impact of three key process parameters: temperature (650°C to 900°C), steam/feed ratio (0.5 to 2), and CaO/feed ratio (0 to 2) on the H_2 yield is also studied. The optimum H_2 production is observed at a temperature of 750°C and a steam/feed ratio of 1.5, with the use CaO/feed ratio of 1 is found to be optimal for all cases. The H_2 yield for individual waste types without and with CO_2 capture is as follows: 62.38% and 78.87% for food, 60.20 and 70.55% for plastic, 62.20% and 79.91% for paper and 61.50% and 77.12% for textile, respectively. For cumulative MSW, the obtained H_2 yield is 63.30% and 78.57% without and with CaO respectively.

Keywords: Hydrogen, gasification, textile, plastic, municipal food waste.

ICH2P14-OP115

PHOTOCATALYTIC HYDROGEN GENERATION FROM SEAWATER USING HIGH-PERFORMANCE POLYMERIC MATERIALS

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Recently, there has been renewed interest in the use of solar energy as a resource to meet the world's energy needs in an environmentally sustainable way. Hence, our research focuses on the generation of hydrogen from non-fresh water using the sun as an energy source. The research aims to characterize, assess, and developed new research-grade materials and commercial photocatalysts that can achieve sunlight-driven unassisted photo-splitting of water. In this work, novel conjugated polymer nanoparticles were developed and characterized. The nanoparticles are composed of a donor-acceptor system where two acceptors, which were acceptor-1 (A1) and acceptor-2 (A2), were developed and tested, and different ratios of each donor-acceptor system were assessed. The use of platinum or molybdenum as co-catalysts was explored. Hydrogen evolution reactions with ascorbic acid as sacrificial reagent was performed using these materials and their performance was assessed. The results show that the first system consisting of acceptor-1 and the donor (A1/D) produce more hydrogen than the (A2/D) system. Furthermore, the best ratio of donor: acceptor was determined to be 10:90 for the (A1/D) system. The use of platinum as a co-catalyst was shown to result in a better performance in terms of hydrogen production compared to the use of molybdenum. Furthermore, the results show that the use of nanoparticles suspended in solution results in a higher hydrogen evolution rate compared to the use of films. Hydrogen production of 2018 micromole per gram of catalyst per hour was achieved using the A1/D nanoparticle system with platinum.

ICH2P14-OP119

LOW PRICE PHOTO AND THERMAL PRODUCTION OF HYDROGEN FUEL FROM HYDROGEN SULFIDE EXTRACTED FROM PETROLEUM NATURAL GAS

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Photo-Thermal production of hydrogen from hydrogen sulfide from some petroleum natural gas contain 10-13 % H_2S. This gas is very corrosive and poisonous gas to the atmosphere. There were two Claus processes in Iraq to produce 2200 ton/day of pure elemental sulfur and water, the new Claus process can be converted to produce 140 ton/day of hydrogen and elemental sulfur in Iraq by using new catalyst in photo-thermal decomposition of H_2S at low temperature due to fact that energy bonding of the H-S is very low compared with H-O bond in water. Therefore shortcut production of hydrogen from H_2S is by extraction of this gas from natural petroleum by ethanolamine's solution and direct photolysis of this gas after passing it over trace TiO_2, ZnO …photosensitizer at low temperature range (5- 35 ^oC) H_2S will decomposes to hydrogen and sulfur, therefore three different pilot plants have been built for cheap production of Hydrogen and sulfur in liquid and gas phase.

***Keywords**:* Hydrogen production, natural gas, H_2S, sensitizer.

ICH2P14-OP120

A LIFE CYCLE ASSESSMENT OF HYDROGEN PRODUCTION WITH CATALYTS

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This paper reviews the significant influence of a chemical catalyst in clean hydrogen production on renewable energy technologies. Utilising data from the GREET program, we analyse three pathways: renewable natural gas production from food waste via anaerobic digestion, renewable natural gas for central plant gaseous H_2 production, and renewable natural gas production from fats, oil, and grease via anaerobic digestion. We assess the emissions (CO_2, CH_4, NOx, PM2.5, SOx, N_2O) graphically. Our life cycle assessment of the catalyst shows its role in the production of pure hydrogen and highlights its importance for renewable energy. In comparison, conventional hydrogen cyanide production produces CO_2 emissions of 1.96 kg, while the pathways used in cyanide hydrogen production are between 0.19 kg - 0.15 kg.

Keywords: Hydrogen, life cycle assessment, hydrogen production, sustainable development.

ICH2P14-OP121

PIEZOCATALYTIC HYDROGEN EVOLUTION ACTIVITY OF SELENO-CHEVREL PHASES

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The use of piezoelectric charges in catalytic applications has been investigated in recent years. Studies have shown that negative and positive piezoelectric charges generated by mechanical vibration can be used for catalytic redox reactions. Semiconductors with non-centrosymmetrical crystal structure such as CdS, CdSe, GaN, BN, AlN, ZnS and ZnO have been used in piezocatalytic hydrogen production studies. In addition to these materials, in recent years transition metal dichalcogenides such as MoS_2 and $MoSe_2$ have also been investigated for piezocatalytic hydrogen production. The recent studies have shown that transition metal dichalcogenides can be used effectively in piezocatalytic applications. It has been observed that Chevrel phases show higher catalytic activity in many catalytic applications due to their more advantageous electrochemical and physicochemical properties compared to transition metal dichalcogenides. In this study, piezocatalytic hydrogen production of $MoSe_2$ as transition metal dichalcogenide and $CuMo_6Se_8$ and $FeMo_6Se_8$ seleno-chevrel phases was examined. We report the effectiveness of chevrel phases in piezocatalytic applications compared to transition metal dichalcogenides and recommend the use of these materials in piezocatalytic applications.

Keywords: Piezoelectricity, piezocatalysis, hydrogen evolution.

ICH2P14-OP122

SYNTHESIS, CHARACTERIZATION, AND APPLICATION OF BIO-TEMPLATED NI-CE/AL$_2$O$_3$ CATALYST FOR CLEAN H$_2$ PRODUCTION IN THE STEAM REFORMING OF METHANE PROCESS

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A porous γ-alumina was successfully created using an eco-friendly method, employing Fig leaves as a biotemplate for the first time in this study. Following the confirmation of the porous Al_2O_3 structure using various characterization techniques, it was employed as a support material for Ni-Ce particles to significantly enhance the conversion efficiency of the steam reforming of methane (SRM) process. To achieve this, we fine-tuned the content of Ni, Ce, and the SRM temperature utilizing both bulk and porous Ni-Ce/Al_2O_3 catalyst structures. The results obtained from field emission scanning electron microscopy (FESEM), temperature-programmed desorption (H_2-TPD), and N_2 adsorption/desorption indicated the formation of more evenly distributed Ni particles with smaller sizes on the mesoporous alumina (MAl), especially when promoted with CeO_2. In addition to the effective influence of CeO_2 on Ni particle dispersion, it enhanced the interaction between Ni and Al, thereby increasing the catalysts' activity and reducing coke deposition during the SRM process. Consequently, the 20Ni-3.0Ce/MAl catalyst displayed the highest H_2 yield at 96.02% and CH_4 conversion at 90.20%, with the lowest CO_2 produced to CH_4 consumed ratio of 0.52% at an SRM reaction temperature of 700°C. In contrast, the bulk catalyst with equal Ni and Ce contents exhibited CH_4 conversion, H_2 yield, and CO_2/CH_4 molar ratio of 86.09, 92.30, and 0.56, respectively, at the same temperature. Furthermore, the 20Ni-3.0Ce/MAl catalyst demonstrated the highest stability during a continuous 12-hour SRM reaction at 700ºC, with the lowest reductions in CH_4 conversion and H_2 yield, amounting to 3.97% and 5.12%, respectively.

Keywords: Bio-templated Al_2O_3, fig leaves template, H_2 production, steam reforming of methane, Cerium promoter.

ICH2P14-OP123

GREEN HYDROGEN BASED AMMONIA PRODUCTION PROCESS: INSIGHT INTO ENERGY AND CO_2 EMISSIONS MINIMIZATION

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Ammonia is one of the important chemicals, which has a wide range of applications in process industries. The demand for ammonia is expected to increase by 1.5% per year with the increase in demand for global demand for food supply. In this work, the Bare Bones Particle Swarm Optimization (BBPSO) algorithm, which is recognized for solving multimodal and nonlinear optimization problems, is used. BBPSO is an extension of particle swarm optimization, which is considered as one of the successful nature-inspired algorithms. The ammonia production process is modeled using the Promax Software. In this process, hydrogen is produced via the electrolysis of water. This green hydrogen is utilized as a raw material for the production of ammonia. Three single-objective-based objectives, namely minimization of CO_2 emissions (tonnes/year), maximization of profit (million \$/year), and maximization of ammonia flow rate (kg/hr) are individually optimized using BBPSO. Nine decision variables are considered which include five feed temperatures of different streams, two pressures of two different streams, and the flow rate of water and nitrogen. A detailed sensitivity analysis is carried out to determine the dependencies of assigned variables on the targeted objectives. Along with optimum objective values, several other important parameters like energy consumed and the purity of ammonia are also reported. This study not only considers sustainable green production of ammonia but also put light on economics, environmental, and energy-specific criteria for a better tomorrow.

Keywords: Green hydrogen, ammonia, BBPSO, CO_2 emissions, energy.

ICH2P14-OP125

GREEN ENERGY FROM WASTE: A SYSTEMS ENGINEERING APPROACH TO BIO-HYDROGEN PRODUCTION

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This study proposes an innovative investigation into the production of bio-hydrogen (bio-H_2) from various types of biomass compositions, which include municipal solid waste, oily sludge waste, and plastic waste, as well as their combinations. The research thoroughly examines the effects of critical variables such as reactor temperature, steam-to-biomass ratios, and CaO-to-biomass ratios on syngas composition and H_2 yield, as viewed through the Process Systems Engineering perspective. The study compared the performance of selected biomasses and their combination for the production of higher amount of H_2. The results indicate that the temperature of the reactor has a substantial effect on the production of Bio-H_2. In addition, the sensitivity analysis were streamlined based on steam-to-biomass ratio reveals a distinct pattern in the pursuit of optimising H_2 gas production. Furthermore, the composition of syngas is significantly influenced by the CaO-to-biomass ratio. Hence, it was proposed that a novel blend of oily sludge with plastic waste in the 10%-90% results in ≥ 99 wt.% H_2 with lower and higher heating value of 56.97 and 62.44 MJ/m^3. The novel blend could promising for recovering green energy in terms of Bio-H_2 from the waste of plastic and oily sludge.

Keywords: Steam gasification, Aspen plus, oily sludge, plastic waste, municipal solid waste, bio-hydrogen.

ICH2P14-OP126

METHODS OF HYDROGEN PRODUCTION, STORAGE AND TRANSPORTATION

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This study explored the different ways for producing, storing, and transporting hydrogen. A comparison of various approaches based on efficiency is offered here to determine the optimum method in hydrogen generation, storage, and transportation. In the production process, there are two main categories of methods used in hydrogen production or hydrogen resources: fossil fuel resources and renewable resources. Physical water splitting, which includes electrolysis, thermolysis, and photolysis, and biomass processes, which include biological and thermochemical processes, are considered renewable methods. While hydrogen reforming and hydrogen pyrolysis are both considered fossil fuel processes. Three alternative hydrogen production technologies are compared based on their efficiency of hydrogen synthesis. There are also several methods for storing hydrogen, including physical storage and liquid hydrogen storage. There are several techniques for transporting created hydrogen, but the two most common are gaseous transportation and liquid transportation. The hydrogen reforming method has the highest efficiency (80%), followed by the water electrolysis method (75%), and the thermochemical water splitting method (55%). The physical storage method has an efficiency of 85%, whereas the liquid storage approach has an efficiency of 45%. The pipe transportation method is preferable for transporting.

Keywords: Hydrogen production, storage, transportation, clean energy, liquid hydrogen.

ICH2P14-OP127

DYE-SENSITIZED PHOTOCATALYTIC HYDROGEN PRODUCTION BY SEPIOLITE CLAY

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While there have been significant efforts to develop photocatalysts for the hydrogen evolution reaction (HER), high charge recombination and low charge separation and migration remain the most importance challenge in using of photocatalysts. Natural clays are increasingly recommended as interesting support materials for various photocatalysts due to its significant physicochemical properties such as low charge recombination, high charge separation and migration. The use of clay minerals in the dye sensitized photocatalytic hydrogen production studies is advantageous in many ways due to advanced surface properties such as surface adsorption capacity of clay. In this study, a fiber-structured clay, sepiolite was investigated by sensitizing it with eosin Y (EY), erythrosine B (ErB) and rhodamine B (RB) dyes for photocatalytic hydrogen production under visible light irradiation. As well as, in order to increase the catalytic activity of sepiolite clay, H_2PtCl_6 was used as the platinum precursor for the *in situ* photodeposited Pt co-catalyst. After dye sensitization of Sepiolite catalyst supports with EY, ErB and RB, the photocatalytic hydrogen production was changed in the order of Sepiolite/ErB > Sepiolite/EY > Sepiolite/RB. When Pt was used as a co-catalyst, the photocatalytic hydrogen evolution rates of Sep/Pt in the presence of dyes have been enhanced approximately 10-times.

Keywords: Hydrogen evolution, photocatalysis, clay.

ICH2P14-OP130

EXERGETIC ANALYSIS OF THE PROCESS FOR HYDROGEN RICH SYNGAS PRODUCTION THROUGH BIOMASS GASIFICATION AND ITS ONSITE USE IN HCCI ENGINE FOR LAND TRANSPORTATION

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This work was aimed to develop and analyze the performance of a system consists of a biomass gasifier producing the syngas rich in hydrogen and its onsite utilization in homogeneous charge compression ignition (HCCI) engine for sustainable transportation. A theoretical formulation for computing the composition of syngas produced after gasification of various biomass materials was developed to predict the percentage of hydrogen appears in the syngas using MATLAB software. The effects of the type of biomass feed and the gasifier operating conditions on exergetic efficiency of the gasifier and on overall performance of the proposed system is performed and a computational method for the investigation based on energy and exergy of the proposed system has also been developed using the EES software. The gasifier operating performance is assessed for the effect of change in gasification equivalence ratio (GER) and steam-to-biomass ratio (SBR) and their significant impact is found on the exergy efficiency of gasifier producing hydrogen. The exergetic efficiency of HCCI engine based is found increasing with the increase of SBR and turbocharger pressure ratio. Exergy results show that gasifier offers 57% second law efficiency followed by HCCI engine with 42%.

Keywords: Biomass gasification, hydrogen rich syngas, HCCI engine, exergy, sustainable transportation.

ICH2P14-OP133

GRADED GYROID-ENHANCED METAL HYDRIDE CONTAINER FOR EFFICIENT HYDROGEN STORAGE APPLICATION

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Hydrogen as energy storage sector grapples with a pivotal challenge: the imperative to devise efficient hydrogen storage systems. Solid-state compounds such as metal hydrides (MH) emerge as a compelling solution among diverse hydrogen storage technologies, owing to their intrinsic safety attributes and superior hydrogen volumetric density. The limitation of MH lies in its gravimetric density, impeding its applicability in contexts involving mobility. This study optimizes the designed MH container featuring a gyroid structure and seamlessly integrates the reactor tank into the vehicle's frame and chassis. Subsequently, this design underwent analysis, employing finite element analysis (FEA) and computational fluid dynamics to evaluate mechanical properties, heat transfer capabilities, and the efficiency of hydrogen charging into the MH within the structure. Through topology optimization of solid isotropic material with the penalization method, there ensued a 17% augmentation in chamber volume, accompanied by a reduction in the material by nearly 50%. This profound transformation positively impacted the reactor's volumetric and gravimetric density. Despite a measurable reduction in strength, the geometry withstands prescribed mechanical shear loads. The structure also exhibited displacement measuring below 0.2 mm, rendering it suitable for components such as vehicle frames or chassis. Notably, the optimized structure showcased a promising enhancement in the rate of hydrogen charging.

Keywords: Hydrogen storage, metal hydride, heat exchanger, topology optimisation, triply periodic minimal surface.

ICH2P14-OP134

THE CORRELATION OF POROUS MATERIAL'S PROPERTIES BETWEEN PARTICLE GEOMETRY FOR HYDROGEN FUEL AND ELECTROLYSIS CELLS

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This study focuses on the impact of particle geometry on the properties of porous materials that are crucial to electrochemical devices, such as batteries, electrolysis and fuel cells. There are numerous studies on the properties, but there is little focus on what factor influences these properties and to what extent. Three-dimensional (3D) models with different particle geometry that mimic porous granular with spherical particles and fibrous materials, which are generally utilized for fuel cells, are developed. The particle geometry is as follows: sphere and cylinders with different height-to-diameter ratios of 0.1, 0.5, 1.0, 2.5, 5.0, and 10. Each model exhibits a $43.5 \pm 0.8\%$ porosity, and its particle's volume follows the Gaussian distribution. Through the models, binarized 3D models corresponding to each model have been generated. They consist of 0 or 1 in 400×400×400 voxels; thus, they are four-dimensional matrixes. Porosity, internal surface area, and tortuosity and chord length of solid and pore phases are figured out and analyzed by utilizing the binarized 3D models and specially written source codes. It is found that specific correlations exhibit Pearson correlation coefficients higher than 0.975 between the particle's sphericity and the internal surface area and chord lengths of solid and pore phases.

Keywords: Porous material, particle sphericity, surface area, chord length, electrochemical devices.

ICH2P14-OP135

PREDICTIVE MODELING OF BIOGAS AND METHANE PRODUCTION FROM COW AND CHICKEN MANURE USING A MODIFIED GOMPERTZ MODEL OPTIMIZED BY PARTICLE SWARM OPTIMIZATION

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In the context of the global energy transition and the imperative of sustainable development, anaerobic digestion of organic waste for biogas recovery presents a compelling alternative. This study aims to develop a robust predictive model for estimating biogas and methane production from organic waste employing advanced optimization techniques. The modified Gompertz model is adopted to characterize the kinetics of biogas production. Parameters optimization of the modified Gompertz model are achieved through the application of the Particle Swarm Optimization algorithm (PSO). To support this research, a comprehensive database sourced from relevant literature is assembled, enabling the creation of predictive models for biogas and methane production. Specifically, this study encompasses the mono-anaerobic digestion of cow and chicken manure, as well as the co-anaerobic digestion of chicken manure blended with sawdust and wheat straw.

