# 12th INTERNATIONAL EXERGY, ENERGY AND ENVIRONMENT SYMPOSIUM (IEEES-12)

December 20 – 24, 2020
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## ABSTRACT BOOK


**EDITORS**

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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.

The university provides an array of graduate programs through its College of Islamic Studies, College of Humanities and Social Sciences, College of Science and Engineering, College of Law, College of Health and Life Sciences, and College of Public Policy.

HBKU is also home to three research institutes – Qatar Biomedical Research Institute (QBRI), Qatar Computing Research Institute (QCRI), and Qatar Environment and Energy Research Institute (QEERI) – which together with the colleges are at the forefront of efforts to seek novel solutions to grand challenges facing Qatar and the region. Additionally, HBKU's Executive Education Center delivers customized programs for the business community of Qatar and the region.

# INDEX

# ACKNOWLEDGEMENT

The IEEES-12 Organizing Committee expresses its sincere appreciation to the following organizations:

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# 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 help organize this prestigious international event, the 12th International Exergy, Energy and Environment Symposium (IEEES-12). I would like to extend my warmest greetings to all the attendees of this excellent event.

The 12th International Exergy, Energy and Environment Symposium (IEEES-12) is an initiative aimed at bringing together academics, researchers, scientists, technocrats and practicing engineers, in the confluence between several related disciplines ranging from energy to environment.

This international symposium serves as a forum that promulgates ideas, experience, and knowledge of fellow researchers and engineers working on sustainable energy and environment systems across the globe.

IEEES-12 will cover a diverse range of cutting-edge topics, including Renewable Energy Technologies, Solar Energy, Oil and Gas Technologies, Smart Grids, Green and Electrified Transportation, Alternative and Clean Fuels, Hydrogen and Fuel Cell Technologies, Nuclear Energy, Desalination Technologies, Waste Water Treatment and Environmental Technologies.

The symposium is intended to increase the visibility and advancement of futuristic and cleaner technologies such as green energy, renewable energy, environmental science and e-mobility. Other highlights are smart cities, green buildings, energy management systems, and desalination technologies.

It also addresses societal and environmental threats, unveiling the challenges in the life cycle assessment, $CO_2$ reduction technologies, bio-waste utilization, wastewater treatment, nuclear energy and fuels for transportation.

We look forward to welcoming you.

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

# FOREWORDS

## Kahramaa President's Welcoming Message

Doha is all set to open the 12th series of the International Exergy, Energy and Environment Symposium (IEEES-12). The conference, whose genesis was in Izmir, Turkey, almost 17 years ago as its first edition, has been running successfully ever since. IEEES is focused on the theoretical and practical aspects of Exergy, Energy, and Environment (3E's) for a sustainable future.

The symposium will be highly significant, as it will discuss several global sustainable agenda and Sustainable Development Goals (SDGs), including methods to procure a better incorporation of the massive research conducted in the area of environmental sciences. It is a unique opportunity for exchanging ideas, experiences, and information in areas where the world faces critical challenges in sustainable development. The 12th International Exergy, Energy and Environment Symposium (IEEES-12) will facilitate close cooperation and intellectual exchange amongst many experts from academia, leading Research & Development institutions, government agencies, sectors, and industries, among others.

IEEES-12 will shed light on a diverse range of cutting-edge topics, such as Environmental Technologies, Renewable Energy Technologies, and Oil and Gas Technologies. It is also a chance to visualize sustainability and preservation related projects and solutions such as Smart Grids, Green and Electrified Transportation, Alternative and Clean Fuels, Hydrogen and Fuel Cell Technologies, Nuclear Energy, Desalination Technologies, Wastewater Treatment, and Solar Energy. Tackling these issues falls in close alignment with Qatar National Vision (QNV) 2030, and the government is committed to ensure long-term human, economic, social, and environmental sustainability.

I take the opportunity to welcome you all to the symposium and hope that all the experts and professionals present here will brainstorm for ideas to overcome environmental, resource, efficiency, cost, energy security, and sustainability-related issues and challenges. It is regrettable that the current circumstances have prevented our physical gathering and deprived us of the chance of being your hosts in the beautiful city of Doha. However, I am hopeful that we will proceed together, armed with faith and determination, to overcome these difficult times, and I hope everyone will find IEEES-12 enjoyable, informative, pragmatic, and solution-oriented.

Last but not least, I would like to express my warmest thanks to the organizers for their exemplary efforts in arranging this colossal intellectual gathering and wish all participants a very fruitful meeting.

**H.E. Eng. Essa Bin Hilal Al-Kuwari,**
President, Qatar General Electricity & Water Corporation "KAHRAMAA"

# FOREWORDS

## Chair's Welcoming Message

It is our great honor to welcome you to the 12th International Exergy, Energy and Environment Symposium (IEEES-12), which is virtually organized by Hamad Bin Khalifa University, in Qatar, from December 20-24, 2020. The IEEES has been organized successfully as a leading symposium in the area since 2003, and previous editions have been held auspiciously in various parts of the world, from Poland to India.

IEEES-12 will be a remarkable event with an even wider reach in terms of technical content including plenary sessions, keynote talks, and several specialized parallel sessions focusing on energy, exergy and environmental topics across diverse disciplines. We anticipate that this conference will provide a forum for the exchange of technical information, dissemination of high-quality research results, the presentation of new policies and scientific progress toward achieving sustainable development. It is our hope that the symposium will lead to effective, fruitful discussions and collaborations between participants from different disciplines, institutes and sectors from all over the world.

The scientific part of IEEES-12 will include talks by keynote and invited speakers, as well as oral and poster presentations from participants. Conference proceedings will be published after reviewing the manuscripts submitted. High quality papers will be considered, in extended form, for possible publication in specific reputable international journals mentioned on the website.

We endeavor to ensure that IEEES-12 will be a valuable, impactful and enjoyable event.

**Dr. Yusuf Bicer**
On Behalf of the Organizing Committee
Symposium Chair

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# KEYNOTE SPEAKERS

## IEEES12 – KN1

## Energy-Climate Change-Sustainability Triangle: How Can We Move Together Toward Achieving a Global Solution?

**Prof. Dr. Feridun Hamdullahpur**
Professor, President and Vice-Chancellor
Mechanical and Mechatronics Engineering
University of Waterloo, ON, Canada

"Climate change is the defining issue of our time and, we are at a defining moment" was the opening statement of the United Nations Secretary General Antonio Guterres at the September 2018 General Assembly. Today, we fully recognize that climate change is one of the most pressing global issues facing the world. As the scientific understanding of human influence on the climate system is continually refined and the impacts become more apparent, action is catalyzing across all scales. We also recognize the ever-growing need for more energy for the growing population of the world as well as satisfying the needs of many sectors including industry, transportation, agriculture, etc.

This presentation provides a realistic analysis of the most up to date energy supply and demand picture and projections for the next decade. The current status of renewable energy capacity and potential of growth technologies will be incorporated into the possibility of carbon neutrality for many nations by 2050. To reach this goal, institutions and, more broadly, nations will need to align foundational directions that increase priority, improve transparency, provide financial support, and build capacity. These require action along several distinct carbon reduction pathways including efficiency improvement and reduction in energy consumption. Finally, the role of higher education institutions will be discussed to provide short and long term perspectives on the convergence of education, research and practice and how they align with institutional policy and systems toward the carbon-neutral goal.



## IEEES12 – KN2

## Novel Methods for Production Hydrogen from Industrial Wastewaters

**Prof. Dr. Ibrahim Dincer**
Professor of Mechanical Engineering
Ontario Tech University, Canada

As the humanity faces great challenges particularly about three primary Es (such as Energy, Environment and Economy), there is a strong need for cleaner solutions to move into a non-carbon based economy which is impossible to achieve it without hydrogen energy options. Of course, hydrogen is not a freely available element, and we essentially need disassociate it from water, although there are numerous other hydrogen sources which are potentially considered by many.

In this presentation, a prime focus is made on hydrogen production from industrial wastewaters by using renewable energy, such as solar energy. The methods considered are particularly thermochemical cycles and photoelectrochemical processes, and their developments, assessments and performance evaluations for various applications are also presented. Numerous cases studies and project results are presented to highlight the importance of innovative hydrogen production methods for better environment and hence better sustainability. Comprehensive life cycle assessment results are also presented to discuss the spectrums of various applications and implications.

## IEEES12 – KN3

## Integrated Footprints Accounting for Sustainability, Emissions and Plastic

**Prof. Dr. Jiří Jaromír Klemeš, Yee Van Fan, Xue-Chao Wang**
Sustainable Process Integration Laboratory – SPIL, NETME Centre,
Faculty of Mechanical Engineering,
Brno University of Technology
VUT Brno, Technicka, Czech Republic
Editor-in-Chief, Journal of Cleaner Production, Elsevier

The circular economy becomes an integrating part of present research directed to smart production and living conditions. The smart concept utilises information and communication (ICT) technologies to supply information for efficient management. It should target operations with less waste and emissions. An important issue for closing the circular economy loop is transforming waste into secondary raw materials while maintaining sustainability. This circularity integration should be an essential part of smart cities, which cannot exist without a smart industry and supplies from smart agriculture.

A number of issues have been raised, and the answers need to be considered:

- Increases with the urbanisation and population growth
- Smart is not just the Internet of Things (IoT), but a lot of engineering (including Chemical and Biochemical) solutions is needed
- Logistics and supply chains of people, materials, energy and waste
- Circularity at any cost of the minimum footprints?
- Footprints as credible assessment of the environmental impact
- Plastic – a friend or foe?
- 100% renewable or minimum GHG footprint
- GHG and/or NOx, SO2, PM - air pollutants
- Drawbacks of IoT (cyber risk and e-waste)

Rather than overstress on circularity as a goal, a more pragmatic vision would be focusing on meeting human needs (demand) and minimising the environmental impact, including consumption for reprocessing waste to the secondary raw material.



## IEEES12 – KN4

## Some implications of the 2nd Law and Its Application to LNG Liquefaction and Regasification Processes

**Prof. Dr. Yunus Çengel**
Professor Emeritus of Mechanical Engineering
University of Nevada, Reno, NV, USA

The share of liquified natural gas (LNG) in the international trade of natural gas is continually increasing. This presents increasing opportunities to build power plants to generate electricity at LNG regasification terminals rather than wasting the power generation potential of LNG at about -162°C by regasifying it by seawater, ambient air or by burning natural gas. Typically, over 5% of the natural gas received at LNG plants is used to liquify the remaining incoming gaseous natural gas at environmental conditions. Theoretically, all the energy consumed at LNG liquefaction plants can be recovered at LNG regasification terminals. In this study, the theoretical and practical power generation potential of regasified LNG is investigated by performing energy and exergy analyses. It is shown that up to 0.20 kWh of electric power can be generated during the regasification of LNG per standard m3 of natural gas regasified. The potential economic gains associated with power generation at LNG regasification facilities are demonstrated by analyzing the 2018 LNG imports of Turkey as a case study and the world. It is shown that the 314 million tons of LNG imported globally in 2018 has the electric power generation potential of 88 billion kWh with a market value of over 10 billion USD.

## IEEES12 – KN5

# Modern Methods for the Comprehensive Evaluation and Improvement of Energy Conversion Systems

**George Tsatsaronis**
Institute for Energy Engineering, Technische Universität Berlin
Marchstr.18, 10587 Berlin, Germany

In order to improve energy conversion systems, the designers and operators of such systems should understand what causes the real inefficiencies, costs, and environmental impacts associated with each system component and how these interact with each other. Methods that are based on the exergy concept are powerful tools for developing, evaluating, understanding, and improving energy conversion systems. This presentation deals with integrated exergetic, exergoeconomic and exergoenvironmental evaluations (exergy-based methods), which identify the location, magnitude and causes of inefficiencies, costs and environmental impacts, respectively.

In addition to the conventional methods, advanced exergy-based analyses consider (a) the interactions among the different inefficiencies, costs and environmental impacts within the overall system, and (b) the real potential for reducing these within each important system component. The main role of an advanced exergy-based method is to provide engineers with information useful for improving the system design and operation from the thermodynamic, economic and environmental viewpoints. Splitting the exergy destruction, the capital investment cost and the component-related environmental impact associated with each single component of a system into endogenous/exogenous and avoidable/unavoidable parts and using a further splitting of the exogenous exergy destruction improves (a) our understanding of the processes that take place, and (b) the quality of the conclusions for improvement obtained from the analysis.

In the presentation, the main features and some recent developments in the area of advanced exergy-based methods will be presented, and an application of these methods to an energy-conversion system will be briefly discussed.

# INVITED SPEAKERS

## IEEES12- IT1

# Thermal Optimization of Heat Transfer Performance Using Nano-technology: A Hybrid Thermal and Environmental Application

**Prof. Dr. Ziad Saghir**
Professor Mechanical and Industrial Engineering
Ryerson University, Canada

The thermal transport mechanism is a key element in thermofluid optimization fields. The heat transfer fluid plays an important role in heat absorption for various industrial applications such as in solar collectors, power plant condensers, electronics cooling, etc. The most common and widely used heat transfer fluid is ethylene glycol, water, and oil base cooling fluid. The major problem with these fluids is; it has a low thermal conductivity value, which produces poor performance in heat removal and cooling applications. It also has limited thermophysical properties. As such, a new approach is in need to be figured to maximize the heat absorption. The development of thermal transport fluid should be primarily focusing on having high thermal conductivity properties as it is vital to fulfilling the industrial requirement for massive heat transfer for cooling and heating purposes. A mixture of nanofluid and microencapsulated phase change material is proposed to be used for heat enhancement and heat storage. Bulk phase change material will also be presented and discussed.

**Keywords:** Nanofluid, Molecular dynamic, Hybrid fluid, Phase change material.



## IEEES12- IT2

# Performance improvement of silicon photovoltaic panels by application of cooling techniques

**Prof. Dr. Sandro Nižetić**
Professor, Faculty of Electrical Engineering, Mechanical Engineering, and Naval Architecture,
University of Split, Croatia

The importance of photovoltaic technologies in the necessary energy transition is more than evident due to the significant rise in annually globally installed PV capacities. The majority of market available photovoltaic (PV) technologies are silicon-based PV technologies with a current market share of more than 90%. Besides a relatively high investment cost and modest overall energy conversion efficiency, one of the main drawbacks related to siliceous based PV technologies is associated with performance degradation caused by the elevated PV panel operating temperatures during their regular operation. In the past two decades, different cooling techniques have been developed for SI- based PVs in order to check the potential increase in performance. Based on existing research findings, different active and passive cooling strategies for PVs are briefly elaborated and discussed from the techno-economic point of view, together with provided overview of the existing market available PV technologies. The necessity for the smart and hybrid cooling approach will be also addressed and discussed as a step further in the development of the more advanced and targeted cooling techniques for PVs.

## IEEES12- IT3

## Plasma Gasification for Better Environmental Sustainability

**Prof. Dr. Adnan Midilli**
Yildiz Technical University, Turkey

The paper focuses on plasma gasification technology for better environmental sustainability. In this regard, the followings will be introduced and discussed: i) Current status, the needs, and comparison of gasification technologies, ii) Introducing the arc plasma gasification technology in terms of environmental sustainability, iii) Some application examples of plasma gasification all over the world, vi) Importance and the key role of plasma gasification for better environmental sustainability. Accordingly, it is expected that the main findings from these important topics will be very useful for researchers to develop the innovative multi-purpose plasma gasification systems aiming at reducing the environmental emissions, and to produce the high-quality fuel from MSW and medical wastes. Thus, it is believed that these will make an important contribution to ensure environmental sustainability.



## IEEES12- IT4

## Some Fundamental Investigations for the Energetic Optimization of Stirling Engines

**Prof. Dr. Fethi Aloui**
Polytechnic University Hauts-de-France
LAMIH UMR-CNRS 8201
Campus Mont Houy - F-59313 Valenciennes Cedex 9 – France

In the energy and environmental context, the interest in improving the thermal performance of piston machines has known recently important developments. Indeed, piston machines have been used to develop several engineering applications: energy production, cogeneration and micro-cogeneration, automotive propulsion, and many other industrial systems. The improvement of these machines can be done only by understanding the flow t ransport/ transfer phenomena and especially the heat transfer induced by the movement of a piston inside the cylinder. Their development requires a complex diagnostic, and the engine test benches have the disadvantage of being expensive and time-consuming to install. The Stirling engine has the advantage of an excellent theoretical efficiency (close to the Carnot efficiency) and experimental (close to 40%), and which facilitates its coupling to any external heat source. A first Stirling Gamma engine type was already optimized by determining the characteristics of its most efficient regenerator. Different materials (stainless steel, copper, aluminum, and monel 400) for this regenerator are used. The objective is to determine the most suitable material, which can present the best compromise between maximizing the power of the engine and minimizing the asymmetry of the heat transfers in the regenerator. The study showed that stainless steel is the material that best meets these two conditions. Subsequently, we tested five stainless steel regenerators, but with different porosities (95%, 90%, 85%, 80%, and 75%). The optimized porosity, which makes it possible to give the best compromise between increased performance and reduced losses in the Gamma engine, has been retained. Thus, the 85% porosity stainless steel regenerator was chosen as the best compromise. A second test bench representing a conventional hybrid thermal/electrical engine, and which constitutes a powertrain with a driving simulator, can recover a large part of the thermal power contained in the ICE exhaust gases, and transform it into mechanical (then electrical) energy to satisfy any need. This system consists of a conventional internal combustion engine (ICE) bench coupled to a double-acting Stirling engine. A feasibility and congestion study of the installation was already studied. The main objective is to propose a solution, which can be adaptable to existing land vehicles by coupling a Stirling thermal engine for the production of electricity from the exhaust gases. This electrical energy can then be used for the battery charge and/or for any other need on the vehicle board. Many fundamental studies are expected and can be undertaken on this test rig of micro-cogene-ration, using either a Stirling engine and/or an Organic Rankine Cycle (ORC). An energetic and exergetic study on this test bench was done already done. It can lead to an optimal optimization of the Stirling engine functioning parameters.

## IEEES12- IT5

# A Review on Energy Storage Technologies with a Focus on Thermal Energy Storage: State of the Art and Prospects

**[1]Lounes Tadrist and [2]Rachid Outbib**

[1] Aix-Marseille Universite, Laboratoire IUSTI UMR CNRS 7343, Technopole Chateau-Gombert, 5, rue Enrico Fermi, 13453 Marseille, France

[2] Aix-Marseille Universite, LIS Laboratory, UMR CNRS 7020, 13397 Marseille, France

Renewable energies are by nature intermittent. For an optimal and well-controlled exploitation and use of these energies, it is necessary to develop storage techniques adapted to the considered applications. In spite of the numerous developments, this process remains one of the major technological challenges because there are still many scientific and technological locks that have not been properly resolved. During this conference, we will briefly review the existing storage techniques, specifying their potential and the fields of application where they are implemented. We will present the limits of the different techniques and the expected potential to enable a large-scale deployment of this energy management technique. The second part of the presentation will examine thermal energy storage. The storage of energy in this form remains a topical issue as thermal energy applications could be very numerous in the tertiary, industrial and transportation sectors.



## IEEES12- IT6

# Field Evaluation of Membrane Distillation Technologies for Desalination of Highly Saline Brines

**Dr. Altaf Hussain**

ConocoPhillips Global Water Sustainability Centre, Qatar Science & Technology Park

Membrane distillation (MD) is a novel desalination technology that has potential to produce distilled quality water from high salinity brine streams. The driving force for MD is the vapor pressure difference across a hydrophobic membrane resulting in transfer of water vapor from hot to cold side. The presentation covers pilot testing of two technologies side-by-side at a thermal desalination plant in Qatar. The integration of MD with humidification and dehumidification process (HDH) were also investigated in US for volume reduction of saline groundwater. The investigations concluded that while MD can produce distilled water quality, the energy efficiency remains the key bottleneck for future deployment of MD. Membrane wetting and fouling also presents key challenges for desalination due to both the high salinity and the presence of organics in the feed water. In addition to water desalination, hydrophobic membrane has a wide range of industrial applications such as hydrogen sulfide removal, the treatment of wastewater from the pharmaceutical, metal finishing industries, direct sewer mining, oily wastewater, and water recovery from flue gas. The presentation also shed lights on emerging nanomaterials (e.g., carbon nanotubes, graphene) to increase hydrophobicity (reduction of membrane wetting) and increase mass transfer rates (increase flux and lower cost).

# ORAL PRESENTATIONS

## IEEES12- P004

## Innovative Cooling Technique Mono and Hybrid Nanofluid in Porous Mini channel: Experimental and Numerical Approach

**[1]M. Ziad Saghir, [2]M. Mansur Rahman**
[1]Department of Mechanical Engineering, Ryerson University, Canada
[2]Dept of Mathematics, Sultan Qaboos University, Oman

As a result of increasing power demands and the decreasing size of computational hardware, the need for an effective cooling technique is more urgent now than ever. Despite this need, there is insufficient research on porous metal foams operating as liquid cooling heat sinks within electronic systems, and documented cases where the results are reported and verified using both experimental and numerical analyses. An experiment has been conducted in a microchannel filled with porous metal foam and mono nanofluid. The heat transfer enhancement was investigated for different flow rates and different concentrations of mono nanofluid of water and $Al_2O_3$ nanoparticles ranging from 0.1% to 0.6%. Three different heat fluxes were tested in the experiment. Numerical comparison with experimental data showed a good agreement. Pressure drop, as well as the friction factor, were investigated in detail. The numerical model was repeated for the hybrid nanofluid of $Al_2O_3$ and Cu. Results revealed an improvement in heat enhancement leading to the belief that such a mixture is suitable for heat removal. Detailed performance of heat enhancement between pure water and mono nanofluid and hybrid nanofluid will be discussed in detail.