Keywords: Biogas, methane, anaerobic digestion, modified Gompertz model, PSO algorithm.

ICH2P14-OP136

3E ANALYSIS AND MULTI-OBJECTIVE OPTIMIZATION OF SOLAR-THERMAL-ASSISTED ENERGY SYSTEM: SUPERCRITICAL CO_2 BRAYTON CYCLE AND SOLID OXIDE ELECTROLYSIS/FUEL CELLS

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In this paper, a small-scale (2 MW) solar-thermal-assisted energy system including solar power tower (SPT), supercritical CO_2 (SCO_2) Brayton cycle, and solid oxide electrolysis/fuel cells (SOEC/SOFC) is proposed. With the heat supply of air medium, the SOEC subsystem can operate at 800 ℃ to reach high energy efficiency and reduce electric demand. This system converts excessive electricity into hydrogen for storage or sale and provides a stable electricity supply for 10-11 hours per day with an energy storage proportion of less than 50%. The key factors for the system performance are investigated including turbine inlet parameters, maincompressor inlet parameters, recompression fraction of the SCO_2 subsystem, and operating temperature and current density of the SOEC/SOFC subsystems. The case study shows that the net hydrogen output can reach 7999.6 kWh/d in summer with SOEC operating at 800 ℃, which is 31.1% higher compared to 6099.7 kWh/d with that at 600 ℃. To recover the cost, the hydrogen price is 7.3 $/kg. After multi-objective optimization, the optimum exergy efficiency and capital investment of the SPT-SCO_2-SOEC subsystem are 31.9% and 2.45 M$, respectively. In terms of the SOFC subsystem, the corresponding values are 50.5% and 1.1 M$.

Keywords: Solar power tower, supercritical CO_2 Brayton cycle, solid oxide electrolysis/fuel cells, 3E analysis, multi-objective optimization.

ICH2P14-OP137

SODIUM BICARBONATES PRODUCTION THROUGH CARBON MINERALIZATION FOR HYDROGEN STORAGE: A TECHNO-ECONOMIC ASSESSMENT

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Hydrogen is a valuable source of energy that can effectively replace fossil fuels. Its combustion mainly yields water, setting it apart from conventional fuels and rendering it a crucial asset for a more sustainable energy future. However, advancements in the utilization of hydrogen fuels remain restricted by the development of efficient storage technologies. In this context, bicarbonates represent a safe and efficient material that can store hydrogen using a catalyst to produce formate, which is well-known for its high storage capacity. Solvay processes produce sodium bicarbonates through the reaction of reject brine and CO_2, providing a pathway for producing an economically attractive product while simultaneously mitigating two major environmental threats. This work reports a systematic techno-economic assessment of the conventional and $Ca(OH)_2$ modified Solvay processes. The model evaluates the effect of varying the brine salinity, temperature and pressure on the CO_2 and Sodium ions removal and bicarbonate production. In addition, the process cost associated with each parameter and the effect of carbon tax on the process profitability were analyzed. The results indicate that varying brine characteristics influence Sodium and CO_2 removal, bicarbonate production, and process profitability. Moreover, $Ca(OH)_2$ modified Solvay was found to be economically feasible, as it generated a satisfactory annual profit. Unlike $Ca(OH)_2$ modified Solvay, conventional Solvay is non-profitable even with the carbon tax implementation of up to 120 $/tonne of CO_2.

Keywords: techno-economic, Solvay, modified Solvay, bicarbonates.

ICH2P14-OP138

DESIGN AND PERFORMANCE ANALYSIS OF AMMONIA-BASED POWER GENERATION

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In the energy transition from petroleum to carbon-neutral fuel, ammonia appears as a promising energy carrier for power generation using combined cycle. However, its low reactivity make ammonia harder to ignite, which leads to low combustion efficiency and high NO emission when it is burned in existing combustor. Mixing ammonia with a more reactive fuel, such as hydrogen from partial cracking of ammonia, could improve the combustion yield. This paper investigates the performance of ammonia-based combined cycle power generation with ammonia cracking facility. The proposed system is evaluated by thermodynamic modelling of each components covering heat transfer, pressure change, and ammonia cracking reaction process. The ammonia and hydrogen co-combustion is verified by computational fluid dynamic simulation using plant scale combustor, which is further validated by similar simulation of pilot scale combustor. The obtained results show general agreement between the conducted simulation and measurement of pilot scale combustor, which results are used to model combustion reaction in the plant scale combustor. In the combined system, the performance is characterized by the technically feasible turbine inlet temperature, overall thermal efficiency, and the permissible NOx concentration in the exhaust gas, which depends on the operation variables such as equivalence ratio and ammonia crack ratio.

Keywords: Ammonia combustion, hydrogen combustion, ammonia cracking, combined cycle.

ICH2P14-OP140

A CRITICAL REVIEW OF HYDROGEN (H_2) FLOW ASSURANCE IN THE PRESENCE OF IMPURITIES

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The future of the oil and gas industry relies on the success of the current energy transition initiatives to net-zero carbon production through sustainability and alternative fuel production. In particular, we highlight the circular hydrogen (H_2) economy. To this end, Industries need to reduce the carbon footprint and create a sustainable flow assurance of the H_2 value chain from the production to the sequestration site. Hydrogen (H_2) generally flows as a gaseous phase. However, below its critical temperature of -240.17°C and 13 bar pressure, hydrogen can condense into a liquid phase. Below the critical point, the liquid phase of H_2 can coexist with the gas phase. One of the cost-effective transport options for H_2 is to use the existing natural gas (mainly CH_4) pipeline transportation. Due to the environmental and safety constraints, operating condition fluctuations, and thermodynamic phase changes with lengths, transporting H_2 alone in the existing natural gas pipelines is challenging. During transportation, H_2 poses safety threats due to its low molecular weight, low viscosity, rapid reaction kinetics with the transmission lines, and several flow assurance challenges such as embrittlement, leakage, high diffusivity, high-pressure drop, and cryogenic temperature effect. Due to these safety concerns, instead of transporting H_2 alone in the existing pipeline, lower fractions of H_2 are mixed with CH_4 at different proportions to transport this emission-free gas to the desired locations. Overcoming the flow assurance challenge involves careful pipeline design. The impact of pure and impure H_2 with CH_4 with different blending ratios as multiphase flow is still not well understood. In this study, we will conduct a systematic literature review on the transient multiphase flow behavior of pure and blended H_2 and its impact on flow assurance challenges.

Keywords: Hydrogen (H_2), natural gas transmission, blending, impurities, multiphase flow, flow assurance.

ICH2P14-OP141

EXPERIMENTAL AND NUMERICAL ANALYSES OF A CATHODE-SUPPORTED MONOLITHIC SOLID OXIDE ELECTROLYSIS CELL

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In recent years, power-to-gas technology has been in progress. Promising methods include steam electrolysis and co-electrolysis using solid oxide electrolysis cells (SOECs). We have developed a monolithic (honeycomb) electrolytic cell with a larger reactive area for unit volume than the conventional planar and tubular cells. The volumetric density of the fuel production rate can be significantly improved, leading to the development of compact and high performance steam electrolysis systems. This study addresses hydrogen production by steam electrolysis using an SOEC with a porous monolithic cathode support of Ni-YSZ. Current-voltage curves were measured, and we thereby develop and validate a three-dimensional finite element model to clarify the current and temperature distributions that are useful for the optimal design of practical monolithic cells.

Keywords: SOEC, porous honeycomb support, volumetric current density, multiphysics simulation, current and temperature distributions.

ICH2P14-OP142

OPTIMIZING GREEN HYDROGEN AND POWER GENERATION FROM URBAN SEWAGE SLUDGE IN THE STEEL INDUSTRY: A KERMAN CASE STUDY

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In this advanced study focusing on hydrogen production from sewage sludge at a steel industry (HYL III technology), a comprehensive analysis was conducted to determine the most effective technologies. The evaluation centered on green hydrogen production techniques, particularly emphasizing biomass gasification as a promising method considering environmental impacts and resource availability. Key technical results indicated that for simultaneous heat and power production, micro turbines exhibited an output power of 118.209 kW and a maximum annual electricity generation of 1.033 GW. In contrast, Stirling Motors achieved 178.67 kW and 1.55 GW, respectively. For hydrogen and synthesis gas production, the PSA (Pressure Swing Adsorption) technology showed a volumetric flow rate of 393.849 m^3/h and a mass flow rate of 480.354 kg/h for hydrogen, indicating high efficiency. The study's economic feasibility analysis revealed the microturbine with PSA unit as the most economically advantageous, primarily due to lower costs in biogas upgrading, coupled with higher profitability in electricity sales. This detailed investigation underscores the potential of utilizing sewage sludge for sustainable hydrogen production, aligning with regional environmental goals and industrial needs.

Keywords: Sewage sludge management, anaerobic digestion technology, combined heat and power, sustainable energy conversion, waste-to-energy technologies.

ICH2P14-OP143

STUDY OF LAMINAR BURNING SPEED CORRELATION' FOR AMMONIA-HYDROGEN FUELED MIXTURE

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The ammonia/hydrogen mixture is a potential fuel for achievement of zero-carbon emission in an internal combustion engine. Combustion modelling requires laminar burning speed' correlation. So, the author has established a regression for laminar burning speed of ammonia/hydrogen fueled mixture. The author has applied Duynslagher et al., Ottama et al. and Goldmann et al. mechanisms for simulation purpose of laminar burning speed (NH_3-H_2) and validation it with literature. The combustion speed was numerically analyzed under a wide range of operating conditions: an equivalence ratio (0.6 to 1.4), hydrogen fractions in ammonia fuel (0 to 100%), inlet temperatures (300 to 400 K) and inlet pressures (0.8 to 1.4 atm). The simulation results from best of the mechanisms was curve fitted to develop a correlation for laminar burning speed of ammonia/hydrogen fueled mixture. The squared regression is R^2=0.934 for laminar burning speed of ammonia/hydrogen fueled mixture.

ICH2P14-OP144

HYDROGEN PRODUCTION VIA STEAM REFORMING OF METHANOL (SRM) USING $Cu/ZnO/Al_2O_3$ CATALYST

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Steam reforming of methanol stands as a promising route for hydrogen production, with $Cu/ZnO/Al_2O_3$ catalysts playing a vital role in enhancing the process. This study explores the effect of catalyst synthesis method and catalyst composition on the physiochemical, morphological and thermal properties of catalyst and on catalytic performance for steam reforming of methanol (SRM). $Cu/ZnO/Al_2O_3$ catalysts were synthesized using coprecipitation, hydrothermal, and sol-gel methods, and characterized through X-ray diffraction (XRD), N_2-sorption, field emission scanning electron microscopy (FESEM), electron dispersive X-ray spectroscopy (EDX), thermogravimetric analysis (TGA), Fourier transform infrared spectroscopy (FTIR), temperature programmed reduction (TPR), N_2O chemisorption, and X-ray photoelectron spectroscopy (XPS). A coprecipitation method yielded a $Cu/ZnO/Al_2O_3$ catalyst with smaller particle size, better surficial morphology, uniform particles distribution, higher BET surface area, higher Cu^0 surface area, higher cu dispersion, and better Cu reducibility as compared to other synthesis methods. Performance evaluations revealed that the coprecipitated $Cu/ZnO/Al_2O_3$ catalyst displayed a superior methanol conversion and hydrogen yield, along with the lowest CO selectivity. A coprecipitation method was further investigated by varying Cu to Zn molar ratio, the results showed that the variation in Cu to Zn molar ratio had significant impact on characterization results and subsequently impact the catalytic performance for SRM.

Keywords: Steam reforming of methanol, hydrogen production, $Cu/ZnO/Al_2O_3$, catalyst synthesis, Cu to Zn ratio.

ICH2P14-OP145

HEAT TRANSFER OPTIMIZATION OF A METAL HYDRIDE TANK TARGETED TO IMPROVE HYDROGEN STORAGE PERFORMANCE

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In this study, the optimization of heat transfer in a metal hydride hydrogen tank to maximize hydrogen storage was investigated. A finite element model of a quarter tank was developed in COMSOL Multiphysics with parameterized geometry. The main objectives were to maximize stored hydrogen mass and minimize tank filling time while maintaining temperature uniformity within the tank. A design of experiments (DOE) approach was used with the key geometrical parameters. Compared to the base case, the hydride storage mass increased from 26.5 kg to 30.17 kg, and filling time reduced from over 1000 s to 450 s. This demonstrates the potential of optimizing heat transfer to improve metal hydride hydrogen storage performance. The model can be further improved by exploring different cooling designs and materials.

Keywords: Hydrogen storage, metal hydride hydrogen tank, Kriging optimisation, heat and mass transfer.

ICH2P14-OP146

ASSESSING THE POTENTIAL AND VIABILITY OF RENEWABLE METHANE AND HYDROGEN AS SUSTAINABLE ENERGY CARRIERS

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In the search for sustainable energy carriers, renewable methane and hydrogen emerge as potential contenders. This research endeavors to offer a combined perspective on both, focusing on energy efficiency and economic sustainability. Renewable methane is distinguished by its energy consumption rate of 31.4 kWh_e/kg, in stark contrast to the 62.3 kWh_e/kg recorded for green hydrogen. Such efficient metrics position renewable methane for quick integration into contemporary energy systems. Infrastructure-wise, renewable methane is further along, benefiting from a robust framework and a complementary regulatory environment. Conversely, despite its promise in specialized applications like marine transportation, renewable hydrogen demands more foundational investments. The economic viability of a renewable methane plant is examined over a 20-year projection. The net present value is tabulated at −$3,818,163, with an internal rate of return at −1%, indicating a challenging financial landscape. Yet, a sensitivity analysis elucidated the potential for change, notably, with methane's selling price as a critical determinant. Shifting prices above $2.1/kg could redirect the plant towards a positive economic trajectory. To summarize, while renewable methane's immediate energy efficiency and mature infrastructure render it a favourable short-term choice, the latent promise of renewable hydrogen and renewable methane technologies cannot be understated. Their widespread adoption hinges on strategic alignments, technological progress, and market adaptability. This study underscores the need for continual assessments, refining and harmonizing the attributes of each energy vector for a sustainable future.

Keywords: Renewable methane, hydrogen, energy efficiency, techno-economic analysis, economic viability.

ICH2P14-OP148

STATE-FLOW BASED ENERGY MANAGEMENT SYSTEM IN MICRO-GRID INCLUDING FUEL CELL

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An Energy Management System (EMS) is a crucial component in microgrids, responsible for optimizing the generation, storage, and consumption of energy. It ensures efficient utilization of available resources. However, State-flow modeling is a graphical programming approach used for designing control logic. It represents the system's behavior through states, transitions, and actions, providing a visual representation of the control strategy. A microgrid that is used in this study can operate independently or connect to the main grid. It typically includes distributed energy resources (DERs) such as solar panels, energy storage, and, in this case, a fuel cell. The State-Flow based Energy Management System aims to optimize energy-related decisions within the microgrid. This includes scheduling the operation of the fuel cell, managing energy storage, and coordinating with other sources. State-flow modeling allows for dynamic control of the microgrid. The system can adapt to changing conditions, such as fluctuations in energy demand, variations in renewable energy generation, or the availability of fuel for the fuel cell. The proposed approach has been simulated using MATLAB based on the investigation of the potential of State-flow as a supervisory controller. The developed system undergoes testing under different conditions to assess its performance and verify the design. In this test, the PV system serves as the primary energy source, while the energy storage system acts as a backup. The energy management system prioritizes supplying load demand from either the PV system or the fuel cell, with load shedding during peak hours. The obtained test results encourage the proposed approach based on State-Flow for enhancing the energy management system's performance.

Keywords: Energy management system, state-flow, micro-grid, fuel cell.

ICH2P14-OP149

SUSTAINABLE PROTON-EXCHANGE-MEMBRANE FUEL CELL (PEMFC) SYSTEM EXERGOECONOMIC ANALYSIS

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This study presents an exergoeconomic analysis of a sustainable energy generation system comprised of a hydrogen (H2) generation reactor using recyclable aluminum for water hydrolysis. The system is composed of a batch reactor for greenhouse gas-free hydrogen generation, a gas-liquid separator, a buffer tank, an air booster compressor, a low-pressure filter, a hydrogen storage tank, and a 5 kW proton membrane fuel cell stack. A mathematical model for hydrogen generation was conceived taking into consideration mass, energy, and exergy balance for transient state and experimentally validated. An exergoeconomic analysis was conducted to determine the cost of the experimental set up and the cost of the energy that it generates. The analysis revealed significant commercial and economic potential for the apparatus. Notably, the approach aids in mitigating adverse environmental effects associated with fossil fuel use, leveraging recycled aluminum—an abundant global waste. In essence, the herein sustainable, on-site production of green hydrogen places the hydrogen generation & fuel cell system technology in the category of a source of clean energy. Therefore, applicable to electric vehicles, electric ships and stationary fuel cells applications.

Keywords: Hydrogen generation, recycled aluminum, exergoeconomic analysis.

ICH2P14-OP150

DRIVING TOWARD HYDROGEN MOBILITY: A LIFE CYCLE COST ANALYSIS OF TRADITIONAL, ELECTRIC, AND HYDROGEN FUEL CELL VEHICLES IN QATAR

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Passenger vehicles in Qatar is the most used mean of transport of the country, which generates a large environmental footprint due to tailpipe emissions. Despite the introduction of a metro, tram system, and plans for electric buses, reliance on electrified transport may not be the most optimum, since the required energy is produced via hydrocarbon-based power plants. This study conducts a life cycle cost (LCC) analysis comparing traditional, electric, and hydrogen fuel cell buses and passenger vehicles. The assessment considers both environmental impacts, adjusted for a Qatar context using GREET, and the economic aspects of purchasing and operating these vehicles. As of current status; traditional vehicles exhibit the best LCC, followed by Electric and Hydrogen Fuel Cell Vehicles (HFCV). The study also explores the impact of specific factors, such as purchase price, and proposes policies to incentivize HFCV use. The findings reveal that, while implementing a 20% purchase price subsidy, HFCV's LCC becomes more competitive than EV's within seven years.