**Keywords:** Nanofluid, forced convection, hybrid fluid, heat enhancement, micro-channel, porous medium



## IEEES12- P009

## Solar Energy Potentials in Southeastern European Countries: A Case Study

**[1]Abdulsalam Alkholidi, [2]Habib Hamam**
[1]Telecommunications Engineering Department, Faculty of Engineering, Canadian Institute of Technology, Rr. Andon Zako Cajupi, (Near Wilson Square), Tirana, 1001, Albania
[2]Optics in Information and Communication Technologies, Faculty of Engineering, Moncton University, Campus de Moncton, Pavillon Leopold-Taillon, 18, avenue Antonine-Maillet, Moncton, NB Canada E1A 3E9

The climate in Southeastern European countries is relatively similar to that of the Middle East and North Africa, where the annual sun irradiation is theoretically high, according to SolarGIS data. Today, the photovoltaic systems technology sector is exponentially expanding in the international energy market. This paper aims to study, compare, and analyze this important field in related countries and propose solutions to develop and encourage a solar energy market in Albania, where the economy has been gradually increasing in the last ten years. The potential for a renewable energy sector in Albania is promising, mainly because of the important presence of wind and solar energy resources. An additional objective of this study is to try to apply the results obtained in similar countries in the Balkans to increase the socio-economic benefits and the creation of job opportunities in the country, as well as contributing to the protection of the environment and economic growth. In this paper, we discuss the importance of exploiting photovoltaic systems in mountainous regions and villages –where public electricity is unavailable – to be widely used in heating, lighting, and irrigation, as well as to support grid systems. In addition, the advantages of photovoltaic technology are introduced and illustrated to motivate public establishments and government-owned electrical sectors to use and develop this technology.

**Keywords:** Heating, education, clinics, home lighting, irrigation, mountainous areas, floating solar.

## IEEES12- P010

## Complexity and Use in the Built Environment: Post-occupancy Evaluation and Proposed Design Alterations for Qatar University's Most Iconic Building

**Mark David Major, Doha Elsaman, Lolwa Al-Mohannadi, Meera Al-Khulifi, Shaikha Al-Thani**
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Constructed in the 1980s using a modular design concept by Egyptian architect Kamal El-Kafrawi, the Building Corridors (BCR) at Qatar University is the most iconic building on the campus, even incorporated in the university's official logo. However, the BCR Corridors are also notorious for presenting way-finding difficulties for end-users. These navigation problems derive from the repetitive similarity of individual parts in the modular design; stairwells, screens, and temporary installations, creating impediments to user readability and visibility; and, the relationship of the BCR Corridors to the immediate surrounding context of the university campus. Recently, faculty and student researchers at Qatar University conducted the post-occupancy evaluation (PoE) of the BCR Corridors. The PoE study included 1) direct observations of movement flows including entry counts at the building perimeter and static occupation of space (i.e., sitting, standing, and interacting) in common areas, 2) extensive room use and photographic surveys, and 3) computer modeling of the spatial layout in the building using space syntax. Space syntax is an international research program of academics and industry practitioners scientifically investigating, mathematically quantifying, and better understanding the role of built space in society from a single building to entire cities based on network science. Space syntax is based on a set of techniques for the simple representation and mathematical measurement of architectural and urban space. The purpose of the study was to: 1) better understand the observed patterns of movement and space use especially with reference to the widely-known problems for navigation and way-finding in the BCR Corridors; and, 2) develop design alteration proposals (some cosmetic, others substantial) to enable easier use of the building complex.

**Keywords:** Educational buildings, innovation, navigation, post-occupancy evaluation, space syntax.



## IEEES12- P011

## Acetylene as an Alternative Fuel for IC Engines- Production Methodology and Performance Tests

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The prime objective of this research work is twofold, which would ultimately ascertain Acetylene gas as a viable alternative fuel in the place of conventional fossil fuels. The first part is the production of acetylene gas at different experimental conditions in order to determine the most favorable yield conditions. The method appertaining to the generation of acetylene from the heat emanating reaction between water and calcium carbide is adopted, taking into account its simplistic and expedient nature. Several trials were conducted by varying the type of water (normal, salt and distilled) used in the reaction and also, at different temperatures. Analyzing the trend of the production curves, the optimal yield was substantiated. The other important part of the research work is subjecting acetylene to various performance tests in an internal combustion engine, testing its compatibility to be used as a fuel. These tests were conducted on a 1.1 kW rated Greaves MK 12/2 HSPP engine. This engine was coupled to an alternator, and various performance parameters, such as brake power and rotational speed were attained by varying the electrical loads at periodic intervals. These studies were performed on gasoline and kerosene as well, for comparison purposes. It was noted that that the rotational speed of the engine running on acetylene was around 23% higher than the speed with gasoline, at a maximum electrical load of 1000 W. Brake power, which follows a similar trend, was found to be greater with acetylene as the primary fuel. Theoretical prediction of indicated power by making use of calculated adiabatic indices leads to the calculation of frictional power. A notable increase in thermal efficiency by 8.4% and 12.4% favored acetylene over gasoline and kerosene, respectively. An extensive study was thus accomplished and acetylene is advocated to help bridge the gap between conventional IC engines and hybrid-electric engines.

**Keywords:** Alternative fuel, acetylene, water, calcium carbide, rotational speed, brake power, indicated power, frictional power, thermal efficiency.

## IEEES12- P016

## Study of Methane Enrichment in a Biogas Fuelled HCCI Engine

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Biogas is one of the promising alternative fuels for IC engines. However, the presence of $CO_2$ in biogas reduces its calorific value and ignitability. The removal of $CO_2$ from biogas is called methane enrichment. In this study, a conventional single cylinder CI engine is modified for HCCI operation. Biogas is used as the primary fuel. It is premixed with air in the intake manifold and inducted into the cylinder. DEE is used as the secondary fuel to initiate auto-ignition. It is injected at the inlet port, and injection timing and duration are varied using an electronic control module. Performance and emission characteristics such as brake thermal efficiency, equivalence ratio, HC, CO, NOx, and smoke emissions are compared for operation with raw biogas (50% methane) and methane enriched biogas (100% methane) for various biogas flow rates and engine torques. Methane enrichment improves brake thermal efficiency, HC, and CO emissions. Ultra-low NOx and smoke emissions can be obtained using raw biogas as well as methane enriched biogas. The maximum improvement in brake thermal efficiency is observed at a high biogas flow rate. A 12% improvement in brake thermal efficiency is observed while using a biogas flow rate of 10 lpm.

**Keywords:** Methane enrichment, HCCI, DEE, smoke, NOx, and biogas.



## IEEES12- P017

## An Overview of the Solar Potential in Qatar: From Theory to Practice

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The Arabian Gulf countries is considered as one of the richest areas in the world in terms of solar irradiation. We could find rapid economic growth in Qatar in the past few decades, and Qatar has shown significant growth in the renewable energy sector in the past five years. The present work is a review of several scientific papers and reports related to solar energy potential in Qatar as well as ongoing and future projects. Recently, several research works have been taken-up to develop this important renewable energy sector. The objective of this paper is to illustrate some of published research in solar energy, what have been achieved so far and practically focus on the most important areas of the solar energy utilization, development of short-term plan to integrate them in the reality, namely: solar distillation, solar cooling, solar pumping, solar furnaces, solar cooking, e-vehicles and generation of solar energy to support. The investment in solar panel manufacturing and energy storage in the Qatar is one of the goals of this study. This study recommends fabricating PV cells and modules in Qatar due to that all necessary conditions are available using for example Singapore approach in the localization of technology.

**Keywords:** Renewable energy, solar energy, PV technology, solar energy projects of Qatar, solar powered vehicles.

## IEEES12- P019

## Solar Thermal Vapor Adsorption Experimental Simulation Setup - Exergy Analysis

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Solar thermal adsorption refrigeration systems use solar energy to produce refrigeration effect. This system enables us to provide air conditioning and refrigeration in remote places. The most common refrigerants used in solar adsorption refrigeration systems are water and methanol. Being noiseless, non-corrosive and environmentally-friendly, there is lots of research going on to increase the efficiency in order to attain performance equal to the vapor compression refrigeration system. This paper emphasizes on an experimental study of the single-stage adsorption system. This report presents the experimental investigation of a novel solar adsorption refrigeration system. The system is tested with two working pairs, silica gel-water and activated carbon-ethanol, in VIT campus, Vellore (12.9718° N, 79.1589° E). Simulations for irradiation and refrigerant properties are done in MATLAB software to study the operating parameters. The novel design consists of an evacuated tubular collector (ETC), which is used the adsorbent bed, and a copper tube with fins and 1 mm wide holes are inserted in ETC to facilitate the passage of the refrigerant. The experiments were carried out in March 2018. The silica gel-water system attained solar COP and SCE of 0.169 and 275.88 kJ/kg, respectively. The activated carbon-ethanol system was enhanced by an (LTC) Linear Trough Concentrator and attained solar COP and SCE of 0.034 and 534.2 kJ/kg, respectively. Exergy analysis of the simulated results was carried out, and results are discussed.

**Keywords:** Solar vapor adsorption, activated carbon, ethanol, linear trough concentrator, exergy analysis.



## IEEES12- P024

## Fabrication and Characterization of Sensor Devices Based on Graphene Decorated with Metal-Oxide Nanorods

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We report on the production of selective and sensitive gas sensors produced using graphene decorated with semiconducting copper oxide (CuO) nanorods. In this work, three types of sensors were fabricated based on graphene grown on $SiO_2$/Si substrates, CuO nanorods, and graphene grown on $SiO_2$/Si substrates decorated with CuO nanorods. The nanorods were fabricated chemically and deposited on substrates: graphene/$SiO_2$/Si, or glass slide substrates. The fabricated sensors were tested for their sensitivity and selectivity against $H_2S$ and $H_2$ gases. The results reveal that sensor devices based on CuO/graphene/$SiO_2$/Si were sensitive and selective to $H_2S$ with low concentrations in the range of 10 ppm. In addition, the sensors could detect $H_2S$ gas at low temperatures that demonstrate their low power requirement. The fabricated sensors have the capability for practical applications in fields that include emission of $H_2S$ gas, such as petroleum production facilities and refineries.

**Keywords:** $H_2S$ sensors, graphene, CuO, nanorods, devices

## IEEES12- P029

## Optimal Solar Hybridization of A Grid-Connected Gas Turbine Combined Cycle Power Plant: A Case Study

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The world is moving toward sustainability, but it may require many years for sustainable energy systems to dominate the market. Many fossil fuel power plants are in commission right now and will be in service for decades to come. Integrating solar thermal to fossil fuel power plants can diminish emitted greenhouse gases and fuel consumption. The efficient integration of solar energy into conventional power plants plays a vital role in persuading investors and owners to provide finance on such projects. The biggest challenge facing the process of integration is the capital cost of modifications for making conventional combined cycle powerplants capable of integration. In this paper, three configurations have been proposed for adding solar thermal energy to the heat recovery steam generator (HRSG) of a gas turbine combined cycle GTCC power plant. The attempt is made to determine the best configuration of the solar cycle regarding the performance, thermodynamic efficiencies and economic indices in a way that the primary cycle faces with the least modifications and capital costs while it provides the highest cash flow and augmented power during the operation lifetime.

**Keywords:** First-law analysis, exergy analysis, economic assessment, ISCC, optimization.



## IEEES12- P030

## Optimized PV Power Curtailment Technique with Absolute Fairness to Eliminate Voltage Rise in Low Voltage Distribution Systems

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The steady proliferation of PV sources within low voltage (LV) distribution systems requires more attention from power systems planners and operators to address all emerging operation challenges. One of the main challenges that could be faced in these systems is the voltage rise due to PV reverse power flow toward the grid. In many cases, PV power curtailment could be the most effective approach to eliminate the voltage rise since LV lines have high resistance to inductance ratio besides the fact that the power curtailment feature is supported by most of the PV inverters. In this paper, a combination of distributed and central control approach is proposed to address the voltage rise in LV systems. The distributed control is used to ensure a high level of operational reliability while the central controller aims to optimize the performance in the long term. The performance is optimized by maximizing the PV power harvest while ensuring a high level of fairness when the power of the source is curtailed within the considered LV system. Messages exchanged with smart meters installed for each PV source is used to achieve the required performance where every PV source is compensated for its fed back as well as its curtailed power. The system's effectiveness is verified by a number of case studies.

**Keywords:** Photovoltaic, voltage rise, power harvest maximization, curtailment fairness.

## IEEES12- P032

### Sustainable Buildings Components: A Technical Review of Green Roofs (GFs)

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Urban development involves environmental, socio-cultural, and economic concerns that are affecting human wellbeing, comforts, and the sustainability levels of cities. Greening the city and its buildings is not a new notion; in fact, it is an old-traditional system that is re-discovered to address and improve deleterious impact on the urban environment sustainably and naturally. Greening has its roots in the natural environment, and it can also be incorporated significantly within architecture and design, particularly applied as a part of the wall and roof. The vertical and horizontal systems are becoming popular as they are evolving. In the last years, the quantity of studies distributed in the scientific writing on this point, including both living walls and roofs, has rapidly expanded. The process of injecting the concept of design and development of green elements in design allows for a more healthy, sustainable urban space and improves the overall quality of life. This paper aims to offer an extensive analytical review of various systems using the SWOT (Strengths, Weaknesses, Opportunities, and Threats) analysis tool of these green elements. The analytical review of these systems would be valuable to architects, planners, and urban designers, by way of investigating the most suitable green design possibilities in Doha, Qatar.

**Keywords:** Sustainable buildings (SBs), construction components, green roofs (GFs), SWOT analysis.



## IEEES12- P037

### Development of Transition Metal/Alloy Nanoparticles/ Nanoclusters for Water Splitting as a Sustainable Source of Energy

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Fossil fuels, currently the leading source of energy, subsidize a lot of $CO_2$ to the environment causing many environmental issues including the greenhouse effect. To address these challenges, there is a dire need to develop alternative and renewable resources of energy. Water, being a renewable source, is a promising candidate in this regard because of its ability for the production of $H_2$ (HER) and $O_2$ (OER). OER is the $4e^-$ multistep process with a demand of 240-600 mV extra energy, which makes it more sluggish kinetically. Until now, $RuO_2$ and $IrO_2$ are among the best electrocatalysts for OER with minimum overpotential. Because of poor stability, unavailability and high cost, these electrocatalysts are not much appreciated for large scale applications in the water-splitting system. Therefore, recently an extensive focus of researchers in this field has been to develop more effective and low-cost OER electrocatalysts, especially those based on earth-abundant transition metals. Because of suitable redox properties of transition metals such as cobalt, nickel, iron, and copper, they have a great potential to be used as effective electrocatalysts for water oxidation. Ni, Co, Fe, and their alloys have been evaluated for water oxidation, but their unsatisfactory activity or instability, as well as poor understanding of the structures of active sites, stimulate further exploration of new electrocatalysts with higher activity, better stability, and lower cost. Herein, we have designed and synthesized inexpensive bi-metallic NPs/NCs using a microwave-assisted method and characterized by X-ray Powder Diffraction (PXRD) and Scanning Electron Microscopy (SEM). These catalysts show superior OER activity in alkaline solution with low overpotential to achieve a current density of 10 mA $cm^{-2}$, and their small Tafel slope suggests the kinetics favorability of the sluggish reaction. These findings demonstrate significant progress in the development of Ni-based nanostructured electrocatalysts that can be used in the alkaline electrolyzer.

**Keywords:** Electrocatalyst, water splitting, oxygen evolution reaction (OER)

## IEEES12- P038

## Resource Provisioning in Plug-in Electric Vehicle Charging Lots

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As the interest in plug-in electric vehicles increase, the design of sustainable charging facilities becomes critical to support mass-market uptake. In this paper, we consider two design problems for plug-in electric vehicle (PEV) charging lots. In the first one, it is assumed that the charging lot is located at a workplace, and PEV arrival statistics are estimated in advance. The goal is to calculate the size of the total incomer feeder from the substation to the charging lot. In the second problem, we consider the case where the parking lot is located in a busy area and the station is fed by a fixed capacity. In this case, the goal is to calculate the optimal arrival rate that maximizes a revenue function composed of financial parameters such as waiting and electricity costs. In both cases, PEV arrival and departures are assumed to follow a Poisson process, and unique optimal solutions are analytically calculated. Presented case studies provide useful insights in this early stage of designing the charging stations of the future.

**Keywords:** Plug-in electric vehicles, resource planning, stochastic modeling.



## IEEES12- P040

## Performance and Emission Characteristics of A Biogas Fueled Dual Fuel Engine with Various DEE Fractions

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Biogas is preferred as an alternative gaseous fuel on account of its ease of production, low price, and a significant reduction in net carbon emissions. The use of biogas in a dual-fuel mode in Compression Ignition (CI) engines helps in reducing particulate matter and $NO_x$ emissions simultaneously. The extent of completeness of combustion can be enhanced by increasing the oxygen content of the fuel. This is usually achieved by blending oxygenated compounds such as Di-Ethyl Ether (DEE) with diesel. DEE is a liquid at ambient conditions and has a cetane number of 125, making it easy to handle and an ideal choice for CI engines. This study involves the experimental evaluation of the performance and emission characteristics of a single-cylinder, water-cooled, four-stroke, constant-speed CI engine operated in dual fuel mode with biogas as the primary fuel and diesel-DEE blends containing up to 9% DEE by volume as the secondary (pilot) fuel across the engine load range. The flow rate and composition of biogas are also varied. It is observed that using a 3% DEE-diesel blend along with a low intake of methane-deficient biogas improves brake thermal efficiency by up to 3%. Blended diesel shows better $NO_x$ and CO emissions.

**Keywords:** Biogas, dual fuel, DEE, efficiency, smoke, and $NO_x$.

## IEEES12- P056

## Exergy Analysis of a Biogas Fuelled Dual Engine

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Since the fuel's heating value is different from its total exergy (chemical as well as thermo-mechanical exergy), an exergy analysis provides a finer insight into the processes and throws light on areas where excessive exergy destruction is taking place. This helps in focusing on those areas where more useful energy is being lost. In the present study, a biogas-diesel fuelled dual-fuel engine is used for exergy analysis. Simulated biogas (a mixture of methane and $CO_2$) is used instead of raw biogas. Single-Cylinder water-cooled four-stroke CI engine is used. Biogas is inducted through the intake manifold, and diesel is injected by using conventional diesel injectors. The purified form of biogas (Methane) and variable methane: $CO_2$ ratios are used. Methane flow rate, methane enrichment, and load are considered as input variables. In this study, along with the energy analysis, a detailed exergy analysis has been carried out, and the 2nd law efficiency, as well as the exergy destruction in each case, has been found. The 2nd law efficiency was slightly lower than the 1st law efficiency and ranged from 16 to 39%. Exergy destruction is found to be in the range from 47 to 80%. Methane enrichment and an increase in load provide lower exergy destruction. Lower biogas flow rate (3 lpm) provides better performance with lower energy destruction compared to diesel-only mode. An increase in biogas flow rate increases the percentage of energy destruction.

**Keywords:** Biogas, dual fuel, exergy, 2nd law efficiency, exergy destruction.



## IEEES12- P058

## Metaheuristic Approaches for Solving the Energy Optimization Problem of Multiple Stage Evaporator System

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With the colossal proliferation of energy requirements, bourgeoning global warming concerns, and flourishing expenses of energy supplies, the present era proclaims towards the utilization of renewable energy sources for guaranteeing sustainability. In addition, the emphasis is on the enhancement in the energy efficiency of energy-intensive industries. Black liquor derived as a waste residual stream during the Kraft recovery process in Pulp and Paper mills is an incipient biomass energy resource. With an eye to produce a combustible material, black liquor is evaporated to high dryness in a Multiple Stage Evaporator (MSE) system, which is the premier energy-intensive unit in Pulp and Paper mills. Thus, the energy optimization of the MSE system is an attention-grabbing concern pertaining to the contemporary global energy scenario. This kindles our attention to maximize Steam Economy (SE) and abate Steam Consumption (SC) by precise steady-state modeling and simulation of MSE. The energy efficiency parameters SE and SC are governed by numerous operating parameters comprising liquor flow rates, the amount of fresh steam input, and temperatures of the vapor generated at each stage. Hence, the optimum values of these parameters reflect the optimum process of energy efficiency. With this insight, the present work reconnoiters the non-linear modeling and simulation of Heptads' Effect MSE operated in the backward feed flow configuration. We present an innovative solution in the quest of optimum unknown process operating parameters via metaheuristic optimization approaches. Optimizers, including Particle Swarm Optimization and Ant Colony Optimization, have been exploited for the energy optimization of MSE. The simulated results demonstrate the robustness, efficiency, and exploratory capabilities of these metaheuristic approach to search the best estimates of unknown process variables. Tabular, evocative and graphical demonstrations have been utilized for comparative analysis of these metaheuristic approaches with reference to various performance parameters of MSE.

**Keywords:** Multiple stage evaporator, energy optimization, steam economy, steam consumption, metaheuristics, particle swarm optimization, ant colony optimization.

## IEEES12- P059

## Metaheuristic-Driven Optimization for Solution of Dynamic Model of Multiple Stage Evaporator System of Paper Mills

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Multiple Stage Evaporators (MSEs) used in paper mills for concentrating the black liquor to produce a combustible material are premier energy-intensive units. The enhancement in the energy efficiency of MSE is prominently accentuated attributable to the contemporary energy scenario. Moreover, tight and appropriate control is essential in order to encounter the necessities for a worthy product quality along with the assurance of optimum energy efficiency. A thorough understanding of the system dynamics is indispensable for the design of an accurate and appropriate control algorithm for effective set-point tracking and disturbance rejection. In order to investigate the open-loop dynamics of MSE, it is mandatory to ascertain the steady-state operating parameters for simulating the dynamic model of the system. Henceforth, in advance of analyzing the system transience, the steady-state analysis has been performed. The optimum steady-state operating parameters are acquired by simulating the nonlinear steady-state model encompassing simultaneous non-linear algebraic equations (SNLAEs). The present work investigates the non-linear dynamic modeling of Heptads' stage based MSE, and further, it has been simulated to obtain the transient response of the system. The dynamic model involves simultaneous non-linear ordinary differential equations (SNLODEs) of the first order. These SNLODEs are represented as an optimization problem by means of elementary ideas of Fourier series expansion along with a metaheuristic approach to yield their approximate solutions. The rigorous simulation of the dynamic model aids in the analysis of the open-loop dynamic behavior of the overall system. For simulation work, Water Cycle Algorithm (WCA), a metaheuristic approach has been exploited to solve these SNLAEs and SNLODEs. The simulation results of steady-state and dynamic models of MSE succor in the selection and design of an efficient control algorithm for optimizing the steam economy and monitoring the quality of the product.