Keywords: Hydrogen fuel cell vehicle, life cycle cost, sustainable transport, alternative vehicles.

ICH2P14-OP151

REGENERATION ENERGY OPTIMISATION OF POST-COMBUSTION CO_2 CAPTURE (PCC) PROCESS BASED ON AMINE COMPOSITION USING ARTIFICIAL NEURAL NETWORK (ANN)

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The post-combustion CO_2 capture (PCC) process is largely appraised as being efficient for reducing CO_2 emissions generated from industrial processes. However, one of the most significant drawbacks of the process is its costly nature, attributed to the high energy required for the regeneration of used solvent. Thus, the energy efficiency of this process demands optimization. Such optimization may be achieved among others by Artificial Neural Network (ANN). In this work, we developed an ANN model used to optimize the solvent regeneration energy based on amine solvent composition. The model aims to provide real-time monitoring and optimization for the processes in post-combustion CO_2 capture (PCC) plants considering necessary operational parameters such as flue gas temperature, pressure, as well as amine composition and absorber solvent temperature. The model was developed using available data from literature for different amine compositions and concentrations. Of the total data, 10% was used for testing and 10% for validating with the rest for training. The obtained results showed that the Narrow Neural Network was able to generate energy requirements with a nearly perfect match between experimental and predicted values.

Keywords: CO_2 capture, artificial neural network, optimization, solvent, regeneration energy.

ICH2P14-OP152

DESIGN, DEVELOPMENT AND INVESTIGATION OF SOLAR-INTEGRATED CO-ELECTROLYSIS FOR METHANOL PRODUCTION

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H_2-rich syngas produced from the renewable-driven co-electrolysis of H_2O and CO_2 utilizing solid oxide electrolysis cells (SOEC) have gained huge attraction because of the efficient and high conversion rate. It further delivers opportunities to reduce global warming and CO_2 emissions by storing periodic renewable energies. Solar-integrated co-electrolysis of H_2O and CO_2 via SOEC is considered in the present study to produce H_2-ric syngas, which is used further for methanol synthesis after a series of heat exchangers and compressors. More specifically, parabolic dish solar collectors and photovoltaic modules deliver thermal energy and electricity to the SOEC, respectively. CO_2 from the industry is captured for co-electrolysis and mixed with steam at the inlet of SOEC. The proposed system is developed and modeled in an engineering equation solver, considering mass, energy, and exergy balance equations. The performance of the system is examined by varying certain influential parameters such as direct normal irradiance, heat exchanger effectiveness, current density, cell temperature, and pressure. The exergy destruction rate of the system components is investigated to find out the component with maximum irreversibility. In addition, the levelised cost of fuel and payback period of the system is calculated by economic analysis.

Keywords: Solid oxide electrolysis, H_2-rich syngas, methanol production, co-electrolysis, solar dish, photovoltaic.

ICH2P14-OP155

ENHANCING Ni-SUPPORTED CATALYSTS FOR EFFICIENT DRY REFORMING OF METHANE: EFFECTS OF HALLOYSITE NANOTUBULAR CLAY SURFACE ACTIVATION

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Dry reforming of methane has recently received wide attention due to its outstanding performance in the reduction and conversion of CH_4 and CO_2 to syngas (H_2 and CO). While Ni catalysts are cost-effective, their susceptibility to deactivation limits their efficiency. Halloysite nanotubular (HNT) clays are largely utilized in catalysis as a support for Ni, thanks to their abundancy, and low-cost. In this study, the surface of HNTs has been activated with acids (HNO_3 and H_2SO_4) and with alkalis (NaOH and Na_2CO_3 + $NaNO_3$) prior to Ni doping in order to assess the effects of support treatment on the stability, and activity of the catalyst. Nickel catalysts on raw HNT, acid-treated HNT, and alkali-treated HNT supports were prepared via wet impregnation method and extensively characterized using X-ray diffraction, BET surface area analysis, scanning electron microscopy, transmission electron microscopy, solid-state nuclear magnetic resonance, H_2-temprature programmed reduction, and CO_2-temperature programmed desorption. Results indicate structural changes in treated HNTs and uniform Ni distribution across supports. Notably, the molten salt-treated supports exhibited the highest CO_2 and CH_4 conversion rates, showcasing superior stability over a 24-hour period. This investigation highlights the significance of support treatment in improving catalyst activity and stability, crucial for efficient DRM processes.

Keywords: Hydrogen production, dry reforming of methane, Halloysite nanotube, clay treatment, gray hydrogen.

ICH2P14-OP156

AN ELECTROLYSER DESIGN FOR MEMBRANELESS ELECTROLYSIS BY USING 3D PRINTING

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This study presents a membraneless electrolysis system for hydrogen production. The system leverages fluidic forces to separate gases in electrochemical processes, offering an alternative to membrane separation. Membraneless electrolysis design is more tolerant to impurities in feed water, simplifying the process and reducing costs. The study introduces a unique electrolysis unit, where water is distributed between the anode and cathode through a specially designed layer. This layer, created using 3D printing technology with tough polylactic acid (PLA), ensures continuous flow and increased gas purity by preventing the mixing of oxygen and hydrogen gases. The system's performance, including electrochemical response and gas purity, was tested. Preliminary results show promising efficiency and scalability potential, despite challenges like ohmic losses and less efficient gas separation attributed to membraneless electrolysers compared to membrane systems. Current density of the system for 15% KOH solution was 100, 188, 318, 470 mA/cm^2 for 4V, 6V, 8V, and 10V, respectively.

Keywords: Hydrogen production, electrolysis, membraneless, 3D printing.

ICH2P14-OP157

POTENTIAL EVALUATION AND OPTIMIZATION OF EXOELECTROGENIC ACTIVITY OF *RHODOBACTER CAPSULATUS*: A SUSTAINABLE STRATEGY FOR BIOELECTRICITY PRODUCTION

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Photosynthetic microbial fuel cell (PMFC) is an emerging technology which can be used for generation of bioelectricity by oxidizing organic substrates. The exoelectrogenic ability of various microbes depends on their potential to export electrons out of their cells. Optimization of operational parameters are considered mandatory for overall efficiency improvement of microbial fuel cell. In current study, a low cost system of PMFC was designed to divert electrons from routine metabolism towards an electricity generation instead to harvest hydrogen gas. Later, the system was optimized further for inoculum size, pH and catholyte's salt concentration while using *Rhodobacter capsulatus* in anodic chamber in double chambered PMFC with salt bridge of potassium chloride (KCl). Response surface methodology (RSM) was used to determine optimized rate of electron flux in terms of voltages (V) and current (A) responses, while optical density at 660 nm for maximum voltage of 1.38 V was noted as 0.837 for 6 mM catholyte concentration, 150 ml inoculum size and 7 pH with corresponding values of 0.15 A of current. The optimized system reveals the possibility to set cost effective framework for bioenergy recovery and wastewater treatment by employing variety of indigenous exoelectrogenic microbes.

Keyword: Microbial fuel cell, *Rhodobacter capsulatus*, catholyte, photosynthetic microbial fuel cell.

ICH2P14-OP159

DEVELOPING A SUSTAINABLE PRODUCTION FRAMEWORK FOR GREEN HYDROGEN TO DECARBONIZE EXISTING INDUSTRIAL CLUSTERS

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Hydrogen as an alternative fuel for power generation has found paramount interest in recent years. In terms of mass, it is regarded as the element with the highest energy density. As the world is transitioning from carbon intensive energy to Green energy, researchers have been trying to find suitable technologies to aid in this process. Green hydrogen production from electrolysis is one such pathway to assure carbon neutrality. Proton exchange membrane (PEM) Electrolyzer integrated with solar energy helps in taking a step towards sustainability. As Water electrolysis requires deionized water to produce high purity hydrogen and oxygen, proposing an efficient treatment method to use treated sewage effluent that is otherwise dumped will help make this process more economical and circular. This paper outlines a framework for decarbonizing existing industrial clusters through the implementation of green hydrogen production, highlighting the potential of renewable sources to create positive change. A Techno economic analysis is done which explores various combinations of pretreatment technologies and energy sources to determine the most cost-effective and environmentally friendly approach for the production of green hydrogen. Three possible paths for water pretreatment: Reverse osmosis, Ultrafiltration, and Capacitive deionization and five potential paths for energy input selection: National grid, Photovoltaic, Concentrated Solar Power, Photovoltaic + National grid, and Concentrated Solar Power + National Grid are considered. It also looks into the carbon footprints, exergy analysis of different components of the system and scaling up opportunities in the future. Lastly, the sustainability assessment is carried out by utilizing the proper sustainability indicators, which encompass economic, energy, environmental, and material aspects, across the various alternative process designs.

Keywords: Green hydrogen, solar energy, water treatment, treated sewage effluent, PEM electrolyzer.

ICH2P14-OP160

ENERGY AND EXERGY ANALYSIS OF A FOUR-STEP COPPER CHLORINE CYCLE FOR ENHANCED EFFICIENCY AND PERFORMANCE

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With the onset of fourth Industrial revolution and rising demand for energy in the emerging economies, there is a strong need to develop new technologies that produce energy efficiently and more importantly using cleaner resources which do not add to growing climate change crisis in our world. Hydrogen has proved itself as a great alternative to oil and gas for producing clean energy. There are various new technologies for producing green hydrogen, one such technology is a thermochemical cycle. One of the most popular one is a Copper Chlorine (CuCl) cycle. In a four step CuCl thermochemical cycle thermolysis can occur at a temperature range of 450°C-530°C which makes it possible to use waste heat from power plants etc to produce clean hydrogen from CuCl cycle limiting the thermal pollution. In this paper using analytical methods energy and exergy analysis of Combined step (hydrolysis + thermolysis) has been performed. By employing analytical methods, the study sheds light on the thermodynamic performance of the Combined Step process, providing valuable insights into its energy utilization and efficiency. The findings from this research contribute to a deeper understanding of the energy conversion mechanisms and offer a foundation for optimizing the overall efficiency.

Keywords: Hydrogen production, thermochemical copper-chlorine cycle, exergy analysis, energy efficiency.

ICH2P14-OP162

THERMODYNAMIC EVALUATION OF A RENEWABLE ENERGY STORAGE CONCEPT INCORPORATING A SOLID OXIDE ELECTROLYZER AND METAL HYDRIDE COMPRESSOR

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Solid oxide electrolysis (SOE) can achieve remarkable efficiency by utilising significant amount of thermal energy. The present study introduces a Metal Hydride (MH) compressor to compress hydrogen generated by SOE. The integrated two-stage MH compressor in this study, effectively elevates H_2 pressure to 350 bar in two steps. The first stage increases the pressure up to 100 bar after which the hydrogen is partially taken for further compression. One half is further compressed to 350 bar whereas the another half can be used for power generation during high electrical energy demand. The compression up to 350 bar is achieved using a heat transfer fluid at approximately 140°C for heating and 20-40°C for cooling. Energy and exergy analysis of the overall system post the integration of the MH compression unit is assessed. The study delves into how critical operating parameters—such as operating temperature, current density, supply pressure, absorption, and heat source temperature—affect the system's energy and exergy efficiency. It was observed that under specific operating conditions, the energy efficiency of SOE alone is approximately 60.57%. This efficiency increases to 66.5% after the system is integrated to the MH compressor.

Keywords: Solid oxide electrolyser, hydrogen storage, metal hydride hydrogen compressor, energy and exergy investigation, thermodynamic assessment.

ICH2P14-OP163

SEAWATER DESALINATION AND HYDROGEN PRODUCTION USING MONOVALENT SELECTIVE MEMBRANES ASSISTED WITH ION-EXCHANGE RESINS FOR HYDROPONIC SOLUTION PRODUCTION

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The dual challenges of water scarcity and energy demand necessitate innovative and sustainable solutions. This study presents a novel integrated system that combines electrodialysis with monovalent selective membranes (ED-MSMs) and ion-exchange resins (IEX-R) to simultaneously produce hydrogen gas and nutrient-rich solution for plants while effectively mitigating membrane fouling, and electrode scaling caused by divalent ions. This integrated approach offers a promising strategy to address these critical challenges by utilizing seawater (SW), an abundant and readily available resource, as the feedstock for generating valuable products. ED-MSMs, characterized by their ability to selectively transport monovalent ions over multivalent ions, are employed to remove salt (NaCl) from seawater, effectively producing nutrient-rich solution. To further enhance the desalination process and ensure the production of a nutrient-rich hydroponic solution, IEX-Rs are strategically incorporated into the system. These resins are strategically positioned at the cathode electrode to selectively capture magnesium and calcium ions that may have leaked from the dilute stream to prevent membranes fouling and electrode scaling. Hydrogen gas is produced at the cathode side and captured in a measuring cylinder. The generated hydrogen, a clean and renewable energy carrier, can be utilized for various applications, including power generation, transportation, and industrial processes. The initial experimental results for the ED-MSMs process with IEX-R show a net energy consumption of 11.47 kWh/m^3 of SW, with a hydrogen production rate of 19.36 mmol/h. The proposed integrated system holds immense potential in addressing the pressing challenges of water scarcity and energy demand while promoting sustainable agriculture practices. By harnessing the power of ED-MSMs, and IERs, this system paves the way for a more sustainable and resource-efficient future.

Keywords: Hydrogen energy, ion-exchange resins, membranes fouling, sustainability.

ICH2P14-OP164

DECARBONIZING ASEAN BY 2050: FROM THE LENS OF A HYDROGEN ECONOMY

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Hydrogen is widely believed to be a promising vector for decarbonization, and the evolution of a hydrogen economy is a complex optimization problem. This study uses an in-house tool (Hydrogen Economy Assessment & Resource Tool, HEART) to find the minimal cost hydrogen roadmap for ASEAN to achieve net zero emissions by 2050. The region has surplus renewable electricity potential to produce green hydrogen even after meeting the total power demand. With realistic limits on the availability of biomass, it is not possible to meet the carbon emission reduction targets with hydrogen produced only from natural gas and biomass (with carbon capture and sequestration) beyond 2045, even if natural gas is unlimited. Optimal green hydrogen production locations in ASEAN include Myanmar and Cambodia, as they have the lowest renewables levelized cost of electricity (LCOE) in the region. Malaysia and Indonesia, although endowed with solar energy, use biomass resources or LNG for hydrogen production instead. This is due to relatively higher solar LCOE. ASEAN's hydrogen economy is expected to evolve from centralised in the early years to one that is decentralised in the later years, due to the large share of production cost of the total landed cost in the early years.

Keywords: Hydrogen supply-chain network, hydrogen economy, decarbonization.

ICH2P14-OP165

HYDROGEN GAS AND BIOCHAR PRODUCTION FROM KITCHEN WASTE VIA DARK FERMENTATION

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Kitchen waste is rich in valuable micro and macronutrients. When these substances are released directly into the natural environment, they can lead to various environmental issues. Recycling kitchen waste for agricultural purposes using different methods helps the economy by decreasing the demand for fertilizers. One of the nutrient recovery techniques involves employing the dark fermentation method to generate hydrogen gas, which serves as a clean energy carrier. The utilization of hydrogen gas as an energy source results in a reduction of the carbon footprint. In this research, the production of hydrogen gas from kitchen waste using the dark fermentation process is investigated. Parameters included waste composition, light intensity, and temperature control, enabling optimal hydrogen production. Various kitchen waste types, including vegetable waste and food remnants, are utilized to assess their effectiveness as substrates for hydrogen generation. The study also investigates the impact of pH levels and bacterial strains on the dark fermentation process. Additionally, biochar is produced by subjecting the solid residue at a temperature of 400 °C by pyrolysis process. The produced biochar is used as supporting material in hydroponic farming. The results of this study offer insights into a sustainable and environmentally friendly approach to managing kitchen waste, producing clean energy, and generating valuable biochar, thereby contributing to both waste reduction and economic growth.

Keywords: Hydrogen, biochar, dark fermentation, nutrient recovery, circular economy.

ICH2P14-OP171

NI-CU BIMETALLIC CATALYSTS FOR EFFECTIVE SYNGAS PRODUCTION VIA LOW-TEMPERATURE METHANE STEAM REFORMING

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In the present work, novel bi-metallic catalysts for syngas production at low temperature steam reforming are developed, characterised and tested. Steam methane reforming by using bi-metallic Ni-Cu catalysts found to balance the product of CO to CO_2 ratios, while affected the water gas shift reaction by increasing the hydrogen selectivity up to 600 °C. The addition of different amounts of Cu (3, 5, 7, 10 wt%) to the Ni catalyst for methane steam reforming showed different reactivity trends. One of the major outcomes of this work is the maximum load capacity of Cu (5wt.%Cu) to maintain the reactivity. For comparison purposes, mono-metallic catalysts of Cu and Ni were developed and tested along with the bi-metallic ones. The activity of the reaction decreased by doping more than 5wt.%Cu which affected the amount of hydrogen produced. This is related to the possible limited number of available sites required for hydrogen adsorption to maintain the reaction of methane steam reforming. Another important outcome of this work is the bi-metallic Ni-Cu catalysts did not decrease the amount of carbon formation.

Keywords*:* Bimetallic catalysts, steam methane reforming, heterogeneous catalysts, syngas generation, bimetallic Ni-Cu/Al_2O_3 catalyst.

ICH2P14-OP173

CIRCULAR ECONOMY OF INTEGRATING GREEN HYDROGEN PRODUCTION WITHIN AN ECO-INDUSTRY PARK

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More research is being focused on the concept of Circular Economy (CE) for evaluatingindustrial systems based on the principles of reducing the impacts of our activities on the environment and society by building resilient supply chains. CE is the continuous circular usage of material with zero discharge, where the value of product is maintained as long as possible. Sustainablity concept shares the the goal of minimizing discharge, however CE aims for a zero discharge. CE emphesises more on the circularity of streams within the process, it is evalauted based on reduce, reuse and recycle of in and out (material/energy) flow. Despite the growing interest of government and academia in CE, practical implementation in industrial systems is still missing. In this paper, we look to evaluate the CE impacts of integrating a green H2 production plant within an Eco-Industrial Park (EIP). The case study investigated has optimized the size of the green H2 plant to achieve varying decarbonization targets for EIP, and they determined the key technical, economics and environmental metrics. The CE evaluation compares three cases of EIP with and without an optimized Green H2 facility that is designed to meet 5% and 25% decarbonization targets. Eight different CE indicators that address social, economic and or environmental aspects are considered. The selected indicators were based on availability of process data and were constrained by the available databases that are required for their evaluation. Results of the study shows that integrating Green H2 production that uses wastewater and waste energy provides a higher connectance between the industries which means a higher material recycling rate and energy usage. The concept of reuse and recycle is highly promoted through CE concept, as wastewater is reuse is maximized for clean H2 production. The expected increase in production cost is managed by the profit generated from the by-product and emissions offset. The study will present more on CE analysis results and will highlight some of challenges faced in applying CE indicators.