**Keywords:** Energy optimization, metaheuristics, multiple stage evaporator, steam economy, non-linear dynamic model, water cycle algorithm.



## IEEES12- P062

## Integration of Solid Oxide Fuel Cell with Flare System in Natural Gas Plant

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The oil and gas industry produces a lot of destructive gasses that cause irreversible natural effects and mainly from the flare gas releases. Gas flaring is one of the most harmful reasons for worldwide contaminations, which has a global warming effect and causes environmental changes. Thus, lessening or disposing of the consumption of flare gases is a decisive strategy to annul the GHG gas level increments. Likewise, the use of flare emissions promises a clean power generation opportunity in oil and gas plants. Accordingly, flare gas reduction, and utilization is fundamental since it meets both natural and financial effectiveness objectives. A few flare gas utilization choices are available, for example, gas-to-liquid (GTL) conversion in addition to others. One of the promising technologies right now is the Solid Oxide Fuel Cell (SOFC). SOFC has been demonstrated to be a profoundly useful electrochemical device that legitimately changes over substance power into electrical power with the possibility to expand framework efficiencies and to lessen releases of harmful gases. The SOFC can be incorporated into the flare structure where the flare gas is utilized as a fuel to the SOFC to produce power. This application in gas plants will require some adaptation by considering the safety and wellbeing of the plant. A techno-economic analysis is performed for this application and the outcomes show that a decrease of practically 70% in the outflows from the flare is possible and it can generate power up to 20 MW for the gas plant utilizing a waste fuel. This consideration will improve and energize the integration of SOFC devices in oil and gas plants for greener operations.

**Keywords:** Electricity, emissions, flare, GHG, natural gas, purge gas, SOFC.

## IEEES12- P072

# Exergy and $CO_2$ Emissions Analysis of an Emerging Alternative Iron and Steel Making Process

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The depletion of coking coal reserves, generation of ore/coal fines, and growing environmental concerns motivated researchers to search for coke-free ironmaking processes using ore/coal fines leading to alternative routes of ironmaking. In this way, several alternative routes of ironmaking have evolved. Rotary hearth furnace (RHF) processes are the emerging alternative routes of ironmaking since it is reported that these processes consume lower energy with lesser $CO_2$ emissions compared to conventional ironmaking process but resource-based energy utilization efficiency has not been reported. Thus, there is a need for exergy analysis beyond emission/energy profiles. The final product of the RHF processes could be either directly reduce iron (DRI) or nugget depending on the process parameters, and those are further smelted in electric arc furnace (EAF) to produce steel. Model-based exergy and $CO_2$ emissions analysis of both variants of RHF-EAF iron and steel making processes are studied. All the thermodynamic data used has been estimated with the help of thermodynamic software FactSage. In the present study, three kinds of exergy indices are measured: total exergy loss, metal-based exergy efficiency, and metal+gas-based exergy efficiency. For the nugget based RHF-EAF process, these exergy indices are found as 6802 MJ/tcs, 37%, and 73%, respectively, whereas for the DRI based RHF-EAF process, those values are calculated as 8549 MJ/tcs, 33%, and 65%, respectively. Results indicate that nugget based RHF-EAF process is superior to the DRI based RHF-EAF process. However, exergy indices of RHF-EAF systems are either superior or comparable (depending on RHF product) to conventional iron and steel making process. In order to calculate the $CO_2$ emissions from the RHF-EAF processes, carbon flows in RHF and EAF; and electricity demand in EAF are investigated. Net total $CO_2$ emissions through both the RHF-EAF processes are estimated to around 1.85 ton/tcs which is comparable to conventional iron and steel making processes.

**Keywords:** Iron and steel making, exergy analysis, exergy loss, exergy efficiency, $CO_2$ emissions.



## IEEES12- P073

# Experimental Investigation of Heat Transfer Characteristics of A Gravitational Water Vortex Flow

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A free vortex is naturally generated under the force of gravity by introducing water in a cylindrical tank with a small hole at the bottom and is called gravitational vortex flow (GVF). To date, only the hydraulic energy of GVF has been converted to mechanical energy despite the fact that a huge potential of thermal energy transfer also exists for such artificially induced vortex flows. For this purpose, another fluid stream may be introduced on the outer periphery of the basin responsible for vortex formation. In the present study, two flow configurations to exchange heat using a GVF are designed and experimentally tested on an in-house built experimental setup. One of the configurations uses spiral flow channels (SFC) built around the basin whereas the other design involves a shell with baffles (SWB) to direct the flow on the outer periphery of the basin. Two sets of experiments, each comprising of seven test conditions for each configuration were performed under different inlet conditions on the developed heat exchange setup of GVF. At first, an energy balance between the two fluids was investigated, and then the same data was utilized to develop the Nusselt number correlation for the GVF heat transfer. Since the flow volumes of the two streams involved in the heat exchange are vastly different and thus requires more time of contact between the two fluid streams. For this reason, the SWB configuration showed better heat transfer and closer energy agreement than SFC design. The present study is expected to act as a benchmark for the new class of heat exchangers based on a new flow configuration, i.e., GVF.

**Keywords:** Energy balance, spiral flow channels, basin, shell with baffles, gravitational vortex flow.

## IEEES12- P074

## Error Correction of Estimation Techniques in a Synchro-Phasor Measurement Unit

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More efforts may be needed to develop models of Phasor Measurement Unit (PMU), which may be utilized in smart grid simulation (offline) or real-time implementation without the need for spending another effort to update the model algorithm when the system parameters change. It is necessary to use a method that can somehow estimate the frequency and correct the phasors. The easiest and convenient way to determine frequency is to detect zero crossings per unit time. However, this method may require a very high sampling rate to capture the point of zero crossings along with some form of interpolation, which might increase the cost and reduce the accuracy. Also, after determining the frequency, the phasor should be correctly estimated by suitably modifying the algorithm without omitting any data which might be critical.

The approach that has been developed in this research work is to generate a configurable input signal, sample it and use the different estimation techniques such as Discrete Fourier Transform (DFT), Sliding Discrete Fourier Transform (SDFT) to estimate the phasors. These estimated values would be incorrect if the input signals are at an off-nominal frequency, and the phase angles would drift away from the true values. To correct this issue, first of all, the off-nominal frequency has been estimated using different estimation techniques such as Least Error Squares, Kalman Filters, Demodulation, and Phasor measurement angle changing and then use it to correct the phasors. The developed PMU model has been verified by simulation first using Matlab and then implemented in a real-time framework using FPGA based NI card and LabVIEW. The obtained results show that the correction has been improved by 0.8 percent.

**Keywords:** Discrete Fourier Transform (DFT), least error squares, keyword, FPGA, LabVIEW.



## IEEES12- P077

## Energy-Efficient Retrofitting Strategies for Hospital Building for Heating Season

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In this study, the current energy consumption values of Balikesir University Health Application and Research Hospital were examined, and methods for reducing energy consumption during the heating season were determined. The building was modeled using the Design-Builder simulation program, and user density, HVAC system, lighting, insulation, and window types were entered into the program, and simulated and actual energy consumption were compared. Then, the saving potential for the heating season was determined by the external wall, and roof insulation, changing the windows and shading devices. The saving potential was determined between 4.88% to 7.84% by changing the roof and external wall insulation, and 0.56% to 12.59% by changing the window types. However, shading devices increased energy consumption between 2.04% to 5.09%.

**Keywords:** Thermal insulation, building energy-saving, design-builder.

## IEEES12- P078

## The Life Cycle Assessment Related to Insulation Thickness of External Walls of the Hospital Buildings

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In this study, energy savings to be gained by the insulation of the external walls of hospital buildings are examined according to the Turkish Building Insulation standard (TS 825) which is renewed in December 2013. In addition, life cycle total cost (LCT) and life cycle savings (LCS) are calculated. In the literature generally, energy saving, life cycle total cost (LCT), and life cycle saving (LCS) values due to insulation thickness are calculated for the external walls of residences. In this study, these calculations were made for hospital buildings with high usage areas and external surface areas. Unlike the residences, the hospital buildings indoor temperatures should be 22 to 24°C during the heating period according. According to TS 825, Balikesir University hospital building in Balikesir province stated in the 2nd zone. Depending on these, the degree-day values of 2nd zone are calculated for the heating season. The basic temperature for the cooling period degree days is accepted as 22°C for TS 825, and 24°C for ASHRAE and the cooling degree-day values are calculated. Finally, the optimum insulation thickness was determined for the external walls of the hospital buildings. The degree-of-day method is used in calculations. Extruded polystyrene (XPS), Expanded polystyrene (XPS), glass wool (GW), rock wool (RW), and polyurethane are used as insulation material. Optimum insulation thickness is the lowest polyurethane insulation material in the highest glass wool insulation material.

**Keywords:** Life cycle assessment, TS 825, thermal insulation, building energy saving.



## IEEES12- P079

## Minimum Insulation Thickness to Prevent the Condensation of Building Outdoor Walls in a Different Direction

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The minimum insulation thickness should be calculated to prevent condensation on the external walls according to the type and property of the insulation material. This thickness is the thickness at which the saturation pressure in the insulation layer of the external wall is greater than the partial pressure. Both heat and mass transfer equations are used in the calculations. In the study, for minimum insulation thickness calculations, cities in five different climate zones were selected according to Turkish Insulation Standard TS 825. The coldest air temperature was determined from January which was the coldest month according to the average outdoor air temperature, relative humidity and wind speed values. The solar radiations in different directions were taken from TS 825. The outdoor solar-air temperature was calculated based on different directions in outdoor walls depends on the outdoor surface, emissivity and absorbance of solar radiation. The outdoor surface has been accepted as white and black painte. In the literature, generally, solar air temperature is not used for condensation calculations for outdoor walls. Expanded polystyrene (EPS) was chosen as insulation material and horizontally perforated bricks and tile were selected as a wall material.

**Keywords:** Outdoor wall insulation, condensation on outdoor walls, solar-air temperature

## IEEES12- P082

# De-watering of Microalgae through Auto-flocculation for Sustainable Biofuels Production

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Microalgae de-watering accounts for 30% of the total biomass processing cost. This study aims to investigate auto- flocculation as an economical route of de-watering. Auto-flocculation is driven by algal organic matter (AOM), which depend on the microalgae growth age. It found that Ettlia sp. microalgae, in exponential produce 96% loose bound AOM (LB-AOM), and 4% as cell-bound AOM (CB-AOM). LB-AOM reduced to 46%, and CB-AOM increased to 54% in the stationary phase. The removal efficiencies (R.E) were 83% and 66% in exponential and stationary phase, respectively. The difference in R.E could be attributed to biomass concentration and the composition too. It is further unravelled that biomass concentration shows no significant impact on R.E ($P<0.01$). However, the biomass composition showed a negative impact on the R.E, as CB-AOM inhibited R.E. In practical, biomass harvesting is carried out in a stationary phase, which must be improved. To this end, it turned out that the addition of a small amount of calcium (17 mg/L) in the stationary phase dramatically increased the R.E up to 90%. The auto-flocculation concept was applied for Chlorella sp. too, but here AOM showed a positive impact on R.E. Co-harvesting of flocculating (Ettlia sp.) and non-flocculating (Chlorella sp.) microalgae did not improve R.E. Thus, the outcome of this study provides a baseline to employ auto-flocculation concept in different growth stages of microalgae to achieve high removal efficiency.

**Keywords:** De-watering, microalgae, auto-flocculation, organic matter, harvesting.



## IEEES12- P083

# Entropy Generation of a FLiBe Molten Salt Modular Nuclear Reactor Cooled by Supercritical Carbondioxide

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The main objective of this study is to investigate the entropy generation of cooling a FLiBe modular nuclear reactor with $sCO_2$ secondary coolant. In this regard, the cooling and power generation cycles of a 200 MW thermal powermodular nuclear reactor with $LiF\text{-}BeF_2$ salt as the main coolant are designed. Consequently, electricity production and energy efficiency are respectively calculated to be 82.9 MW, 41.5 % for the power generation system. The entropy generation of the turbine is calculated as 3.12 kW/K, the entropy generation of the low pressure compressor 0.77 kW/K, the entropy generation of the high pressure compressor 0,68 kW/K and the entropy generation of the reactor vessel 160 kW/K.

**Keywords:** Nuclear, Supercritical carbondioxide, Molten Salt, Energy, Entropy.

## IEEES12- P085

## Wind Speed Analysis by Using Mixed Extreme Value Distributions

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The wind speed analysis is mandatory in the design and development of large infrastructure projects, airports, mass transit, and wind energy farms. It helps us in understanding the geographical distribution, the expected return period of extreme wind events, and it supports structural engineers to design and plan appropriate reinforcement for a resilient system. Four extreme value distributions such as Gumbel, Weibull, Frechet, and Generalized Extreme Value are generally used for probability distributions to model the wind speed data. The objective of this study is to establish a comparison between univariate and mixed distributions (with the combination of two distributions and three distributions models). Due to the complexity associated with the mathematical formulation with the partial derivatives relative to the unknown parameters, direct minimization will be used to determine the unknown parameters. The optimum distributed univariate or mixture can be selected based on the minimum standard error of fit (SEF) criteria, such as Kite. We found that mixed distributions with the combination of three distributions are more accurate than univariate and mixed distribution with the combination of two distributions. In the given data set, 80% is fitted better for mixed distributions with a combination of three distributions, while the remaining 20% supports the mixed distributions with a combination of two distributions. Furthermore, the addition of more parameters resulted in improved results. It can be deduced from this statistical study that mixed distributions with the combination of three distributions can opt as a mathematical tool for investigating extreme wind speeds.

**Keyword:** Wind speed, mixed extreme value distributions, parameter estimation.



## IEEES12- P086

## Commodities Relationships Effect on Adopting Pro-Environmental Measures

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This Research examines the form of relationships among commodities (either being substitutes or complements) ability to incentivize the adoption of pro-environmental measures. The study concentrates on producers in the manufacturing and food industries in different countries competing in the global market. Therefore, they are faced with different environmental regulations. Understanding the behavior rising from such relations would enhance our estimation of environmental policies' importance with respect to market dynamics. For instance, a firm is taking the lead on adopting pro-environmental technology due to government regulations. The substitute's producer in a country with fewer regulations would not adopt such technology to keep prices low and gain market share. However, if the follower decides to adopt the same change, it can indicate the market preference for green production. This research would be conducted using an econometric model to study survey data of firms' adopting measures to reduce environmental impact. The outcome of the econometric model used will indicate the degree of causality between the market relation and pro-environmental measures through time. The empirical work would be analyzed considering organizational behavior theories and sociocognitive dynamics that could explain firm tendencies to adopt such measures in relation to other firms and consumers.

**Keywords:** Pro-environmental behavior, substitute products, complementary products, environmental regulations, econometric model.

## IEEES12- P104

## Moistchar: A Sustainable Approach for Water Stress and Plant Growth

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Food waste is a major issue globally, and due to inputs and emissions through the supply chain results in large contributions to greenhouse gas emissions. On the other hand, producing food is a water-intensive process, particularly in arid environments, which often also have poor soil. Food waste-derived biochar is an approach to address both of these issues at once, by turning waste into a soil amendment material that can improve soil productivity and watering efficiency. In this study, biochar was produced from a mixture of vegetable wastes (cauliflower, cabbage, banana peels, and corn) at pyrolysis temperatures from 300 to 600 °C and characterized for properties that have a major influence on plant germination, growth, and soil water retention. A temperature of 400 °C produced the optimum biochar and was used for pot tests with two ornamental plant seeds (sunflower and capuchina) and one crop seeds, cucumber. Biochar at 2% mass loading in sandy soil was tested against a control without biochar (0%). Biochar addition reduced soil salinity and increased cation exchange capacity, which is related to fertilizer retention. In the 2% biochar pots, after 5 days and 50 mL of water, 28 sunflower seeds germinated out of 30 with the height from 1.8 to 4.5 cm. Under the same conditions in control, no germination was observed. Similarly, with capuchina, all seeds were germinated in biochar amended soil, while only 24% of seeds germinated in the control after five days. Germination of cucumber occurred for six seeds out of 10 in biochar compared with 3 in the control after four days, and the height of the germinated seeds was approximately three times greater in biochar amended soil after ten days. This study demonstrates the effective application of a circular economy to manage the waterfood nexus.

**Keywords:** Food wastes, biochar, water retention, seeds germination, water food nexus.



## IEEES12- P110

## Thermo-Hydraulic and Exergy Analysis of Parabolic Trough Collector with Wire Matrix Turbulator: An Experimental Investigation

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The present energy crisis due to exhaustion of fossil fuels, global warming, the surging gap between energy supply and demand, high electricity price, etc. have paved a path to harness renewable energy resources effectively. Among various sources, due to enormous potential and implicit superiority, solar thermal energy has been proved to be the best solution for the energy crisis. Further, the parabolic trough collector (PTC) is the oldest and prevailing solar concentrating technology. As the receiver of PTC is subjected to highly non-uniform concentrated heat flux (circumferentially), the majority of the studies are numerical. Even outdoor testing is a laborious task due to the transient operating condition. Hence, an innovative method encompassing analytical model-SOLTRACE®-differential resistance heating is incorporated in the present indoor experimental study to simulate the realistic highly non- uniform solar irradiance over the receiver. In order to effectively utilize the solar energy and to improve the exergetic efficiency of PTC, three variations of wire matrix have been employed and its thermo-hydraulic effect is studied using performance evaluation criterion (PEC). Apart from energy analysis, exergy analysis is done to gauge the energy conversion process. In the analysis, DNI of 800 W/m$^2$ is chosen as the SOLTRACE® input, and Therminol VP-1 is the heat transfer fluid with a flow range of Re=2800-7800. Various energy parameters viz. Nusselt number, friction factor, PEC, and exergetic efficiency have been analyzed. Nu increment of 2.46 times at the cost of 10.37 times is observed in the best wire matrix case. The PEC analysis yielded the best value of 1.14. Eventually, an exergy enhancement ratio of 4.3 is achieved due to the wire matrix insert.

**Keywords:** Parabolic trough collector, SOLTRACE®, wire matrix, performance evaluation criterion, exergetic efficiency.

## IEEES12- P111

## Novel Passive Heat Transport Device for Solar Indoor Cooking: A Numerical Study

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Thermosyphon heat transport device (THTD) is a fluid-filled unit employed for transporting heat from a source to sink by natural circulation. Both the source and sink are amalgamated within the THTD. Hence, once the geometry, fluid, and boundary conditions are defined its heat transport capability is fixed. THTD can incorporate single-phase, two-phase and/or supercritical fluids. THTD overcomes limitations in heat pipe like slower capillary action. It has been attempted in a diverse passive fuel cooling system for advanced high-temperature nuclear reactors. The present numerical study explores the possibility of employing THTD in solar indoor cooking by utilizing beam down concentrated heat flux. The vertical tube-in-tube design has been incorporated which consists of heat source, adiabatic height, and sink. Design and numerical analysis are carried out using ANSYS Fluent module. The parametric study focuses on eight variations of adiabatic height and sink-length using Therminol VP-1 as heat transfer fluid (HTF) and water circulation chamber as the sink. As THTD is meant for transferring heat from the source to sink, time-based transient analysis is of practical importance. The variation in heat transport time, flow path, flow velocity, and HTF temperature are extracted from the simulation. Eventually, the THTD is compared with a simple closed-loop thermosyphon tube/system (CLT) for different adiabatic heights. The results portray that the heat of 1 kW can be transferred in 1742 minutes for the cases of 0.25-2 m adiabatic height. However, the CLT shows a noticeable amount of recirculation zones which results in time as 28-120 mins. In comparison, only 50% of the heat is transported in CLT at a time when THTD has transported 100%, and thus, the novelty of THTD is proved. Based on the application type, the numerical results suggest the optimum sink length as 0.25-0.3m due to an increase in recirculation zones in other variants.

**Keywords:** Thermosyphon heat transport device, simple closed thermosyphon system, transient analysis, natural circulation.



## IEEES12- P113

## Numerical Analysis of a Hybrid Thermal Energy Storage System for Low-Temperature Applications

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Thermal energy storage is one of the viable solutions for the existing energy demand and supply mismatch. Among the different types of thermal energy storage systems thermochemical energy storage system is one of the best options for the long term and high-density energy storage. These consist of chemical reversible reactions which are able to store solar thermal energy in one direction and to release it in the reverse. Thermochemical energy storage is an interesting technology for the future seasonal storage of solar heat. This technology gets the attention of researchers because of its high energy density and less or no storage losses. The main drawback of this storage technology is the sudden release of energy, which causes high-temperature levels at the start of the reaction. Since most of the applications are at constant temperatures, this drawback of the thermochemical energy storage leads this technology unsuitable for such applications. In this paper, we suggest a hybrid thermal energy storage system that is continuously supplying constant temperature while releasing energy. It has the advantages of both thermochemical energy storage and a latent heat storage system. In this paper, we use $MgSO_4$ (Magnesium sulphate) and paraffin wax pair as our hybrid thermal energy storage materials. The system is analyzed using COMSOL Multiphysics.

**Keywords:** Thermal energy storage, thermochemical energy storage, thermochemical reaction.

## IEEES12- P116

## A Strategic Flexible LNG Production for Uncertain Future Demand

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Gas is converted to liquefied natural gas (LNG) to be transported via ships where pipelines are not feasible. The LNG chain consists of five main sections: upstream, midstream liquefaction process, shipping, regasification, and distribution to local markets via pipelines. The core of the LNG chain is the liquefaction process where the treated gas is liquefied to -164$^{o}$C. Different LNG liquefaction technologies were adopted in the industry based on the production capacity. Small to mid-scale technologies are used for productions up to 5 MTPA, while in large scale technologies, the production capacity reaches 7.8 MTPA. An LNG project falls into two phases: pre-final investment decision (FID) and post-final investment decision (post-FID). The pre-FID activities include project feasibility, market analysis, technology design, location selection, sales, and purchase agreements, and project's financing, while post FID activities focus on the technicality of project's feasibility, construction, utilities, ports and terminals, operations, shipping, regasification, and future build-ups. The business opportunities for LNG production are economically risky. Initial investments are subject to great demand and market uncertainties due to competitiveness and price changes of LNG. Moreover, the change in the contractural structures of LNG has impacted the decision-making process in the pre-final investment decision due to the high uncertainties involved. In this study, a strategic flexible approach is proposed for LNG production systems to maximize the expected economic value under uncertainties. First, an optimal fixed design was selected using the analytical hierarchy process (AHP) and used as a benchmark. Then, flexible designs were evaluated and compared to the fixed design. The flexible design is essential in minimizing possible losses when the demand is less and maximizing the profit when the demand is high. In short, the main objective of this study is to justify why and how a flexible LNG system is essential under market uncertainties.