Keywords: Circular economy, waste stream utilization, green hydrogen, de-carbonization.

ICH2P14-OP174

ELECTROCHEMCIAL CONVERSION OF CARBON DIOXIDE INTO FORMIC ACID AS HYDROGEN CARRIER: ROLE OF ANOLYTE

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Electrochemical reduction of carbon dioxide (CO_2) represents a sustainable and promising strategy for resolving the global warming issue. However, a number of challenges, such as large overpotential, electrode instability, and low Faradic efficiencies of the desired products, restrict the implementation of this method. The importance of the catalyst in the electrochemical conversion of CO_2 has led to the development of several materials that can meet these challenges. In order to solve the aforementioned challenges, this study focused on two aspects: the development of a metal-based catalyst and the role of the anolyte. The co-precipitation method was used to synthesize a metal-based catalyst. A straightforward technique was used to deposit the catalysts uniformly on the substrate electrode. A comprehensive characterization of the prepared nanometric materials (Pb-based) was conducted using SEM, EDX, XPS, XRD, and ICP. When compared to other electrodes, Pb-based catalysts show significantly greater faradaic efficiency in the electrochemical reduction of CO_2 to produce HCOOH (as a hydrogen carrier). The results indicated that the Pb-based catalyst played a pivotal role in enhancing the catalytic activity and selectivity towards formic acid (as a hydrogen carrier), and suitable anolyte enhanced the conversion performance by up to 30%.

Keywords: Electrochemical conversion, Pb-based catalyst, CO_2 reduction, role of anolyte, formic acid, hydrogen.

ICH2P14-OP176

FLOWSHEET SAFETY AND TECHNO-ECONOMIC ANALYSIS OF OPTIMUM AMMONIA AND UREA PRODUCTION ROUTE

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This research examines the pivotal role of urea in nitrogenous fertilizers within the context of escalating global food demand due to an anticipated population surpassing 9 billion by 2050. Addressing climate change concerns emanating from fossil fuel-dependent industrial practices. The indispensability of ammonia-urea in global agriculture is underscored, given its critical role in meeting rising food demand. However, conventional fertilizer production, reliant on fossil fuels, poses sustainability challenges. This research aims to comprehensively evaluate the significance of urea for global food security and conduct a comparative analysis of hydrocarbon-based ammonia-urea synthesis techniques, emphasizing techno-economic and safety considerations. The methodology involves meticulously comparing hydrocarbon-based synthesis techniques, focusing on optimizing downstream petrochemical industries, safety enhancement, environmental sustainability, and resource efficiency. Specific methods include early safety considerations, emission and waste reduction, processing unit streamlining, and optimization of raw material utilization. Anticipated outcomes encompass a detailed comparative analysis of hydrocarbon-based synthesis techniques, offering insights into economic efficiency, safety enhancement, and environmental sustainability. This research work presents a comparative approach for multiple HC-Ammonia-Urea production routes through techno-economic and safety analysis. All the studied process routes are commercially available and operated. The analysis is done using the built in capabilities of Aspen software through utilizing safety analysis, economic evaluation, environmental impact assessment and energy optimization techniques. The outcomes of Aspen simulations are used in optimization formulation to identify the optimum HC-Ammonia-Urea production routes achieving lowest environmental and safety concerns and highest economic profit. The utilization of these techniques would provide insights about the optimum production route early enough to ensure sustainable process design. The route optimization results indicated that the conventional technology of steam reforming has an attractive process and economic potential with inherently safer operation over partial oxidation technology. The steam reforming is coupled with nitrogen stripping unit as an optimum syngas purification option preferred over methanation and pressure swing adsorption options, and Toyo-ACES (Advanced Process for Cost and Energy Saving) process as the best urea production route selected against Stamicarbon, Snamprogetti and Avancore process technology options. The study further aims to provide a roadmap for transitioning towards sustainable practices in the fertilizer industry. This study holds value for future researchers by offering a comprehensive understanding of energy efficiency, process economics, and safety considerations. The demonstrated economic and utility savings through synthetic reforming, exemplified by Qatar's case, provide practical insights for industries seeking sustainable practices.

Keywords: Ammonia, urea, fertilizer, simulation, techno-economic analysis, optimization.

ICH2P14-OP177

SHADES OF SUSTAINABILITY: AN IN-DEPTH ANALYSIS OF THE DIRECT AND INDIRECT CARBON FOOTPRINT IN BLUE AMMONIA MANUFACTURING

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Integrating sustainability principles into the distribution network process poses a significant challenge for industries aiming to prosper in today's dynamic environment. This challenge is particularly pronounced in the fertilizer industry, given the crucial role of gas as a primary fuel source. Despite extensive research on the environmental implications of such endeavors, there is a noticeable gap in the literature on the life cycle assessment (LCA) of blue ammonia production and its associated processing units for environmental evaluation. This study addresses this gap by conducting the inaugural LCA of blue ammonia production, offering a comprehensive evaluation from the raw material processing stage to the final product. The analysis focuses on direct and indirect greenhouse gas emissions, including carbon dioxide, methane, and nitrous oxides. Notably, our life cycle model incorporates the Aspen HYSYS simulation, recognized for its precision in engineering and design contexts. The results shed light on the major contributors to carbon dioxide equivalent (CO2-eq) emissions, with blue ammonia production, particularly the Ammonia Synthesis Loop Unit, emerging as the primary source, yielding the highest direct carbon footprint. Subsequently, the Natural Gas Reforming Unit follows with contributions of 33.3% and 32.2%, respectively. Conversely, the Ammonia Synthesis Loop Unit is identified as the primary consumer of electrical energy, thereby emerging as the most significant contributor to indirect carbon footprint with a contribution of 66% compared to all other units in the Blue Ammonia process, mainly due to the high-pressure requirement. We propose an integrated framework model based on the insights derived from this study. This model establishes the foundation for a spectrum of sustainability strategies and policy recommendations aligned with broader business sustainability objectives.

Keywords: Life cycle assessment, blue ammonia, carbon footprint, sustainability, policymaking.

ICH2P14-OP178

TANK TO TANK LIFE CYCLE ASSESSMENT OF GREENHOUSE GAS EMISSION FROM METHANOL PLANT

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Integrating sustainability principles into the distribution network poses a significant challenge for industries aiming to flourish in today's dynamic environment and meet the UN sustainable development goals. This challenge becomes particularly crucial in the additive industry, where natural gas is the primary fuel source. Despite extensive research on the environmental implications of such initiatives, there is a noticeable literature gap concerning the life cycle assessment (LCA) of Methanol production and its associated supply chains regarding environmental evaluation. This research addresses this gap by conducting the first-ever LCA of Methanol production, offering a comprehensive evaluation of its performance from raw material processing to the final product. The LCA includes a particular analysis of both direct and indirect greenhouse gas (GHG) emissions, encompassing carbon dioxide, methane, and nitrous oxides. Significantly, our life cycle model incorporates the reliable Aspen HYSYS simulation, widely recognized for its precision in engineering and design applications. The findings shed light on the primary contributors to carbon dioxide equivalent (CO2-eq) emissions, known as Scope 1, pinpointing Methanol production, particularly the Methanol Synthesis Loop, as the predominant source with the highest carbon footprint at 61.1% of the overall direct carbon footprint. Conversely, the Methanol Purification Unit emerges as the leading contributor to Scope 2 GHG emissions, constituting 77.7% compared to other units in the Methanol production process chain, mainly due to the presence of high energy demand separation columns. Based on the insights garnered from this research, we propose an integrated framework model. This model forms the basis for various sustainability strategies and policy recommendations that align with the broader objectives of business sustainability.

Keywords: Life cycle assessment, methanol, greenhouse gas, sustainable development, policymaking.

ICH2P14-OP179

MODELING FOR MULTI-MECHANISMS PERMEABILITY OF HYDROGEN USING A MEMBRANE PROCESS

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Membranes used for gas separation are typically dense, characterized by permeability defined as the product of solubility and diffusivity. However, in microporous systems, especially under conditions like high temperature and in membranes with large pores, the Knudsen diffusion mechanism also becomes relevant. This study introduces a model that combines surface and pore permeabilities to predict permeation flux and selectivity during H2/N2 mixture separation. We explored how pore size and porosity influence both permeability mechanisms and their impact on membrane selectivity. Furthermore, the model was simplified to predict membrane permeability at various pressures without needing isotherm data, streamlining the process of assessing gas separation performance under different operational conditions.

Keywords: Membrane, permeation, hydrogen, Knudsen, pore.

ICH2P14-OP180

LIFE CYCLE ASSESSMENT OF A DIRECT AIR CAPTURE AND CO_2 UTILIZATION SYSTEM

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This paper consists of a comprehensive cradle-to-gate life cycle assessment (LCA) study focusing on the production of formic acid as a hydrogen carrier. Formic acid is produced by capturing carbon dioxide (CO_2) from indoor environments using an integrated Heating, Ventilation, and Air Conditioning (HVAC) – Direct Air Capture (DAC) unit. DAC is a pivotal technology, actively combating climate change by extracting CO_2 directly from the atmosphere. Integration of DAC units within HVAC systems leads to higher energy efficiency and improved indoor air quality. The LCA is conducted following ISO14040 standards using GaBi software. The research systematically evaluates the environmental impacts associated with the entire life cycle of formic acid production from HVAC-DAC-captured CO_2. The environmental impacts studied are climate change, freshwater eutrophication, ozone depletion, particulate matter formation, and water depletion for 1 kg formic acid produced respectively. As the paper unfolds the environmental advantages of formic acid production through DAC, it underscores the significance of this dual-purpose strategy, wherein the carbon captured from the air serves not only to combat climate change but also contributes to the development of sustainable hydrogen carriers. This study stands as a crucial contribution to advancing global efforts towards a more sustainable and carbon-neutral future.

Keywords: Climate change, formic acid, CCUS.

ICH2P14-OP182

A TECHNO-ECONOMIC ANALYSIS OF HYBRID SOLAR-WIND ENERGY SYSTEMS WITH HYDROGEN STORAGE FOR RESIDENTIAL COMMUNITIES

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In response to the escalating demand for sustainable energy solutions, this paper conducts a comprehensive techno-economic analysis of a hybrid solar-wind energy system integrated with hydrogen storage for residential communities. The study uses the HOMER software to explore the intricate interplay of key components: wind turbine, PV system, AEM electrolyzer, PEM fuel cell, converter, inverter, charge controller, battery storage systems, and hydrogen storage tank. The research examines the proposed hybrid system's techno-economic viability, efficiency, and reliability. The analysis considers the dynamic nature of energy demand and supply, incorporating real-world complexities. The study investigates key performance indicators, cost-benefit ratios, and financial feasibility, offering a holistic understanding of the economic implications. The research explores various geographical locations and meteorological conditions to determine optimal configurations based on the minimum cost of energy and net present cost. It compares the proposed hybrid system against grid extension options in different regions. This techno-economic analysis contributes valuable insights into the feasibility and economic implications of renewable energy integration for residential communities in Qatar. The research utilizes models and optimizes diverse system configurations, emphasizing the economic sustainability of hybrid renewable energy solutions.

Keywords: Economic feasibility analysis, energy sustainability, HOMER software modelling, renewable integration.

ICH2P14-OP183

COMPARATIVE THERMODYNAMIC ANALYSIS OF TWO GREEN FUEL PRODUCTION AND POWER GENERATION PATHWAYS

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This work presents a comparative novel evaluation of two distinct fuels (methanol and hydrogen) production and power generation routes (hydrogen and methanol fuel cells). The first route includes the methanol production from photocatalytic partial oxidation of methane to methanol at ambient conditions; the methanol will be condensed, stored, and sent to a direct methanol fuel cell. The second route is hydrogen production from solar methane cracking, where heat is supplied from concentrated solar power, and hydrogen is stored and directed to a hydrogen fuel cell. This study aims to provide valuable insights into their production conditions, method of storage, energy and exergy efficiencies. The proposed system is simulated on Engineering Equation Solver and a thermodynamic analysis of the entire system, including all the equipment and process streams, is performed.

Keywords: Methane photoconversion, methanol fuel cell, hydrogen fuel cell, hydrogen storage.

ICH2P14-OP184

FLEXIBLE NATURAL GAS ALLOCATION TO BLUE-HYDROGEN MONETISED PRODUCTS: AN AGENT-BASED MODELLING APPROACH

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With the increased demand for cleaner energy resources, natural gas is a bridging fuel for smoothening the transition to renewables. Syngas (hydrogen-rich stream) is a fundamental intermediate for different utilisation routes. The syngas can then be treated for pure hydrogen production or monetised into value-added products. Despite the estimated demand growth in product demand, each utilisation process is subject to exogenous market uncertainties. Hence, accounting for operational flexibility in the early design stages allows the producers to react proactively to market changes. This work evaluates the flexibility of natural gas utilisation to final hydrogen carriers: methanol, ammonia, urea, synthetic fuels, and ethylene by investigating plant design configurations and natural gas production allocation to different production routes. Aspen HYSYS is used for process modelling and simulation, followed by identifying each process's costs and operational flexibility. Simulation results and forecasted price and demand data are then used as input into an agent-based model to identify the optimal annual natural gas allocation to different processes subject to environmental and economic objectives. The preliminary results of Qatar's case study revealed the importance of prioritising GTL process to maximise profitability. In comparison, the production of ammonia and urea is maximised to reduce the environmental impact.

Keywords: Hydrogen-rich stream, hydrogen carrier, agent-based modelling, natural gas.

ICH2P14-OP187

OPTIMUM GREEN HYDROGEN PRODUCTION THROUGH BIOMASS FEEDSTOCK BLENDING

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Concerns surrounding global warming and the depletion of fossil fuels have motivated the international community to explore alternative, renewable energy sources. Biomass emerges as a nonconventional and renewable energy reservoir with the potential for sustainable heat and power production. The thermal gasification process serves as an effective means of converting and utilizing biomass, resulting in hydrogen-rich syngas as the product gas. This research delves into the intricacies of a biomass gasification process and its subsequent optimization, taking into account various parameters such as feedstock type and gasifying agent (gasifier) selection, with the aim of maximizing green hydrogen production. The study utilizes Aspen Plus software to develop three agent-based biomass gasification models tailored to the characteristics of specific materials from Qatar's built environment. The overarching objective is to optimize gasification processes to generate diverse biomass blending options, ensuring the maximization of green hydrogen production under different scenarios. The study employs the capabilities of the built-in activated analysis package through Aspen Energy Analyser and Aspen Process Economic Analyser to assess both environmental and economic perspectives. The findings underscore the efficacy of steam-only biomass gasification in producing profitable and environmentally friendly products. Specifically, the steam-only gasification yielded a high fraction of 5.23% in green hydrogen production from biomass blending. In contrast, the yield increased from 1.63% to 5.22% for oxygen/steam gasification when aiming to maximize the hydrogen fraction. Furthermore, selectively limiting biomass capacity was found to enhance syngas quality by enriching green hydrogen production, thereby reducing the need for subsequent adjustments and manipulation of gasifying agent quantity and operating energy.

Keywords: Green hydrogen, biomass, gasification, sustainability, optimization.

ICH2P14-OP189

BIOCATALYTIC CONVERSION OF LIGNOCELLULOSIC BIOMASS INTO BIOHYDROGEN VIA PHOTOFERMENTATION ROUTE

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Photofermentative hydrogen production from crop residue is pointing towards the use of low/no cost substrates as source of carbon. A comparative study on photofermentative biohydrogen production from potato starch, sugarcane bagasse and acid and enzymatically treated wheat straw was conducted by employing different species of purple non sulfur bacteria. Maximum hydrogen production yields of 580ml/L was produced by *Rhodopseudomonas palustris*-SS in potato starch, 483ml/L in sugarcane bagasse and 712ml/L in enzyme treated hydrolysate of wheat straw were obtained by *Rhodobacter capsulatus*-PK under light intensity of 120-150W/m^2. Maximum monosaccharide (glucose, arabinose and galactose) contents upto 12.6 g/L were obtained with 7% H_2SO_4 but maximum inhibitors (acetic acid, furfural and hyroxymethylfurfural) concentrations also appeared in it. After employing detoxified and non-detoxified acid treated (1-7% H_2SO_4) liquid hydrolysates of wheat straw yields ranged from 158 to 314 ml/L within 160 hrs of post-incubation. H_2 production in media containing acid treated hydrolysates of wheat straw remained limited probably due to the presence of inhibitors. Maximum substrate conversion yield of 6 moles of H_2/ mole of substrate was obtained for enzymatically treated hydrolysate of wheat straw. The one stage photofermentation system addressing crop residue appears promising as an alternative to two stage systems.

Keywords: Photofermentation, phototrophes, microbial hydrogen production.

ICH2P14-OP190

FEASIBILITY STUDY OF BACKING UP ENERGY SUPPLY FOR ELECTRIC CHARGING STATIONS WITH HYDROGEN INTEGRATION

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The smart grid is designed as an electric grid that can distribute electricity in a commanded, smart way from points of initiation to end consumers. Considering that electric cars will expand, the electricity required for their charging stations will impose a burden on the grid. The most important motivations for adding distributed energy resources to conventional power systems are government incentives to utilize green energy, concerns related to rising prices of fossil resources, and environmental matters. Installation of electric vehicle stations working with hydrogen fuel cells independent of the grid is possible. Regulating and Measuring Stations (RMS), which are in Natural gas networks, are suitable for electricity generation with the help of turbo expanders. Installing electrical charging stations near renewable energy power plants in convenient locations is possible. In an electrical charge station, hydrogen can be produced directly and can be stored for a short time and given to the fuel cell. Feasibility results for the small-scale pilot application are positive. This concept is also applicable across the world for fuel-cell cars.