**Keywords:** Liquefied natural gas, liquefaction, flexible design, uncertainty.



## IEEES12- P123

## Thermodynamic Analysis of a Hybrid Multi-generation System Using Solar and Wind Power

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This paper focuses on the development and thermodynamic analysis of a multi-generation system based on two renewable sources – solar and wind energy. Solar energy enters into the system by installation of parabolic trough collectors whereas wind energy is extracted by wind turbines in a wind farm. The outputs include refrigeration, electrical power, and heating of water for domestic purposes. The power output of the system is obtained through two turbines. A thermodynamic assessment of the system is carried out by calculating energy and exergy efficiencies of the system. The relationship between outputs and inputs are also studied by varying various input parameters. The Engineering Equation Solver software is employed in the analytic study by constructing and generating codes on the software.

**Keywords:** Multi-generation system, solar, parabolic trough collectors, wind, exergy, energy.

## IEEES12- P125

## Preliminary Energy Audit of a Residential Engineering University Campus

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Sustainability of our energy resources is becoming of increasing importance to the wellbeing of this and all future generations. To prevent harm to the planet and its living inhabitants' immediate steps are required to be taken towards the development of sustainable energy while making the existing infrastructure more efficient to speed up this process. This study focuses on identifying energy consumption patterns of a residential university campus in its current and retrofitted form. This was made possible by collecting loads of individual machines were the power consumption of buildings and analyzing them. The past four years of billing data were analyzed for future consumption. Results present in this study suggest significant energy saving can be accomplished by applying different retrofitted techniques.

**Keywords:** Consumption, optimization, retrofitting, GIK Institute, energy audit, energy management, bill analysis, load management.



## IEEES12- P127

## Effects and critical analysis for Carbon Emission Estimation in the Transportation Sector

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Road transportation and the corresponding GHG emissions are one of the major causes of environmental pollution in almost all countries, and Kuwait is not an exception. Emissions of $CO_2$, $NO_x$, CO, and $CH_4$ due to the operation of vehicles lead to environmental pollution and serious health issues. This research focuses on the use of Effects and Criticality Analysis (ECA) which identifies how a product, service, or process can fail –for analyzing the effects and associated risk assessment due to these emissions. A structured approach is made in this study to estimate the risk associated with specific failure causes and prioritize the actions to reduce the risk of failure. ECA requires identifying different possible failure modes of the present road transportation system, their frequency, and potential causes in conjunction with the emission sector. The standard ECA process evaluates failure modes for occurrence, severity, and detection. The focus of this study was mainly on automobiles' fuel consumption, energy consumption, and emissions produced by private vehicles. ECA was made to calculate these measures and predict them for the future. The multiplication of the parameters leads to what is known as the Risk Priority Number (RPN). A rating is assigned for severity, occurrence, and detection to calculate RPN for each failure mode and to select the first five high priority failure modes to be used in the improvement phase, as they are approximately 70% of all RPN. The reason for 70% comes from the Pareto principle. Based on the obtained results, some important recommendations were made such as, service intervals for the optimum time to change the filter, tire pressure check at regular intervals, tire inflation its effect, the effect of carrying excess weight, vehicle idling time and its effect on fuel consumption, and the harmful effect of $CO_2$ into the atmosphere.

**Keywords:** Fuel consumption, energy consumption, emissions, exhaust gases, ECA.

## IEEES12- P132

## The Advantages of Microwave Technology in Commercially Biodiesel Production

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One of the major hurdles of spreading commercial biodiesel is the higher production costs compared to the petroleum based diesel. Transesterification is the most used method to produce biodiesel, and the academic and industrial investigations have been performed for optimizing transesterification reaction parameters to enhance fuel conversion efficiency and properties. Besides, in recent years, using advanced technologies in biodiesel production has increasingly become the focus to decrease production costs by minimizing reaction time and energy consumption in production processes. In this review work, the utilization methods of the alternative energy stimulant, "microwave technology" in biodiesel production are examined, and the alkali-catalyzed transesterification reactions carried out under the microwave irradiation are compared with the similar conditioned ones using conventional heating systems. As a result, it is observed that using the microwave technology can reduce the biodiesel production cost by providing considerable influence on reducing reaction time and increasing biodiesel yield in comparison with similar conventional methods. In biofuel industry, any industrial scale microwave assisted biodiesel reactor has not yet been used. Therefore, to compete with petro-diesel, commercial biodiesel processing cost should be decreased by developing microwave assisted reactors for industrial scale biodiesel productions.

**Keywords:** Microwave, biodiesel production, transesterification, methyl ester, alkali-catalyzed.



## IEEES12- P133

## Flowsheet Development for the Steam Gasification of Camel Manure with Subsequent of $CO_2$ Capturing Using Cao: An ASPEN Plus® Modelling

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Animal manure is one of the important wastes present in the state of Qatar. Gasification is a promising technique that could convert that waste into valuable chemicals and gaseous fuels. This can help not only reduce the waste of Qatar as well as make energy mix with renewable fuel. The objective of this study, to develop a process for the steam gasification of camel manure for syngas production. The most important feature of this study, to investigate the effect of CaO for the reduction of $CO_2$ and on syngas composition. Aspen plus was utilized for the development of a flow sheet for the steam gasification process using the Gibbs free energy minimization. The effect of three important parameters, such as the temperature of (600-800°C), steam/feedstock ratio of (0.5-2), and CaO/feedstock ratio of (0-1.2) on syngas production. The $CO_2$ reduced from 23 to 1vol % and $H_2$ increased from 56 to 88 vol% by varying the CaO/feedstock ratio from 0-1.2 at the temperature of 600°C and steam/biomass production is increased from 64 to 84 vol% with the increase of temperature and steam/feedstock ratio of 0.5. Whereas the $CO_2$ reduced from 16 to 15 vol% at a higher temperature of 750°C by varying CaO/feedstock ratio. The reduction of $CO_2$ contents is due to the activation of the carbonation reaction. Steam/feedstock ratio and temperature have a direct impact on hydrogen production, which is due to the acceleration of water gas shift reaction. Methane production found suppressed with the increase of steam as well as temperature is due to the activation of steam methane reforming reaction.

**Keywords:** Camel manure, $CO_2$ capturing, gasification, Aspen plus, syngas.

## IEEES12- P134

## A Novel Multi-Generation System with Reverse Osmosis for A Greenhouse in the Sabkha-Tah Region of Western Sahara in Morocco

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The Sahara region of Africa is characterized by low rainfalls and high temperatures. Such conditions make it difficult to have a natural supply of fresh water for domestic purposes and food production. The Sabkha-Tah region of Western Sahara is one such location were the adverse weather conditions make it difficult for the conventional farming of certain crops to occur. The region is, however, uniquely situated 60 m below sea-level. This study analyzes the deployment of a multi-generation system to produce power, cooling, and freshwater for a 250 $km^2$ greenhouse situated in the Sabkha-Tah region of Western Sahara. The system is powered by the sun and uses the hydrostatic energy of the Atlantic Ocean to power the reverse osmosis (RO) water desalination system. A solar-powered Rankine cycle is used to meet the electricity demand of the RO and vapor compression units. A thermodynamic analysis of the system is performed and the results show that the use of an energy recovery turbine along with the geographical advantage of the region decreased the power requirement of the RO unit. The energy saved using the static pressure of the water was 3.27 kW. The net power consumption in the RO unit is 102.2 kW, and it was able to provide 0.0185 kg/s of freshwater to the greenhouse. The overall energy and exergy efficiencies for the multi-generation system were calculated to be 50% and 35%, respectively.

**Keywords:** Multi-Generation, reverse osmosis, solar tower, energy, exergy.



## IEEES12- P135

## Removal of Toxic Cadmium From Water Using a Binary Site Ion Exchange Resin Derived From Waste Printed Circuit Board

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Many industries discharge effluents containing toxic heavy metal ions into receiving waters. These industries include nickel-cadmium batteries, metal plating, microelectronics, mining, metal fabrication, etc. It is important to find effective and economical solutions to process these effluents by removing the contaminating metal ions to make the water suitable to meet environmental standards and trying to recover and recycle the metals.

Cadmium is known to be toxic and carcinogenic, and in water, it can be absorbed by plants, crops, aquatic species and then enter the food chain by these routes. In humans, it can adversely affect the kidneys, cause renal dysfunction, bone lesions, and cancer.

In this study, an activated alumina-silicate resin (AASR) has been prepared from the waste motherboard of printed circuit board e-waste. The preparation and characterization of this resin are described, then its ability and the mechanisms involved in the removal of cadmium are described and modeled. The mechanism is unique as the AASR contains both potassium and calcium ion exchange sites for the cadmium. The analysis of this type of binary ion exchange waste-derived material explains the high capacity of the AASR for cadmium. Schematics are provided of the AASR production path route and for the ion exchange mechanism.

**Keywords:** Cadmium removal, ion exchange, adsorption isotherm, waste printed circuit board.

## IEEES12- P139

## Study of GaAsPN/GaP Quantum Dots Sturcture for Solar Cell Applications

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This study focuses on the simulation and modeling of GaAsPN/GaP quantum dot solar cell QDSC. This quaternary alloy is one of the III-V semiconductors, which gained importance in the recent years for optoelectronic applications due to its perfect lattice matching to Si and GaP substrates and to its band gap that can be decreases drastically with the incorporation of Nitrogen and Phosphorus on GaP improving consequently the absorption the wavelengths near the red part. These superiorities of GaAsPN make it a good candidate for growth with Si substrate, then a good option to decrease the cost of the solar cell. The heterostructures consist of $GaAs_{0.18}P_{0.814}N_{0.006}$ quantum dots separated by GaP barrier layers. The width and thickness of the quantum dot are 10 nm and 5 nm, respectively. Our results have been shown that 20 $GaAs_{0.18}P_{0.814}N_{0.006}$/GaP QD layers produce a short circuit current and efficiency of about 3.555 mA/cm2 and 7.5 %, respectively. In addition, the same number of QD layers extends the absorption edge of the GaP solar cell from 0.447 µm to 0.5 µm.

**Keywords:** Component; efficiency, QDSC, solar cell, III-V semiconductors.



## IEEES12- P140

## Optimal Sizing of a Residential Grid-Interactive PV with Battery Storage Using HOMER

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In this paper, the optimal size of a residential grid-interactive photovoltaic system with a battery storage system is computed using HOMER software. The proposed grid-interactive system operates under the Time of Use and Feed-in tariff in the South African context. Based on the simulation results, it is found that the optimal configuration is composed of one 2.1 kW PV, with one 2kW converter and four batteries. This system's configuration met the load demand at no shortage and incurred a levelized cost of energy of US$ 0.32 or ZAR 5/kWh. The annual average electricity production from the PV is about 49% of the total generation, while the remainder of the necessary power is purchased from the grid. Therefore, the major share of the power is obtained from the PV to meet the load requirement and to keep zero unmet energy by the system.