Keywords: Electrical vehicle, hydrogen, smart grid.

ICH2P14-OP191

WIND POWER'S EVOLUTION: UNVEILING ADVANCES AND CHALLENGES IN THE QUEST FOR SUSTAINABLE ENERGY

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The global shift towards affordable, reliable, and clean energy sources aligns with the goals outlined in international climate change agreements such as the United Nations Framework Convention on Climate Change (UNFCCC), its Conferences of Parties (COP), the Kyoto Protocol, and the UN Sustainable Development Goals (SDGs). A pivotal player in this global transition is wind power, which plays also a central role in climate change mitigation efforts. The substantial growth in the global capacity of wind turbines over the past two decades positions wind energy as the fastest-growing renewable source on a worldwide scale. One particularly promising avenue within the realm of wind power is its application in green hydrogen production. This paper not only sheds light on the latest advancements and trends in wind energy but also explores its pivotal role in generating green hydrogen. By addressing persisting and emerging challenges within the wind energy sector, we underscore the significance of ongoing innovation and strategic planning to ensure the long-term viability of both wind power and its pivotal role in green hydrogen production.

Keywords: Wind turbine, reliability, sustainable hydrogen production, energy transition.

ICH2P14-OP193

STRATEGY OF TURKIYE ON HYDROGEN ENERGY

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In the light of regional and global developments and built on the topics of energy supply security, localization and predictable markets, "more domestic and more renewable" approach has been adopted and sustainability has been made a priority. In this context, the priority policy of Turkiye is to increase the share of our domestic and renewable energy resources in the energy portfolio by using more efficient, environmentally friendly, safe and domestic technologies with a sustainable understanding, thus reducing import costs in energy. For this purpose, it is important to diversify resources and localize this diversity while ensuring our country's energy supply security. Since it is known that the energy sector will be most affected by the climate change regime, our country is determined to use the energy resources effectively, efficiently and with the least impact on the environment, within the framework of sustainable development goals. Hydrogen has brought new energy to our country by increasing the share of production and use of renewable energy in Turkey, improving production, storage and usage technologies, reducing greenhouse gases in the heat sector by mixing it with existing natural gas lines, and allowing the use of domestic resources such as coal and boron. It will offer an export potential. However, Turkey has a large green hydrogen production potential due to its high renewable energy potential and lower renewable energy power plant installation costs compared to Europe. For this reason, it is evaluated that our country will be a strong player in the global hydrogen market.

Keywords: Sustainable, hydrogen, energy sector, strategy.

ICH2P14-OP194

PROTON EXCHANGE MEMBRANE BASED FUEL CELL GENERATION SYSTEM MODELING FOR POWER SYSTEM STUDIES

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This paper presents the modeling of Proton Exchange Membrane based Fuel Cell generation System (FCGS) for power system studies. The Fuel cell is modeled by considering its internal chemical reaction inside its cell and relations of fuel flow of its fuels. Power electronic Inverter utilizing IGBT as switching devices is model in details. The decouple power control technique is used for controlling the inverter. The performance of FCGS in adhering to requirement under steady state operation is investigated via simulation.

Keywords: Proton exchange membrane, fuel cell generation system, power system, distributed generation.

ICH2P14-OP195

OPTIMIZING GREEN HYDROGEN PRODUCTION IN THE GCC: A PILOT STUDY OF CAPACITY FACTOR ENHANCEMENT VIA TRANS-CONTINENTAL ENERGY IMPORTS

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This pilot study addresses a critical aspect of the green energy transition within the Gulf Cooperation Council (GCC) countries. Recognizing the variable nature of regional renewable energy resources, particularly solar and wind, this research explores the feasibility and potential benefits of importing renewable energy from diverse global sources to stabilize and augment green hydrogen production in the GCC. The study begins with a thorough analysis of the current renewable energy landscape in the GCC, identifying the limitations in capacity factors that challenge consistent hydrogen production. It then proposes a novel approach, wherein energy imports from strategically selected global partners can supplement local renewable energy, thereby increasing the overall efficiency and reliability of green hydrogen production. Key aspects of this approach include a detailed exploration of suitable energy import sources, logistical considerations, and the infrastructural requirements necessary for such an undertaking. The study also takes into account the economic, environmental, and technical feasibilities of this strategy, providing a comprehensive overview of its potential impact. As a pilot study, this research serves as a foundational exploration, setting the stage for more extensive future investigations. It aims to inform policymakers, industry stakeholders, and researchers about the viability of trans-continental energy imports as a strategic solution for enhancing green hydrogen production in the GCC. The findings of this study could play a pivotal role in shaping the future of sustainable energy in the region, contributing significantly to global efforts in combating climate change and promoting green energy initiatives.

ICH2P14-OP196

MATHEMATICAL MODELING OF A SUSTAINABLE ENERGY SYSTEM FOR RESTAURANT COMMUNITIES: WASTE-TO-H_2 CONVERSION, CO_2 MITIGATION, CLEAN FUEL PRODUCTION, AND POWER GENERATION

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In the world of sustainable energy, our project presents a comprehensive mathematical model for a sustainable energy system within a restaurant community. The restaurant community of 50 restaurants produces waste cooking oil on daily basis that is utilized for biodiesel production, providing power for the community, while the wasted food and other organic waste is processed in an anaerobic biogas digester to produce methane for community use. Additionally, Glycerol that is produced as a by product in the biodiesel plant is fed into a microbial fuel cell (MFC), resulting in the production of electricity, pure water and carbon dioxide. The community's waste water is used for hydrogen gas production through electrolysis. The Hydrogen gas produced is reacted with the carbon dioxide produced in the MFC, biogas digester, and that captured from atmosphere to produce methanol, which is then used in the production of biodiesel. The project also involves the deployment of a control system for increased efficiency. The mathematical modeling results demonstrate the potential for waste-to-H2 conversion, CO2 mitigation from environment, clean fuel production, and green power generation within the restaurant community. The mathematical model predicts and provide valuable insights into the advantages and environmental impact of utilizing restaurant waste for sustainable energy production.

Keywords: Sustainable energy, biodiesel, microbial fuel cell, electrolysis

ICH2P14-OP197

A NET-ZERO EMISSION SYSTEM WITH BIOGAS-FED SOLID OXIDE FUEL CELL FOR HYDROGEN PRODUCTION TO ADVANCE SUSTAINABILITY IN THE TEXTILE INDUSTRY

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Increased dependency on non-renewable energy-dependent processes and vast industrialization has led to a drastic increase in the release of greenhouse gases, with very few active efforts to control these emissions. Notably, the textile industry stands as one of Pakistan's largest sectors, generating substantial environmental concerns. In response to these challenges, this study presents an innovative approach by introducing a novel solid oxide fuel cell multigeneration system powered by biomass waste derived from a textile industry and feeding all its energy generation back into that industry, hence achieving net zero emissions. This model aims to reduce waste by limiting greenhouse gas emissions as it uses a renewable energy source as fuel. A biogas purifier is added to the system for eliminating waste by using low-value outputs from the biogas digester. Hydrogen, electricity, and methanol for the textile industry are produced simultaneously by the system, with heat recovery through a simple Rankine cycle for improving efficiency. This multigeneration system has been modelled in MATLAB Simulink to obtain optimized results for the industry. Control systems such as level and feedback controllers have been employed in this model to ensure that best performance is achieved.

Keywords: Hydrogen, solid oxide fuel cell, multigeneration, Rankine cycle, control systems.

ICH2P14-OP203

A REVIEW OF THE FEASIBILITY OF UTILISING HYDROGEN AS A MARINE FUEL IN AUSTRALIA

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The new targets of the IMO MEPC (80) include a 20% reduction in greenhouse gas (GHG) emissions by 2030, a 70% reduction by 2040 (compared to 2008 levels), and the ultimate goal of achieving net-zero emissions by 2050. The implementation of alternative fuels to conventional fossil-based fuels is key to decarbonising the global maritime and shipping industry. Green Hydrogen is currently one of the prime candidates among alternative shipping fuels, as it offers ship owners and operators a low-carbon and low-emission fuel option for potential use in internal combustion engines and fuel cells. However, there are several complex challenges concerning the adoption of green hydrogen in the Australian shipping industry (and elsewhere). This study examined the viability of utilising hydrogen as a power source for domestic vessels in Australia. It investigated the motivating factors driving the acceptance of hydrogen as a marine fuel, explored the existing and anticipated advancements in hydrogen-powered vessels, analysed the technological and economic considerations involved, evaluated the readiness of regulations and standards, and assessed the need for training. Additionally, the study identified specific vessel types that are well-suited for hydrogen adoption and provided a comprehensive overview of the safety design principles applicable to hydrogen-powered vessels.

Keywords: Green hydrogen, shipping industry, decarbonization, ships.

ICH2P14-OP205

PV-AWG-H_2: A POTENTIAL METHOD FOR SUSTAINABLE HYDROGEN PRODUCTION IN QATAR

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Due to climate change caused by greenhouse gas (GHG) emissions, the pressing demand for energy generation from renewable resources, as well as the increasing activities in the energy transition using alternative fuels, are driving significant progress in the research, development and implementation of new technologies. A key pillar of Qatar's national vision is energy diversification to achieve 20% of non-gas energy by 2030. Green hydrogen generated through water splitting using renewable energy stands out as a primary energy carrier in transitioning to a low-carbon economy. This research proposes an integrated solar-powered system of water and hydrogen production units. The system includes an Atmospheric Water Generating (AWG) unit utilizing hygroscopic materials is to address water supply and an electrolyser to produce green hydrogen. The study will first review existing literature, technological readiness, resource assessment, and evaluate the concept's feasibility, efficiency, and sustainability. Based on the initial findings and assessment, the PV-AWG-H2 concept can potentially enhance access to clean energy in Qatar where water sources are constrained. Furthermore, the utilization of renewable energy and the extraction of fresh water from the air for green hydrogen production is expected to have positive impacts on sustainability by minimising emissions and improving air quality.

Keywords: Green hydrogen, water supply, solar energy, Qatar's national vision, sustainable energy.

ICH2P14-OP211

INTEGRATED SMR SYSTEM FOR EFFICIENT HYDROGEN AND POWER PRODUCTION

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In this study, the conventional Steam Methane Reforming (SMR) process is integrated with Solid Oxide Fuel Cell (SOFC) for efficient production of hydrogen and electricity. The proposed integrated system uses SOFC to provide the heat requirement for the SMR while a portion of the hydrogen produced from the latter is used to produce electricity in the fuel cell. The high operating temperature provides high quality heat that can sufficiently cover heat requirement of the SMR. Furthermore, the performance of the currently proposed integrated system is compared with that of the conventional SMR process considering the energy and exergy efficiencies. In addition, the environmental factors such as the rates of carbon emission are considered. The results are highlighting an important alternative that can provide electricity in addition to hydrogen from conventional SMR reactors that are responsible for the largest share of hydrogen production compare to all other processes.

Keywords: Steam methane reforming, SOFC, hydrogen, exergy, energy.

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ICH2P14-PP005

EFFICIENCY HYDROGEN PRODUCTION VIA WATER PHOTOREDUCTION OVER FENPS ELABORATED VIA GREEN WAY

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The photocatalytic hydrogen production represents a fascinating way to convert and store solar energy as chemical energy, in the form of renewable hydrogen, the ideal fuel for the future. The novelty of the present work is using iron nanoparticles (FeNPs) prepared via green method using lemon peel. Green synthesis is an effective method more than traditional one, it provides a sustainable approach to nanomaterial manufacturing by using naturally sourced starting materials and relying on low energy processes. The hydrogen is produced via water photoreduction under visible irradiation using KOH and Na_2SO_4 electrolytes in the presence of hole scavanger. The obtained materials were characterized by XRD, TEM, SEM/EDX, FTIR, DRS, DSC/TGA and photoelectrochemical procedures that provided information about the synthesized materials which exhibited photocatalytic properties. The photo-catalytic properties of the materials were evaluated for hydrogen production through the water photo-reduction reaction and photoelectrochemical method. After 60 min of irradiation, the photo-catalysts exhibited a good photo-catalytic activity with hydrogen efficiencies more than 100 μmol/g.min with a photoconversion efficiency of 0.78 % which was much superior to FeNPs elaborated by other techniques.

Keywords: Hydrogen generation, photocatalysis, visible light, iron oxide, lemon peel, green synthesis.

ICH2P14-PP008

LONG-TERM ASSESSMENT OF HYDROGEN TECHNOLOGY DEPLOYMENT FOR LARGE SCALE DECARBONISATION OF POWER PRODUCTION

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At times of low renewable shares in the electrical grid, natural gas is the fuel of choice for power production in many countries. In a bid to further reduce carbon emissions, hydrogen from electrolysis and low-carbon production is an alternative for power production. While low-carbon hydrogen is more competitive in current market conditions, it is essential to take a long-term approach considering the impact of the potential influencing factors and carbon policies. Therefore, this study aims to evaluate the impact of gas prices on the future deployment of hydrogen production technologies to achieve strict emission targets. A cost optimisation model of a power system was developed based on electrical supply-demand balancing and gas balancing. Electricity generation from wind and solar technologies, gas turbines and fuel cells were included in the model. Hydrogen and batteries were the selected energy storage options. The sources of hydrogen were from electrolysers and the purchase of low-carbon hydrogen. Reducing the gas price from 50 to 35 EUR/MWh, reduced total electrolyser installations from 8 GW to 5.3 GW between 2023 and 2050. However, it did not impact short and mid-terms installations. The levelised electricity cost trends were influenced significantly, while the overall cost reduced by 6%.

Keywords: green hydrogen, electrolyser, decarbonisation, renewable energy, renewable gas.

ICH2P14-PP011

FIELD INVESTIGATION OF GREEN HYDROGEN PRODUCTION THROUGH THE PEM ELECTROLYZER IN OUARGLA CITY

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The search for new fuel types to replace fossil fuels has intensified in recent decades within the energy transition context. Moreover, green hydrogen has been classified as one of the most prominent environmental solutions to reduce greenhouse gas emissions due to its many advantages, especially cleanliness, and availability, where it is produced cleanly by electrolysis of water using renewable energy sources. Therefore, this paper presents an experimental study of solar hydrogen production through water electrolysis by indirect coupling between photovoltaic modules and PEM electrolyzer HG-60 at the Electrical Engineering Laboratory of Ouargla University, Algeria. In the first part, we present an experimental investigation of the performance of the system components. In contrast, we present in the second part an adaptation of the system by developing a program in the MATLAB environment to determine the energy potential and the hydrogen volume produced in the actual situation of the system and under the same experimental conditions. The most notable results indicated that the efficiency of the photovoltaic cells was 12.59 %, resulting in approximately 160,531 liters of hydrogen volume. While the system adaptation simulation results showed that the PV efficiency reached 13.5907 %, and the volume of hydrogen was 208.994 liters during the experiment periods from 09:47 to 16:30.

Keywords: Hydrogen production, photovoltaic, PEM electrolyzer, system adaptation, Ouargla region.

ICH2P14-PP012

COMPARATIVE STUDY BETWEEN GBO AND BES OPTIMIZATION ALGORITHMS FOR OPTIMAL PEMFC PARAMETERS IDENTIFICATION

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There is an increasing trend for fuel cell systems applications in electricity generation systems instead of traditional power generation systems because of their advantages, such as high efficiency, almost no environmental pollution, desirable dynamic response, and reliability. Moreover, the functioning of fuel cells necessitates understanding the different phenomena and their properties based on specific mathematical models. So, in order to deliver a reliable simulation of the properties of a fuel cell system, accurate parameter estimation of the fuel cell model is a crucial step. Due to this reason, a comparative investigation between two robust methods, the Gradient-based Optimizer, and Bald Eagle Search Algorithm, has been presented for the optimum unknown parameters identification of the Proton Exchange Membrane fuel cell (Heliocentris FC-50). The primary concept is to lessen the mean absolute bias error (MABE) amount of the observed output voltage and the output voltage of the PEMFC stack by those algorithms. The achievements show that although the algorithms were close, in contrast, the GBO algorithm gives a better superiority than the BES for optimum estimation of the PEMFC model, where the best fitness was recorded with the GBO at 0.036796, compared to 0.036837 with the BES. Also, the GBO has generated the minimum error values in all statistical tests and the lowest deviation with 0.001323 and 0.007040 for the BES algorithm. These results indicate that the GBO method is more stable and robust for PEM fuel cell parameter extraction.

Keywords: PEM fuel Cell, parameters identification, gradient-based optimizer, bald eagle search algorithm, statistical test.

ICH2P14-PP013

USE OF REFINERY OFF GAS (ROG) AS CO_2 EMISSION REDUCTION AND NATURAL GAS (NG) SAVINGS IN HYDROGEN (H_2) PRODUCTION

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In recent years, stricter regulations regarding the presence of pollutants in gasoline and diesel have significantly increased the consumption of hydrogen. This is due to a greater severity in the hydrotreatment processes where hydrogen plays a fundamental role, not only to reduce the amount of sulfur present to the desired values, but also to increase the duration of the run due to the effect of higher precision partial on the catalytic bed. Everything mentioned above makes hydrogen a critical and expensive input for Refineries. In the present work, mainly it is explored how, in theory, to use the Refinery off Gas (ROG) in a Steam Methane Reforming (SMR) in order to recover the hydrogen contained in it and reform the remaining hydrocarbons. Possible difficulties offered by this technique and how to solve them are shown. On the other hand, the main operating variables obtained experimentally, their evolution over time and the meaning of their variations are analyzed. Using natural gas (NG) and different ROG / NG ratios as feed to the SMR. This technique is very attractive, due to the low cost of ROG compared to other raw materials. In addition, and no less important, it reduces emissions.

Keywords: Hydrogen, SMR, ROG, recovery.

ICH2P14-PP014

INVESTIGATING THE EFFECT OF USING HYDROGEN AS A FUEL ON PERFORMANCES OF GAS TURBINE OPERATING AT LEAN CONDITION IN SITE OF HASSI R'MEL

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Green hydrogen is emerging today as a necessary energy solution to ensure the sustainability of energy resources and to reduce carbon footprint. Electricity production in Algeria is mainly based on gas turbines, therefore the use of green hydrogen, produced from solar sources, in gas turbine is a way to support an efficient transformation of the Algerian energy supply, which is almost exclusively based on natural gas and oil. The aim of this study is to assess the influence of using hydrogen as fuel on the performance of the TG-M5002C gas turbine operating under the specific climatic conditions of the Saharan region. To achieve this goal, a numerical study using THERMOPTIM software was developed to assess the influence of the monthly ambient temperature variations throughout the year on the performance of both natural gas and hydrogen gas turbines, operating at lean conditions with $\lambda=4.5$, under the climatic conditions of the Hassi R'mel gas site. The results have proven the capability of hydrogen as a fuel to improve thermal efficiency, reduce fuel consumption, and decrease pollutant emissions, regardless of the climatic conditions of operation.

Keywords: Hydrogen fuel, gas turbine, excess air ratio, performances, pollutant emissions.

ICH2P14-PP015

SORPTION PROPERTIES OF BALL-MILLED POROUS SILICON FOR HYDROGEN STORAGE UP TO 80 BAR

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Hydrogen is emerging as a potential energy carrier candidate for cost-effective, clean, and sustainable practices, ultimately contributing towards economic security. Though solid-state hydrogen storage using metal and complex hydride is an attractive storage solution, it operates at high temperatures (>400 ℃) and exhibits slow reaction kinetics. Due to high surface energy and hydrogen affinity, using porous materials (e.g., carbon nanostructures, MOFs, zeolites, and porous polymers) is an alternative approach. However, cryogenic temperature operation and insignificant storage at ambient conditions (due to poor surface coverage) are major demerits of these porous materials. This work proposes an intermediate solution to use Ball-milled Porous Silicon (BMPS) and is focused on studying its structure and physical characteristics during pre- and post-hydrogenation. BMPS surpasses the US DOE target to achieve a storage capacity of 10.7 wt.% at 80 bar and 120 °C. XPS studies the surface states and Si hydride bonding. The effect of nanostructuring on decomposition energy is observed by differential scanning calorimetry. Reduced particle and crystallite size, analyzed by XRD and Raman spectroscopy, expose nano-pores to hydrogen. The exposure improves storage capacity in both free and surface-attached forms, making BMPS attractive for reversible storage applications.

Keywords: Solid-state storage, adsorption thermodynamic, isosteric heat, nano-crystallite size, decomposition, energy.

ICH2P14-PP016

EVALUATION OF SYNERGISTIC INTEGRATION OF NICKEL, POROUS SILICON, AND THERMALLY REDUCED GRAPHENE OXIDE FOR HYDROGEN STORAGE

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Solid-state hydrogen storage by metal hydrides is a potential way to achieve high storage capacities; yet, high-temperature operations (>400°C), heat exchange issues, and exothermic formation process are major drawbacks. Under this perspective, adsorption on porous materials emerges as a viable solution to address these challenges. Carbon nanostructures (such as graphene and graphene oxide (GO) based derivatives) are adequate for hydrogen storage due to their lightweight, low density, and large surface area. However, the poor storage capacity of carbon nanostructures under ambient conditions is the major bottleneck for practical applications. Using a cost-effective transition element like Nickel as a catalyst holds significant potential for storing hydrogen in atomic and molecular forms, invoking the spillover mechanism. The porous silicon (PS) acts as a stabilizer when decorated on thermally reduced GO (TrGO). PS modifies the surface properties of the graphene sheets and attracts hydrogen toward the surface. The current work evaluates a composition of TrGO, PS, and Ni, synthesized to take advantage of individual properties for hydrogen storage. Field-emission scanning electron microscopy investigates the sheet structure of TrGO and the incorporation of PS and Ni onto its surface. The presence of various phases in the composition is identified using X-ray diffraction. Raman spectroscopy quantifies the degree of disorder in the composition. The pressure-composition isotherms indicate hydrogen storage capacities of 6.53 wt.% and 2.43 wt.% for TrGO-PS and TrGO-PS-Ni compositions, respectively. Even though the wt.% of TrGO-PS-Ni decreases due to the higher Ni weight, dissociation improves the adsorption rate from 0.35 wt.% hr^{-1} to 0.53 wt.% hr^{-1}.

Keywords: Pressure composition isotherm, Isosteric heat energy, catalytic effect, thermodynamic stability, adsorption rate.

ICH2P14-PP028

RECENT ADVANCES IN GREEN SYNTHESIS OF CU_2O AS A PHOTOCATALYST FOR CONVERSION OF SOLAR ENERGY INTO H_2

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Massive consumption of carbon-based fuels has triggered an explosion of greenhouse gas emissions into the environment, causing catastrophic consequences, such as global warming, melting glaciers, sea level rise and ecological imbalance. Therefore, the development of clean and renewable energy is of great importance to maintain energy supply and curb environmental pollution. Within the types of clean energy, solar energy is a clean and durable energy, which can be harnessed through photocatalysis technology that has made advances in H_2O splitting, CO_2 reduction, pollutant degradation, air purification, antibacterial properties, which is gradually becoming an important way to solve energy and environmental problems. The strategy for the development of green synthesis in recent years has provided a new perspective through the use of a solvent system compatible with the environment as ecological reducing and stabilizing agents. The Cu_2O (cuprous oxide), is a semiconductor material with a medium forbidden band gap of 2.10 eV and has potential to reduce CO_2 to CO or CH_4 and H_2 production. It is also a material that efficiently absorbs the visible range of the solar spectrum. The Cu_2O synthesized by a green mechanism exhibited a photocatalytic hydrogen yield of 1303.0 μmol/g, due to its unique properties having photocatalytic application in energy conversion in the generation of H_2.

Keywords: Cu_2O, hydrogen, green synthesis.

ICH2P14-PP030

EFFECT OF SCALE-UP IN MEMBRANELESS MICROBIAL ELECTROLYSIS CELLS ON HYDROGEN PRODUCTION

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Microbial electrolysis cells (MEC) are a bioelectrochemical system to produce hydrogen by transforming organic matter present in wastewater with the help of microorganisms. This is a promising technology, however, it has several challenges to solve such as: the decrease in the supplied potential, electrode material and the scaling of the technology. In this study two microbial electrolysis cells (MEC) were built, the first one with a chamber with a capacity of 160 mL for a pair of electrodes. The second, a multi-chamber cell with a 1 L capacity, for three pairs of electrodes. In the first cell, anodes with geometric areas of 2 cm^2 (A) and 5 cm^2 (B) were tested. In the second cell, anodes with areas of 9 cm^2 (C) and 27 cm^2 (D) were used. Batch and semibatch tests were carried out using two organic loads of 1500 and 2000 mgCOD/L. Using cyclic voltammetry (CV) data obtained it was calculated the rate of electron transfer (K_{app}). The hydrogen production rate (Q_{H2}) and COD (chemical oxygen demand) removal percentages (RCOD) were also evaluated. By increasing the area in the anodes up to 27 cm^2 and the use of a multi-chamber cell, a K_{app} of 0.84 s^{-1}, Q_{H2} of 0.35 m^3/m^3d, Rc of 51% and RCOD of 71% were achieved.

Keywords: Hydrogen, MEC, electrodes.

ICH2P14-PP055

FORCED CONVECTION IN POROUS MEDIUM USING TRIPLY PERIODICAL MINIMUM SURFACES: EXPERIMENTAL AND NUMERICAL APPROACH

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Hydrogen storage in depleted oil and gas fields is suggested as means to overcome imbalances between supply and demand in the renewable energy sector. Recent development in the 3D printing of metals is attracting many researchers and engineers. Tailoring a porous structure using triply periodic minimum surfaces is becoming an excellent approach for cooling electronic equipment. The availability of metallic 3D printing encouraged researchers to study cooling systems using porous media. In the present article, we designed a porous structure using a gyroid model produced using 3D printing. A porous aluminum has a 0.7, 0.8 and 0.9 porosity, respectively. The porous medium is tested experimentally using distilled fluid as the cooling liquid, while the structure is subject to bottom heating with a heat flux of 30,000 W/m^2. Different inlet velocity from 0.05 m/s to 0.25 m/s is applied. On the numerical side, the porous medium is modelled as a porous structure, and only the Navier-Stokes equations and the energy equation were solved using the finite element technique. Besides an excellent agreement between experimental measurement and numerical calculation, an optimum porosity of 0.8 is obtained. The performance evaluation criterion led us to believe that pressure drop plays a significant role in heat enhancement for this type of gyroid structure. As the porosity increases, the boundary layer becomes more noticeable.

Keywords: TPMS, gyroid, porous medium, porosity, forced convection, water, hydrogen storage.

ICH2P14-PP066

HYDROGEN PROTECTION OF THE MECHANICAL PROPERTIES AND ELECTROCHEMICAL EFFECTS BY BIO-CORROSION INHIBITORS ON CARBON STEEL IN THE PRESENCE OF AGGRESSIVE MEDIA

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Corrosion of metals is an electrochemical degradation of these materials under the oxidizing influence of their environment. The use of inhibitors is the most practical method for protecting metals against corrosion and hydrogen embrittlement. Our work is focused on the study of the corrosion inhibiting efficiency of A60 carbon steel in an aggressive environment in the presence of hydrogen. By attempting to determine the inhibitory effect of organic fig leaf oil extract. The effect of time and the addition of green inhibitor in 1 M HCl on impact resistance is studied. Green inhibitor concentration of 5, 10 and 15% is produced by natural plant compound extract. V and U notch Charpy specimens are fabricated where they are immersed and then subjected to high velocity impact with an energy of 150 J. The green inhibitor concentration of 10% resulted in optimum properties.

Keywords: Hydrogen, green inhibitor, carbon steel, protection.

ICH2P14-PP068

HYDROGEN SULFIDE H_2S – FOR THE SERVICE OF HUMANITY!

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The main provisions of the recently developed concept of the crucial role of catalysts in the process of low-temperature decomposition of H_2S to produce hydrogen and elemental sulfur are considered. The concept is based on the non-equilibrium thermodynamics of an irreversible process in an open system. Within the framework of this concept, the prospect of using H_2S to solve many scientific and practical problems in the field of chemistry, ecology, energy and economics is analyzed. In particular, one of the most urgent problems is the replacement of the long-outdated technology for the disposal of toxic H_2S by the Claus method with an environmentally safe, highly efficient low-temperature catalytic technology for producing hydrogen from H_2S with an H_2S conversion of up to 100%. This technology will allow obtaining an additional more than 5% hydrogen to existing needs without involving additional H_2S sources in processing. The developed paradigm of catalytic processing of H_2S allows realizing for unexpected chemical reactions that cannot be carried out by traditional methods under normal conditions. First of all, we are talking about the atomic species of hydrogen and sulfur obtained as a result of the H_2S dissociation on the surface of solid catalysts at room temperature. It is shown that atomic hydrogen interacts on the catalyst surface with chemically inert nitrogen and argon molecules to form chemical compounds stable under normal conditions. It is concluded that at present all the prerequisites have been created for initiating full-scale scientific, technological and commercial projects to implement the innovative idea of using the toxic substance H_2S to serve Humanity. Today we have a unique opportunity to use the "gift" of Nature to solve scientific and technological problems that cannot be implemented within the existing paradigm of H_2S processing. A qualitative shift to a new paradigm of the science of catalysis can be achieved if we direct our efforts to create "man-made" irreversible catalytic processes operating under thermodynamically non-equilibrium conditions characteristic of all biological processes.

Keywords: H_2S decomposition, hydrogen production, solid catalysts, non-equilibrium thermodynamics, alternative renewable energy source.

ICH2P14-PP075

MODELING OF HYDROGEN LIQUIFACTION PROCESS PARAMETERS USING ADVANCED ARTIFICIAL INTELLIGENCE TECHNIQUE

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The main subject of this work is the application of advanced Artificial intelligence (AI) techniques to predict with accuracy hydrogen liquefaction process parameters. This technique is carried out using a hybrid method based on Neuro fuzzy systems and particle swarm optimization. The training and validation strategy has been focused on the use of a validation agreement vector, determined from linear regression analysis of the predicted versus experimental outputs, as an indication of the predictive ability of the ANFIS model. The modelling strategy is performed using the temperature, pressure, and the mass flowrate as inputs parameters and the stream energy as output parameters. Statistical analysis of the predictability of the optimized ANFIS model shows excellent agreement with a previous research study (coefficient of correlation equal to 0.9988). Also, the comparison between estimated and the referenced values is carried out using average absolute relative deviation objective function (AARD) and shows a high predictive ability of the conceived model with global deviation equal to 1%.

Keywords: Modelling, hydrogen liquefaction process, ANFIS, PSO, optimization.

ICH2P14-PP101

$La_{0.6}Sr_{0.4}Co_{0.2}Fe_{0.8}O_{3-\delta}$ (LSCF) CATHODE SUPPORTED ON GADOLINIUM-DOPED CERIA ELECTROLYTE PREPARED BY SCREEN-PRINTING METHOD AND PERFORMANCES EVALUATION AS SOLID OXIDE FUEL CELL AT INTERMEDIATE TEMPERATURE

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Operating temperature is the main drawback of materials involved in Solid Oxide Fuel cells (SOFC)/ Electrolysis (SOEC) and several fabrication methods have been followed targeting higher material stability with improved ionic conductivity and reduced costs. Compared to state of art Ceria-based electrolytes, Gadolinia-doped ceria (GDC), offer higher conductivity while reducing polarization resistance, making GDC suitable for intermediate-temperature SOFCs. On the other hand, screen printing was reported among the cost-effective methods for preparing planar electrodes/electrolytes for SOFC/SOEC technologies. This method was adopted, in the present work, for fabrication of planar electrodes and electrolytes assembled as single cells that were tested in our laboratory using a setup equipped with impedance measurements built by Fiaxell® company. Hence, single cell with an active area about 1.54 cm^2 and a thickness of 0.32 mm, was obtained using a dense GDC electrolyte deposited on a support mixture based on NiO and GDC (anode). The latter was assembled with a cathode based on $La_{0.6}$ $Sr_{0.4}$ $Co_{0.2}$ $Fe_{0.8}$ $O_{3-\delta}$ (LSCF) prepared following screen-printing method and sintered at 1100°C for 2 h. This single cell was tested under fuel cell mode at 700°C using a hydrogen and air flows of 100 ml min^{-1} and 420 ml min^{-1}, respectively. Thus, the as prepared fuel cell involving GDC electrolyte permitted an open circuit voltage of 0.943 V while achieving a maximum power density of 900.36 mW cm^{-2}. Furthermore, these result allowed determination of GDC electrolyte conductivity value about 6.1×10^{-2} S cm^{-1} at 700°C and the cell performances remains without any significant change during 6 hours under the aforementioned operating conditions. Note that these electrical properties are higher than those obtained with traditional SOFC electrolytes typically used under similar intermediate-temperature.

Keywords: Solid oxide fuel cell, GDC electrolyte, screen-printing, electrochemical performances.

ICH2P14-PP105

NEURAL NETWORK FOR THE PREDICTION OF BIOHYDROGEN PRODUCTION DURING DARK WASTE ORGANIC BIOMASS FERMENTATION

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This project explores cutting-edge technologies and biohydrogen production by dark fermentation of organic biomass waste. The study uses Neural Networks to forecast biohydrogen production during dark waste organic biomass fermentation. Neural Networks, a type of artificial intelligence, are used to improve biohydrogen production prediction. Advanced computational algorithms evaluate complex fermentation patterns to accurately predict hydrogen gas production. This novel approach improves our understanding of the mechanics and opens new avenues for biohydrogen production optimization. Our study has advanced by incorporating Neural Networks to investigate the complex interaction between substrate composition, microbial behavior, and environmental circumstances. We use artificial intelligence to gain insights that could transform biohydrogen production. Our holistic approach, combining conventional research methodologies with cutting-edge technology, supports sustainable energy solutions. We want to improve biohydrogen production efficiency, sustainability, and environmental impact by merging scientific expertise with cutting-edge computational methods. This integrative method is a scientific breakthrough and a step toward a greener, more sustainable future.

ICH2P14-PP108

HYDROGEN ADSORPTION CHARACTERISTICS OF ACTIVATED CARBON DERIVED FROM PRICKLY PEAR SEED CAKE

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In this study, we investigate the hydrogen adsorption behavior on activated carbons at pressures up to 100 bars and a temperature of 298 K. The activated carbons are produced by activating Prickly Pear Seed Cake with phosphoric acid, with different impregnation ratios, producing a range of activated carbons with distinct porosities. These activated carbons uniformly exhibit microporous structures and demonstrate consistent adsorption properties. The hydrogen adsorption exhibits complete reversibility and rapid kinetics, indicating a predominantly physical adsorption mechanism. Notably, a linear correlation between hydrogen adsorption capacity and pressure is observed across all samples, irrespective of their porosity variations. The hydrogen adsorption capacities display linear relationships with key porosity parameters, including specific surface area, micropore surface area, total pore volume, and micropore volume. Remarkably, these materials achieve a maximum hydrogen adsorption capacity of 0.82 wt.% at 100 bars and 298 K.

Keywords: Activated carbon; hydrogen adsorption; prickly pear seed cake; adsorption efficiency.

ICH2P14-PP114

PHOTOCATALYTIC HYDROGEN GENERATION FROM SEAWATER USING HIGH-PERFORMANCE POLYMERIC MATERIALS

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Recently, there has been renewed interest in the use of solar energy as a resource to meet the world's energy needs in an environmentally sustainable way. Hence, our research focuses on the generation of hydrogen from non-fresh water using the sun as an energy source. The research aims to characterize, assess, and developed new research-grade materials and commercial photocatalysts that can achieve sunlight-driven unassisted photo-splitting of water. In this work, novel conjugated polymer nanoparticles were developed and characterized. The nanoparticles are composed of a donor-acceptor system where two acceptors, which were acceptor-1 (A1) and acceptor-2 (A2), were developed and tested, and different ratios of each donor-acceptor system were assessed. The use of platinum or molybdenum as co-catalysts was explored. Hydrogen evolution reactions with ascorbic acid as sacrificial reagent was performed using these materials and their performance was assessed. The results show that the first system consisting of acceptor-1 and the donor (A1/D) produce more hydrogen than the (A2/D) system. Furthermore, the best ratio of donor: acceptor was determined to be 10:90 for the (A1/D) system. The use of platinum as a co-catalyst was shown to result in a better performance in terms of hydrogen production compared to the use of molybdenum. Furthermore, the results show that the use of nanoparticles suspended in solution results in a higher hydrogen evolution rate compared to the use of films. Hydrogen production of 2018 micromole per gram of catalyst per hour was achieved using the A1/D nanoparticle system with platinum.

ICH2P14-PP117

REDOX REGULATION OF HYDROGEN PRODUCTION IN *ESCHERICHIA COLI* DURING GROWTH ON BYPRODUCTS OF THE WINE INDUSTRY

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Lignocellulosic wine grape waste (WGW) is considered a suitable medium for *Escherichia coli* growth and H_2 production. Growth, H_2 production, and redox potential (ORP) kinetics of *E. coli* BW25113 wild type were investigated upon utilization of WGW, pH 7.5. ORP and H_2 production of bacterial cultures were studied with the platinum (Pt) and titanium-silicate (Ti-Si) redox electrodes. Physicochemical pretreatment of 4 % WGW was performed using 0.4 % H_2SO_4, at 121 °C. K_2HPO_4 and KOH were used for the pH adjustment of the media. The significant decrease of readings of Pt electrode from positive up to low negative (-440 to -560 mV) values has been measured after 24 h, which indicates H_2 production during bacterial growth in both 2- and 4-fold diluted WGW mediums. Compared to the non-diluted WGW medium, 1.2-fold higher (2.14±0.07 mmol L^{-1}) H_2 yield was observed in a 2-fold diluted medium. Less acidification, prolonged H_2 production, and high biomass formation (OD_{600},1.5) were observed in a 2-fold diluted medium after 48 h when K_2HPO_4 was used for pH adjustment. It has been suggested that the environmental ORP could influence bacterial metabolism. The redox reagent dithiothreitol (DTT) was found to enhance the growth and H_2 production of *E. coli* BW25113 wild type when investigating 2-fold diluted hydrolysates of WGW at pH 7.5. H_2 production was observed starting from the 24th hour of growth, reaching a maximum yield of 5.10 ± 0.02 mmol/L, and continued until the stationary growth phase (48h). However, when the bacterial growth included 3 mM DTT, H_2 production was evident from the 1st hour of growth, indicating both H_2 production and the stimulatory effect of DTT on hydrogenases. The obtained results point out the importance of the high buffering capacity of the newly developed medium for H_2 formation. Findings demonstrate that ORP can be utilized to control the growth and hydrogen production in inexpensive WGW, making it a valuable tool in biotechnology.
References

Keywords: Biohydrogen, lignocellulosic wine grape waste, *E. coli*.

ICH2P14-PP118

COMPARATIVE ECONOMIC ANALYSIS OF SMALL MODULAR REACTOR HYDROGEN COGENERATION AND CONVENTIONAL GAS-FIRED PLANT FOR LOAD FOLLOWING: A CASE STUDY

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Load following by nuclear hydrogen cogeneration is seen as an effective strategy to increase the efficiency and resiliency of future electricity grids, which will contain higher proportions of Variable Renewable Energy Sources (VRES). The Canadian province of Ontario provides an ideal subject for decarbonizing a major industrialized electricity grid using a load following cogeneration strategy. Ontario produces carbon-free baseload power; however, natural gas plants are required to meet peak demand. This paper explores a case study for potentially replacing peak-demand natural gas plants with Small Modular Reactors (SMRs) load following by hydrogen cogeneration. Two peaking plants are compared using Levelized Cost of Electricity (LCOE) to the grid, the First-Of-A-Kind (FOAK) BWRX-300 SMR currently being built with an expected completion date of 2028, and an existing 393 MWe Natural Gas Simple Cycle (NGSC) plant. A subsidized LCOE for a SMR cogenerating hydrogen during “non-peak” grid hours is estimated using the Hydrogen Economic Evaluation Program (HEEP). The results show that a SMR cogeneration strategy produces a lower LCOE than a conventional natural gas plant and can also decrease the SMRs LCOE. Through preliminary economic analysis, research identifying potential SMR applications is expected to help accelerate the deployment of commercially viable, carbon-free small modular nuclear power plants while also facilitating the growth of hydrogen production.

Keywords: Hydrogen production, small modular reactors, load following, cogeneration, HEEP.

ICH2P14-PP124

SHIP DESIGN ADAPTATIONS FOR LNG PROPULSION, CARBON CAPTURE UTILIZATION, AND HYBRID TECHNOLOGIES

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The aim of this work is to explore and summarise recent publications on ship design considerations/modifications towards sustainable energy implications such as LNG as an alternative fuel, carbon capture and utilisation technologies, and others. It was also necessary to discuss differences between navy ships and traditional shipping vessels regarding the possibility of using sustainable energy resources. A systematic literature search was carried out in scientific databases. Publications obtained from the databases described above indicated that LNG as an alternative energy source in modern ships was on the rise. In particular, tankers that transport LNG may take advantage of this fuel and use it during transportation. Carbon capture and utilisation were also established as a sustainable technology. Alumina-supported K2CO3 was identified as a highly promising sorbent. Another important sustainable energy solution is using hybrid electricity/hydrocarbon-powered engines. Respective publications in the area indicated that ships will take advantage of this type of engine at low speeds. Finally, the possibility of using alternative energy sources in the navy ware discussed taking into consideration their differences from traditional ships.

Keywords: Ship sustainability, design, LNG, carbon capture and utilisation, navy.

ICH2P14-PP128

GREEN HYDROGEN PRODUCTION: A COST COMPARISON OF DIFFERENT ELECTROLYSIS TECHNOLOGIES

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Hydrogen production from conventional fossil fuel-based energy systems often results in CO_2 by-products, and has the potential risk of contributing towards the global greenhouse gas emission (GHG) problem, the primary factor of climate change. Unlike conventional technologies, renewable sources for green hydrogen production are very attractive and environmentally friendly. Green hydrogen is produced through water electrolysis with the integration of renewable electricity generation systems such as wind and solar power. In this study, a cost comparison for green hydrogen production methods has been made by analysing different types of electrolysis such as alkaline electrolysis (AEL), polymer electrolyte membrane (PEM) electrolysis, and solid oxide electrolysis (SOE). The overall results show that hydrogen production from solar-connected electrolysis technologies is the most cost-efficient when compared to wind solar-connected electrolysis technologies. Moreover, the cost analysis has been categorized into best and worst cases, using US pricing as a basis for all costing parameters. The hydrogen production cost from AEL is 6.6 \$/kg-H_2 and 10.03 \$/kg-H_2 in both best and worst cases respectively which is less than the cost of hydrogen produced from PEM and SOE which in turn ranges from 12.78 \$/kg-H_2 to 20.14\$/kg-H_2 and 8.7\$/kg-H_2 to 12 .26\$/kg-H_2.

Keywords: Green hydrogen, hydrogen economy, electrolysis.

ICH2P14-PP132

MODELING OF SUPERCRITICAL HYDROGEN STORAGE SYSTEM PARAMETERS USING ARTIFICIAL INTELLIGENCE TECHNIQUE

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In this work, an advanced Artificial intelligence (AI) technique is applied to predict with accuracy high-density cryogenic supercritical hydrogen storage system parameters. The modelling process is carried out using a hybrid method based on artificial neural network (ANN) and particle swarm optimization (PSO). The training and validation strategy has been focused on the use of a validation agreement vector, determined from linear regression analysis of the predicted versus experimental outputs, as an indication of the predictive ability of the conceived ANN model. The modelling strategy is performed using the mass flow rates of liquid nitrogen and helium, the inlet and outlet temperature of the heat exchangers (T) and the pressure of helium (P) as inputs parameters and the specific energy consumption of the process (SEC) as output parameter. The statistical analysis of the predictability of the optimized ANN model shows excellent agreement with referenced data (coefficient of correlation equal to 0.988). Also, the comparison between estimated and the referenced values is carried out using average absolute relative deviation objective function (AARD) and shows a high predictive ability of the conceived model with global deviation equal to 0.85%.

Keywords: Modelling, hydrogen storage system, ANN, PSO, optimization, specific energy consumption.

ICH2P14-PP139

PERFORMANCES OF COMMERCIAL ZEOLITES WITH DIFFERENT ACIDITIES FOR CATALYTIC CO_2 HYDROGENATION TO DIMETHYL ETHER USING COPPER/ZINC/ALUMINA CATALYST

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In this study, we present the utilization of three distinct commercially available zeolites, specifically HZSM-5, possessing different Silica/Alumina ratios referred to as Z_1, Z_2, and Z_3, for the direct carbon dioxide conversion to dimethyl ether (DME) using a Cu/Zn/Alumina (CZA) catalyst. The employed CZA catalyst with a constant composition of 60 wt.% Cu, 30 wt.% Zn, and 10 wt.% Alumina was synthesized using solution combustion synthesis (SCS) technique. Synthesized catalysts were characterized using scanning electron microscopy (SEM), transmission electron microscopy (TEM), X-ray diffraction (XRD), nitrogen adsorption-desorption isotherm measurements, hydrogen temperature-programmed reduction (H_2-TPR), and ammonia temperature-programmed desorption (NH_3-TPD). Using the synthesized catalysts, the two-step process of CO_2 hydrogenation to DME was carried out in a high-pressure packed bed reactor under different pressures of 40, 50, and 60 bars, a fixed temperature of 250 °C, and a hydrogen to carbon ratio of 3:1. Performances of synthesised catalysts for CO_2 hydrogenation were evaluated in terms of overall CO_2 conversion and products selectivity. Obtained results showed that CZA/Zeolites were very active in CO2 conversion to methanol and DME, with CZA/Z_3 displaying the highest CO_2 conversion rate of 27.7% and DME selectivity of 38%.

Keywords: CO_2 hydrogenation, methanol, dimethyl ether, catalyst, zeolites.

ICH2P14-PP147

PHOTO-ELECTRO-ELECTROLYSIS SYSTEM UTILIZING TiO_2-COATED STAINLESS STEEL AND FTO AS PHOTOELECTRODES FOR ENHANCED DYE REMOVAL IN WASTEWATER AND HYDROGEN PRODUCTION

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This study explores an electrochemical approach, specifically electrolysis, for effective dye removal in wastewater treatment with a primary emphasis on unique electrode modifications. In the first configuration, stainless steel electrodes undergo a titanium dioxide (TiO2) coating process, known a photoactive material, using the sol-gel and dip-coating method. This includes creating a suspension of TiO2 and Polyvinylpyrrolidone (PVP) surfactant in an ethanol-based solvent as the sol-gel solution. The electrodes are then immersed and annealed at 550°C for 2 hours to ensure proper adhesion, transforming them into photoelectrodes. A parallel configuration involves fluorine-doped tin oxide (FTO) electrodes similarly coated with TiO2. Both configurations leverage photoelectrochemical processes, fostering oxidation to augment the degradation of dyes in wastewater. The experimental design comprises two separate runs, differing only in the choice of the photoelectrode material. A comprehensive evaluation considers coating quality, electrochemical performance, overall treatment efficiency, and simultaneous hydrogen co-production on the cathode side. This study aims to investigate the impact of electrode material on dye removal and hydrogen coproduction efficiency, offering insights into optimizing electrochemical methods for comprehensive wastewater treatment. Specifically, the cathode side of the electrolysis process yields hydrogen gas through water molecule reduction. This functionality enhances energy efficiency, making the system not only photo-powered through electrode coatings but also benefiting from hydrogen production. Concurrently, at the anode side, the formation of hydroxyl radicals enhances the system's capability to remove dye from wastewater. This dual-focus study addresses environmental remediation and contributes to understanding sustainable hydrogen production within a unified electrolytic framework, advancing multifaceted applications in wastewater treatment.

Keywords: Electrolysis, textile wastewater, wastewater treatment, electrochemical, photo-anode.

ICH2P14-PP153

SYNTHESIS AND EVALUATION OF CU-BASED CATALYTIC MATERIALS FOR CO_2 HYDROGENATION TO VALUE-ADDED PRODUCTS

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In this work, novel Cu-based catalytic materials containing different proportions of an adsorbing substance for CO_2 capture and an active catalytic component for its conversion have ben synthesized and tested for CO_2 conversion to methanol and other value-products. Synthesized materials of $Cu/CaO/Al_2O_3$ in variable compositions using sequential incipient wetness impregnation synthesis method were characterized using different characterization techniques and tested in a packed bed high-pressure reactor under reaction conditions of P=60 bars, T=300ºC, and H_2/CO_2 = 3. The obtained results of the activity tests showed that both Cu and CaO contents have different effects on the overall efficiency. The highest CO_2 conversion of 17.96 obtained for $20Cu5CaO/Al_2O3$ while the highest Methanol selectivity of 17.75% obtained for Cu 20% $CaO10\%Al_2O_3$ catalyst.

Keywords: Copper based catalyst, methanol synthesis, CO_2 conversion, Cao adsorbent.

ICH2P14-PP154

FACILITATING PRODUCTION OF ACETATE AND HYDROGEN THROUGH ENHANCED ELECTRON TRANSFER AND SUBSTRATE MASS TRANSFER USING A MULTIFUNCTIONAL PHOTOCATHODE WITH Nio/G-C_3N_4/POLYTHIOPHENE

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The process of microbial electrosynthesis (MES) represents a promising method for carbon dioxide (CO_2) fixation, wherein biocatalysts derive electrons from electrodes, serving as a driving force for the reduction of CO_2 into more valuable multicarbon products. In this investigation, we designed a novel multifunctional photocatalyst incorporating NiO/g-C_3N_4/Polythiophene, and subsequently established an MES system utilizing a mixed culture as the biocatalyst. Comparative analysis with NiO/g-C_3N_4 revealed that the integration of Polythiophene into NiO/g-C_3N_4 not only amplifies the light absorption capacity but also enhances the efficiency of photogenerated electron-hole separation and migration. With an escalating reducing power influence, NiO/g-C_3N_4/Polythiophene manifests the capacity to expedite the electron transport rate to microbes through three distinct pathways: indirect conduits via formate, indirect routes via hydrogen, and direct electron transfer. Moreover, the presence of NiO/g-C_3N_4/Polythiophene proves advantageous in fostering the enrichment of electroautotrophic microorganisms, leading to an augmented abundance of Acetobacterium and Arcobacter. Additionally, the photocatalyst demonstrates an enhanced CO_2 adsorption capability. Operating at a potential of -0.9 V (versus Ag/AgCl), the MES employing the NiO/g-C_3N_4/Polythiophene photocathode achieves an acetate production rate of 4.12 mM/d, showcasing a remarkable 4.2-fold increase compared to the control. n a controlled environment, the MES system yielded less hydrogen production (0.00905 m^3/m^3/d) than when utilizing the NiO/g-C_3N_4/Polythiophene combination (0.02105 m^3/m^3/d). This study presents an innovative approach for semiconductor photocathodes to improve MES performance within mixed cultures.

Keywords: Hydrogen production, acetate production, carbon dioxide, bio-photocatalysis, bio nanocomposite.

ICH2P14-PP161

TEXTILE WASTEWATER TREATMENT AND HYDROGEN GENERATION WITH ION-EXCHANGE RESINS ON SOLAR-ASSISTED BIPOLAR MEMBRANE ELECTROLYSIS PROCESS

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Bipolar membrane electrolysis has emerged as a promising and efficient process for sustainable hydrogen production, offering a potential solution to the escalating global energy and environmental challenges. Hydrogen, being a clean and versatile energy carrier, holds immense promise in mitigating greenhouse gas emissions and transitioning towards a low-carbon economy. Bipolar membrane electrolysis, in comparison to conventional water electrolysis, offers distinct advantages by directly splitting water into hydroxide and hydrogen ions at the anode and cathode sides of the membrane surface, respectively. To further enhance the efficiency of bipolar membrane electrolysis for hydrogen production, the incorporation of photocatalysis and ion exchange resins has emerged as a valuable strategy. Ion exchange resins, possessing functional groups with high affinity for specific ions, play a pivotal role in the electrolysis system by aiding removal of specific ions from the solution and releasing OH^- ions from anion exchange resins and H^+ ions from cation exchange resins. By introducing ion exchange resins into the electrolysis setup, it becomes possible to optimize ion conductivity, reduce ohmic losses, and minimize membrane fouling. Additionally, the use of photocatalysis can effectively mitigate the negative impacts of impurities present in the wastewater by photooxidation, ensuring prolonged membrane lifespan and consistent hydrogen generation performance. In this context, this study aims to generate hydrogen gas by high-efficient bipolar membrane electrolysis system, with a specific focus on the integration of ion exchange resins and photocatalysis to enhance process efficiency and treat textile wastewater containing reactive dye. The synergistic effects of the BPM, IEX-R and photocatalysis such as TiO_2 nanoparticles pave the way for a more sustainable and economically viable hydrogen generation technology while treating textile wastewater.

Keywords: Bipolar membrane, electrolysis, hydrogen, ion-exchange resins, textile wastewater.

ICH2P14-PP166

EVALUATION OF HYDROGEN PRODUCTION FROM AMMONIA REFORMING ON NI/ZNO NANOWIRE CATALYSTS

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Ammonia has attracted attention as a hydrogen storage medium for applications such as fuel cells. However, ammonia reforming catalysts have led to decreased activity owing to heating and agglomeration. To suppress the agglomeration, we have applied a nanowire (NW) structure to improve the durability and efficiency of the reforming catalysts. ZnO NWs prepared by hydrothermal synthesis[1)] were soaked in ethanol (0.3 M) in which nickel nitrate hexahydrate was dispersed. They were dried and heated (350°C) to deposit nickel oxide on the NWs (NiO/ZnO NW). Nickel was supported on two types of ZnO NWs (rod-like and tree-like) prepared by hydrothermal synthesis. Reforming tests were conducted using these catalysts under different inlet ammonia flow rates to compare their conversions. The reforming temperatures were between 400°C and 700°C. The WHSV dependence of the ammonia conversion showed that the conversion reasonably tended to increase with decreasing WHSV. The highest ammonia conversion of 76% was observed for a WHSV of 18000 at 700°C. The activation energy and frequency factor were derived. Ammonia reforming using Ni/ZnO NW catalysts exhibited promising conversion for hydrogen production. Dendritic NWs[2)] would increase the surface area for an even higher conversion and hydrogen production rate.

Keywords: Ammonia decomposition, hydrogen storage, hydrogen carrier, ZnO nanowire, nickel catalyst.

ICH2P14-PP167

RECOVERY OF SPENT ACIDIC AND ALKALINE LIQUORS GENERATED IN METAL INDUSTRY AND HYDROGEN PRODUCTION BY AN INTEGRATED SYSTEM

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Industries, such as mining, textiles, and metal processing, annually utilize tons of acid and caustic solutions. These solutions contain environmentally harmful and hazardous substances. Disposal often involves high-cost neutralization processes before discharge. Meanwhile, achieving a sustainable environment and economy necessitates the transition to carbon-free and renewable energy sources. Hydrogen, with its abundance and high energy content, stands out as a key energy carrier globally. Consequently, developing high-efficiency and cost-effective hydrogen production techniques has gained significant importance in recent years. This study aims to create an integrated system through electrodialysis and membrane electrolysis processes, facilitating the recovery of diluted acidic and alkaline waste solutions while simultaneously producing hydrogen gas. The optimal conditions for operating the electrolysis and electrodialysis reactors with different ion-exchange membranes and electrode groups are investigated to recover spent acidic and alkaline liquors in metal industry. The hydrogen production rate of the electrolysis with bipolar membrane system is calculated as 300 ml/h, while the recovery rate of the acid and base is around 85% with the electrodialysis process. The energy and exergy analysis of the integrated system is found as 55% and 45%, respectively. The results reveal that the proposed integrated system might used instead of energy-intensive thermal recovery processes.

Keywords: Waste acid and base, electrodialysis, hydrogen, metal industry.

ICH2P14-PP168

CURRENT AND TEMPERATURE DISTRIBUTIONS IN A PLANAR SOLID OXIDE ELECTROLYSIS CELL IN-SITU ASSESSED WITH SEGMENTED ELECTRODES

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This study investigates current and temperature distributions in solid oxide electrolysis cells (SOECs) for high-temperature steam electrolysis. Segmented anodes enable successful separation of current measurements upstream, midstream, and downstream along the gas flow channels (co-flow) under voltage control. The results are useful to validate three-dimensional finite element models for enhanced SOEC design, improving performance and durability. A cathode-supported planar cell was used for the experiments. The cell consisted of a Ni/8YSZ cathode, LSC anode, and 8YSZ electrolyte. The anode was segmented using silver mesh current collectors and stainless-steel interconnectors. Voltage-controlled current-voltage measurements were performed to simulate a normal cell, while temperature variations with electrolysis voltage were monitored using K-type thermocouples. A low inlet steam flow rate led to a reduced current density downstream owing to the concentration overpotential from the reduced steam concentration with upstream consumption. Temperature changes revealed that heat absorption prevailed at low currents below the thermoneutral voltage, transitioning to heat generation at higher currents with more dominant Joule heat from the overpotentials. The segmenting anode allowed successful current separation measurements in different sections, enabling generalized numerical models for improved cell stack performance through operational optimization and interconnector design.

Keywords: SOEC, steam electrolysis, hydrogen production, electrode-segmentation method, current and temperature distributions.

ICH2P14-PP169

DYNAMIC MODELLING APPROACH FOR UNDERSTANDING THE INFLUENCE OF CARBON POLICIES ON ELECTROFUELS UTILISATION WITHIN THE AVIATION SECTOR

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Prior to the COVID-19 pandemic, the airline industry achieved rapid growth, leading to an increase in its share of carbon dioxide (CO_2) emissions. This value increased by 9.3% in 2021 with the expectation that this percentage would reach approximately 53.3% by 2032. In order to achieve a net zero carbon by 2050, four mitigation techniques were suggested: carbon policies, alternative fuels, technological advancement, and operational enhancement. Electro-fuels are a specific category of alternative jet fuel, commonly called Power to Liquid (PTL). Electrofuels are hydrogen-based fuels with the capability to replace fossil fuels. These fuels are expected to be cleaner in aviation since they use hydrogen as the building block. Along with hydrogen, CO_2 is another important element in PTL pathways to produce electrofuels, making them a vital energy carrier for decarbonisation within the aviation sector. The integration of multiple mitigation techniques can help the aviation industry to move towards sustainable aviation. Therefore, including policy can act as a supporting tool to incentivise the development of electrofuels towards a cost effective and low carbon transportation modes. They also motivate airlines to maximise their revenue. Optimisation techniques were used in previous literature for modelling energy systems along with studying policies aspects. A single valid optimisation tool to study policy impacts is system dynamics. This study attempts to understand the influence of integrating carbon policies such as Carbon Offsetting Reduction Schemes for Aviation (CORSIA) with the utilisation of electrofuels, on reducing aviation emissions and its reflection on operators' expenses. The developed system dynamics model considers several factors such as carbon pricing, fuel prices, fuel demands, lifecycle analysis (LCA) values, flight load, flight routes, and emissions reduction to find out the optimal scenarios for a future sustainable aviation industry.

Keywords: Electrofuels, aviation, system dynamics.

ICH2P14-PP170

IN-SITU CURRENT DISTRIBUTION MEASUREMENTS OF A PLANAR SOLID OXIDE FUEL CELL FOR A THREE-DIMENSIONAL FINITE ELEMENT MODEL TO TRAIN A MACHINE-LEARNING SURROGATE MODEL

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Solid oxide fuel cells (SOFCs) offer advantages such as high efficiency and fuel flexibility without costly catalysts, owing to their high working temperature. To date, investigating the three-dimensional (3D) distribution of current density, gas concentration, and temperature in cells and stacks has been associated with significant computational expenses. Past efforts involved 3D simulations based on conservation laws to optimize cell and stack designs. In this research, we conduct current distribution measurements on a planar test cell (Ni/8YSZ anode, LSC cathode, and 8YSZ electrolyte) with segmented silver mesh current collectors and stainless-steel interconnectors for upstream, midstream, and downstream parts along the flow channels. They were electrically insulated from one another. Current–voltage characteristics were measured using three electronic loads under voltage control. Thereby, we develop and validate a 3D finite element model. Employing machine learning techniques, we generate a surrogate model from current densities for various cell voltages, inlet gas conditions and cell temperatures as training data predicted by the finite element model. The surrogate model can offer significant computational cost reduction.

Keywords: Solid oxide fuel cell, Multiphysics simulation, Segmented electrodes, Machine learning, Surrogate model.

ICH2P14-PP172

INTEGRATED HYDROGEN PRODUCTION AND PURPLE PHOTOTROPHIC BACTERIA BIOMASS RECOVERY VIA ELECTROCOAGULATION

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Purple non-sulphur bacteria (PNSB) are pivotal in biological wastewater treatment, efficiently converting wastewater constituents (Carbon, Nitrogen, Phosphorus) into valuable bioproducts like proteins, lipids, and polyhydroxyalkanoates. However, post-treatment PNSB biomass recovery is challenging due to poor settleability and low density. This study explores electrocoagulation for PNSB biomass recovery from high-strength gas-to-liquid process water. Using a Cu cathode with various anodes (Zn, Mg, Al, C, Cu), the Cu:Mg combination was found most efficient, achieving a coagulation efficiency of 67.0±0.31%, outperforming other groups (2.7% to 20.2%) and registering the highest zeta potential (-10.7±0.82 mV) . Optimization indicated pH 7.0 and reaction time over 20 minutes as optimal, yielding a coagulation efficiency of 71.7±0.8% at 10 V and current density of around 133 A/m^2. Additionally, this process facilitated hydrogen generation, measured via water displacement, with a theoretical yield of 70 mL/minute and an energy efficiency of 0.0115 mL per joule. This dual benefit of biomass recovery and hydrogen production is advantageous for integrated waste-to-energy applications. Although the energy efficiency may seem modest, it is notable in a system primarily focused on biomass recovery. In conclusion, this study presents a promising wastewater treatment approach, enabling efficient biomass recovery and hydrogen production.

Keywords: Resource recovery, circular economy, wastewater treatment, biomass recovery, hydrogen production.

ICH2P14-PP175

TURQOISE HYDROGEN PRODUCTION: CARBON MANAGEMENT AND CONVERSION TO SUSTAINABLE ENERGY CARRIERS

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This work explores methane cracking or pyrolysis as an alternative pathway for converting methane into sustainable energy carriers, aiming to optimize Qatar's natural gas resources. Turquoise hydrogen production from methane cracking is known for its zero greenhouse gas emissions, presenting a more sustainable option than steam methane reforming. The co-produced carbon-black can be used in other industries and adds economic value. To enhance sustainability, using concentrated solar energy is proposed to achieve the high-temperature. Three integrated systems based on solar methane cracking are proposed for examining the conversion of turquoise hydrogen into transportable forms with low CO_2 emissions. The co-produced carbon is managed using direct carbon fuel cells to generate electricity. Using Aspen Plus® software, thermodynamic properties are modelled, and mass, energy, entropy, and exergy balances are assessed. The integrated system and subsystem energy and exergy efficiencies are determined. The solar methane cracking subsystem achieves 82.2% and 92.5% energy and exergy efficiency, respectively, when considering carbon product as a valuable commodity. Comparatively, hydrogen conversion to methanol and dimethyl ether (DME) proves more energy-efficient than hydrogen liquefaction.

Keywords: Methane cracking, turquoise hydrogen, direct carbon fuel cell.

ICH2P14-PP181

UNDERGROUND GAS STORAGE SYSTEMS: NATURAL GAS, HYDROGEN, AND CARBON SEQUESTRATION

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The concept of underground gas storage is based on the natural capacity of geological formations such as aquifers, depleted oil and gas reservoirs, and salt caverns to store gases. Underground storage systems can be used to inject and store natural gas (NG) or hydrogen, which can be withdrawn for transport to end-users or for use in industrial processes. Geological formations can additionally be used to securely contain harmful gases, such as carbon dioxide, deep underground, by means of carbon capture and sequestration technologies. This paper defines and discusses underground gas storage, highlighting commercial and pilot projects and the behaviour of different gases (i.e., CH_4, H_2, and CO_2) when stored underground, as well as associated modelling investigations. For underground NG/H_2 storage, the maintenance of optimal subsurface conditions for efficient gas storage necessitates the use of a cushion gas. Cushion gas is injected before the injection of the working gas (NG/H_2). The behaviour of cushion gas varies based on the type of gas injected. Underground NG and H_2 storage systems operate similarly. However, compared to NG storage, several challenges could be faced during H_2 storage due to its low molecular mass. Underground NG storage is widely recognized and utilized as a reference for subsurface H_2 storage systems. Furthermore, this paper defines and briefly discusses carbon capture and sequestration underground. Most reported studies investigated the operating and cushion gas mixture.

Keywords: Reservoir, energy storage, oil and gas, natural gas.

ICH2P14-PP185

MULTI-PURPOSE CHARGING STATION FOR ELECTRIC AND HYDROGEN VEHICLES ENABLING SUSTAINABLE TRANSPORTATION

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In this paper, an innovative integrated charging system is proposed for the design of both electric and hydrogen vehicles, leveraging renewable energy sources. The system harnesses solar energy and extracts moisture from atmospheric air to generate clean electricity through advanced technologies, including Atmospheric Water Generators (AWGs) and photovoltaic (PV) panels. This study highlights the hydrogen production and storage component as it utilizes an Anion Exchange Membrane (AEM) electrolyzer powered by PV-generated electricity for hydrogen generation. A dedicated hydrogen storage tank ensures a reliable supply of hydrogen-powered vehicles, emphasizing their role in the sustainable transportation ecosystem. This study employs the Engineering Equation Solver (EES) software to analyze and optimize the proposed system, leveraging its robust computational capabilities for comprehensive engineering simulations. The charging station's features include a 125-kW solar panel array, a 150-kWh battery system, and a 100-kW AEM electrolyzer producing hydrogen at 35 bars. The active integration of H2 compression and storage ensures efficient hydrogen fueling and electric vehicle charging infrastructure. A methanol system that provides backup, clean electricity utilizing a methanol fuel cell is also studied in this paper.

Keywords: Resilient energy storage, urban green mobility, sustainable energy integration.

ICH2P14-PP186

STUDY OF THE ENERGY AND FINANCIAL PERFORMANCE OF HYDROGEN PRODUCTION WITH SOLAR ENERGY AND PHOTOELECTROLYZER/PEM IN THE ALGERIAN DESERT REGION (OUARGLA)

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The general goal of our work is an experimental study of the maximum production of hydrogen by water electrolysis, and the production of electrical energy is ensured through photovoltaic panels with the use of climatic data from the Ouargla region (Algerian Sahara). This work contains mathematical models in addition to experimental studies of the components of the solar hydrogen production system for both the photovoltaic generator and the electrolyser (HG-60) which provides a characterization of the photovoltaic unit and a study of the effects of ambient temperature and solar radiation on the performance characteristics of solar photovoltaic energy using modelling and simulation analysis in addition to experimental studies. The results showed that the root mean square error (RMSE) was 0.025%. Then the direct coupling of the photoelectric electrolyser was simulated for different irradiances and temperatures. The results show that when adding three of the number of electrolysers (HG-60) respectively it shows a convergence Large with the maximum power points of the photoelectric generator, which means an increase in the volume of hydrogen produced by the system. At the end of the experiment period, the real amount of hydrogen was about 83.756 liters, and the efficiency of the electrolyser with the photoelectric generator was 96%. The price of hydrogen was also estimated at 5.0342 $/kg

Keywords: experimental study, hydrogen, electrolysis, photovoltaic panels, modelling and simulation analysis.

ICH2P14-PP188

HYDROGEN NAVAL PROPULSION: PROBLEMS AND SOLUTIONS

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Main ships emissions in Algeria are nitrogen oxides, sulphur oxides, carbon dioxide, fine particles and polycyclic aromatic hydrocarbons. According to IMO data, ships emissions were estimated around 4.5 million tonnes, which represents an increase of 50% compared to 2012. Algeria has developed a national strategy to combat against climate change aimed at reducing greenhouse gas emissions by 7% by 2030 compared to 2015 levels. The main objective of this work is to highlight the effectiveness of hydrogen propulsion in the field of maritime transport in the fight against air pollution by comparing to other types of propulsion in Algeria. The hydrogen propulsion system is an effective solution to reduce greenhouse gas ships emissions. It can reduce emissions by 50-100% compared to traditional internal combustion engines. Additionally, hydrogen propulsion system is quiet and requires less maintenance than internal combustion engines, still relatively new and expensive, but it is under development and expected to become more affordable in the future. Many ships using this system are already in service around the world, including ferries and cruise ships. It is a promising solution to reduce greenhouse gas ships emissions and contribute to the fight against climate change. Hydrogen is stored in liquid or gas form on ship board, and when burned in the fuel cell, it produces only water as a by-product. In longer term, hydrogen, ammonia or methanol could emerge as the future fuels. Carbon neutral, provided they come from clean sources, they still present numerous technical constraints: specific storage conditions (temperatures, adapted tanks and toxicity), larger volume than conventional fuel oil and production costs that are still too restrictive. The adoption of these new fuels could take ten or even twenty years.

Keywords: Emission, Algeria, hydrogen propulsion, reduction, fuel cell.

ICH2P14-PP192

HYDROGEN FROM CATALYTIC STEAM REFORMING OF BIOMASS

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Gasification of agricultural by-products and organic waste can produce a gas mixture which, appropriately conditioned, can be used to produce fuels by means of the Fischer-Tropsch synthesis. A bench scale gasification plant, composed of a fluidized bed reactor having an ID of 0.1 m, heated externally with an electric furnace, capable of operating at temperatures higher than 900 °C is used to perform the catalytic gasification tests. The fluidized bed inventory is made with 3 kg of olivine particles having a density of 3000 kg/m3, an average diameter of 0.250 mm, and almond shell particles with an average diameter of 1.1 mm as biomass. Gasification tests were performed in presence of steam. Filter candles having an external diameter of 0.06 m and a maximum length of 0.6 m are inserted in the freeboard of the gasifier. The gas leaving the gasifier, free from dust, is cooled to room temperature. Gas flowrate was monitored online and approximately 1 l/min was sent to the TCD and IR analyzers, for the instantaneous measurement of H2, CO, CO2, CH4 and NH3 concentrations. Tar content was 225 mg/Nm^3, with toluene and naphthalene concentrations below the permitted limits for the SOFC safe operation.

Keywords: Hydrogen, biomass, catalyst, fluidised bed, filter.

ICH2P14-PP201

RECENT TECHNOLOGICAL DEVELOPMENT AND ADVANCEMENTS IN HYDROGEN STORAGE TECHNOLOGIES

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In response to the world's expanding energy and environmental problems, hydrogen has emerged as an ensuring clean energy carrier. Effective and secure hydrogen preservation technologies are essential for utilizing hydrogen to its full potential as a source of renewable energy. The review paper sheds light on the creative strategies that have been pursued to tackle the difficulties related to hydrogen storage by giving a thorough overview of recent technological advancements and developments in hydrogen storage technologies. The review begins by highlighting the drawbacks of conventional hydrogen storage techniques, such as compression and liquefaction, in terms of conservation of energy and security. The fascinating field of solid-state storage of hydrogen materials, such as metal hydrides, complicated hydrides, and carbon-based materials, is then explored in depth. Recent advances in the design and manufacturing of such materials have greatly improved their kinetics and hydrogen storage capabilities, making them more and more suitable for use in practical applications. In this paper, the promising hydrogen carrier ammonia is discussed as part of the expanding the field of chemical hydrogen storage. It is highlighted that improvements in the production of ammonia and decomposition procedures have the potential to provide a high level of hydrogen storage with enhanced security features. The creation of sophisticated porous substances, such as metallic-organic frameworks (MOFs) and covalent organic frameworks (COFs), that possess remarkable hydrogen adsorption capacities, is another significant topic covered in this review. To maximize the performance of these materials' hydrogen storage, researchers have made outstanding progress in modifying their structure and properties.

Keywords: renewable energy, environmental problems, hydrogen storage, technologies, materials.

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