**Keywords:** Time of use, feed-in tariff, grid-interactive, photovoltaic, battery, sizing.

## IEEES12- P142

## Numerical Analysis of 3-D Vanadium Redox Flow Battery with Flow Field

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Vanadium redox flow battery (VRFB) is a kind of rechargeable battery with large scale energy storage capacity. It can be used as intermittent energy storage for renewable energy sources. The performance of the battery depends on many factors, such as mass transfer losses, electrolyte contamination, and thermal precipitation of electrolyte. The mass transfer losses can be rectified by employing proper flow field design. Flow channels are carved on the surface graphite plate to enhance the mass transport of electrolyte. The pressure drop occurs due to the circulation of the electrolytes through the cell can be reduced by flow channels. A 2-D numerical model for VRFB using electrochemistry model is first validated with the available results in the literature using COMSOL (a CFD simulation tool). The model is then further extended to a full-scale 3-D numerical model for comparative performance analysis of Conventional, Serpentine, and Parallel flow fields. This model includes the fluid flow coupled with the electrochemistry. The active area of the VRFB considered is 25cm$^2$. A parametric study is performed by varying the flow rate of electrolyte and state of charge of battery to analyze the current density, cell voltage, pressure drop, and over-potential of a cell. From the present study, it can be concluded that the serpentine flow channel layout gives the optimal performance among all the cases considered

**Keywords:** Vanadium redox flow batteries, flow field design, 3-D multi-physics COMSOL modeling.



## IEEES12- P143

## Integration of Petroleum Refinery and Petrochemical Plants for Condensate Feedstock: Challenges and Opportunities

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This paper presents a case study about the global move in liquid hydrocarbon industries on the integration of petrochemical plants into the refinery business to struggle against the decline of profit margins in the petroleum refinery field. Challenges in the petroleum refining business are increasingly growing with new markets, feedstocks and restrictive regulations. The refinery and petrochemical systems discussed here were modelled as a mixed-integer problem with the objective of minimizing the operational cost over a given time horizon and maximizing the added value of the petrochemical network. To maintain sustainable profitability, the refinery of the future must respond quickly to changing market conditions, switching from one stratagem to another as profit margins change. It is known that consistent profitability in the refinery sector is a challenge. In this case study, the Pearl Refinery Company (PR) is discussed, which was built and is operated strategically to meet domestic consumption needs and optimize the profitability. In addition, PR has a critical support role for local LNG plants. As it processes' in continuous operation through relinquishing all condensates produced during LNG production. PR also functions as a swing-producer to buffer low-prices as the condensate market fluctuates. This case study considers how a refinery can make better use of process enhancements to improve profit margins by 20.5%. It is proposed to implement an integrated refinery and petrochemical complex model to sustain profitability through optimization. This paper demonstrates that an appropriate equitable cost allocation mechanism will help withstand overall PR corporate performance and profitability to justify implications of case study results. It is concluded that with proposed enhancements to the refinery and a combination of solutions to improve the current performance through the restructuring of the budgeting process, an update of the organizational model, new ingenuities, and overall cost optimization opportunities.

**Keywords:** Performance management, profit margin, process enhancements, cost optimization, profitability.

## IEEES12- P144

### A sustainable PV-powered energy retrofit modeling to achieve net ZEB in churches: A simulation study for San Marcello Al Corso

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This study proposes practical modifications for achieving net zero energy building (net ZEB) in historical churches while all the values of the church have been recognized and preserved. The church studied from three perspectives; 1) structural: horizontal air curtains used with the aim of decreasing ample space to decrease energy loss and conserving artworks and masonry in the facade 2) Mechanical: a heat pump has been installed to provide HVAC and utilities of the church. Phase change materials have been used in underfloor heating and cooling system to minimize temperature fluctuations in the church. 3) Electrical: A grid-connected PV system has been set up and a net metering scheme implemented using a grid-tie inverter to achieve net ZEB in the church. Energy analysis is carried out for the church before and after applying modifications. It is concluded that proposed modifications have positive effects on increasing the first and second law efficiency of the church. In heating mode, energy and exergy efficiency increased to 58.3% and 18.2%, respectively. Therefore, a 25.9% rise in energy efficiency and an 8.1% rise in exergy efficiency are observed. Also, a 98% match in annual energy exchange has been reached between the power generated on-site and the utility grid.

**Keywords:** Energy retrofit, PV system, net zero energy building (net ZEB), net metering, sustainability, horizontal air curtain; exergy analysis.



## IEEES12- P151

### Performance Evaluation of Crofer®22 APU Solid Oxide Fuel Cell (SOFC) Metallic Interconnects Manufactured Through Powder Metallurgy

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Fuel cells are used as primary or auxiliary power units in many applications including transportation, military, stationary power source. Fuel cell vehicles (FCVs) have gained popularity in recent years, and a few automakers released their FCV models to the market. Also, fuel cell-powered unmanned aerial vehicles (UAVs) are increasingly preferred as they offer longer flight time over battery-powered systems. It is; therefore, the development of fuel cell components will be an everlasting endeavor as the implementation of fuel cells become widespread.

This study, in particular, aimed to evaluate the performance evaluation of solid oxide fuel cell (SOFC) interconnects made of commercially available bulk Crofer®22 APU alloy through machining as well as through powder metallurgy approach (P/M) from powders. In each case, interconnects with 40x40 mm2 active area were fabricated. The coefficient of thermal expansion (CTE) of Crofer®22 APU powder was measured and optimized considering the process parameters, compaction temperature, and pressure as well as sintering temperature. The porosity values of the P/M interconnect were determined and compared. In addition, thermal shock tests were carried out to reveal whether the P/M interconnect affected by thermal cycling. From performance tests, maximum power values of 3.12 and 2.97 W were obtained for machined commercial interconnect, and P/M interconnect, respectively, at 800°C operating temperature. Similar power values were obtained at 750, and 700°C operating temperatures for both interconnects. It was concluded that P/M Crofer®22 APU interconnect can be a reliable alternative to the commercial bulk Crofer®22 APU interconnect.

**Keywords:** Solid oxide fuel cell, powder metallurgy, Crofer®22 APU, metallic interconnects, performance tests.

## IEEES12- P154

## Investigation of Performance Improvement of Geothermal Energy Assisted Power, Heating and Hydrogen Generation Plants with Thermoelectric Generator

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Renewable energy, which is generally composed of solar, hydroelectric, wind, and geothermal energy sources, is very important in the combat against environmental problems. Geothermal energy is a power source that produces clean, reliable, and minimal environmental impacts. In this paper, a geothermal energy supported hydrogen, power, and heating generation plant are investigated in terms thermodynamic approach. In addition, in the proposed study, if the thermoelectric generator is used instead of the condenser sub-component, its effect on the system's performance and hydrogen production rate is researched extensively. this system consists of an ORC with transcritical $CO_2$ (t-$CO_2$) working fluid, a heat pump with R134a, a thermoelectric generator, and a PEM electrolyzer for hydrogen production. The effects of parameters such as reference and geothermal temperature, ORC component pressure, PEM efficiency on the performance of the proposed system, and hydrogen production rate are calculated, using Engineering Equation Solver (EES). Finally, the energy and exergy efficiency of the examined plant is determined as 28.01% and 24.13%, respectively. Also, the total hydrogen generation rate is 0.0004502 kgs-1.

**Keywords:** Energy, exergy, geothermal, hydrogen, renewable energy.



## IEEES12- P155

## Development of a Solar Energy Based Multigeneration Plant with SOFC for Hydrogen Production

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The main purpose of this paper is to design a new multi-generation plant, based on a solar energy source, and to investigate its performance using the thermodynamic approach. The most important outputs of this work, hydrogen generation, along with the power, cooling, heating and hot water. The modeled plant contains a solar power cycle, a Solid Oxide Fuel Cell (SOFC) plant, a gas turbine (GT) plant, a supercritical $CO_2$ reheat power cycle, cooling cycle, organic Rankine cycle (ORC) plant, a PEM electrolyzer, hot water generation process and hydrogen liquefaction process. Energetic efficiency, exergetic efficiency, and also exergy destruction rates of the overall system and sub-components are studied in detail, according to under the various system and environment conditions. Also, the effects of changes in parameters such as dead state temperature and solar radiation on system performance were investigated in terms of thermodynamics. According to analysis results, the highest exergy destruction rate is determined in the solar power cycle, while the lowest exergy destruction rate is calculated in the cooling plant. Furthermore, the energetic and exergetic performance of the total plant is computed as 56.48% and 54.06%, respectively.

**Keywords:** Energy, exergy, hydrogen, PEM electrolyzer, solar energy, thermodynamic analysis.

## IEEES12- P159

## Potential Energy Optimisation of the Coefficient of Performance of a Residential Air Source Heat Pump Water Heater

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Air source heat pump (ASHP) water heaters are very efficient devices for sanitary hot water heating. The study focused on the determination of the coefficient of performance (COP) of a 1.2 kW, 150 L split type ASHP water heater in terms of enthalpy and energy factor, and the potential opportunity to optimise the COP. The COP was based on the changes in enthalpy of the refrigerant of the ASHP unit and the input and output energies of the ASHP water heater. A power meter, flow meters, temperature sensors, pressure sensors, ambient temperature and relative humidity sensor were installed at precise locations of the ASHP water heater. Specific controlled volume of 150, 50 and 100 L were drawn off from the tank of the ASHP water heater during the morning, afternoon and evening for a full year. The results depicted that during the summer periods, the average COP in terms of the input electrical consumed and output thermal energies gained by the ASHP water heater was 3.04. The COP in terms of the change in the enthalpy of the refrigerant at the inlet and the outlet of the condenser and the evaporator of the ASHP unit was 3.53. It can be concluded that the derived COPs of the ASHP unit was higher than that of the ASHP water heater. The difference in the two COPs could be ascribed to the electrical energy consumed by the fan and the water circulation pump. The input power consumed by the ASHP unit was 12.8% lower to that of the ASHP water heater. The corresponding change in enthalpy of the refrigerant in the condenser was greater than that at the evaporator throughout the different volumes of hot water drawn off. A potential replacement of the existing electric motors in the prime movers with energy efficient types, will enhanced the COP.

**Keywords:** Air source heat pump (ASHP) water heater, Coefficient of performance (COP), COP of ASHP unit, COP of ASHP water heater, change in enthalpy of refrigerant, input electrical energy, useful output thermal energy.



## IEEES12- P160

## Formulation of Indicators for Sustainable Groundwater Development in Qatar

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Effective water resources management is very essential to cope with limited resources, especially in arid countries. Qatar is one of the most arid countries in the world with very limited rainfall. Over the last few decades, the stresses on water resources have been intensified due to the sharp increase in population and the very high per-capita water consumption. Domestic and industrial water demands are met totally by desalination, while groundwater is used for agriculture, which overexploited the aquifer. Many studies recommended Managed Aquifer Recharge (MAR) as a means to increase water security and to improve the groundwater quality, especially in arid areas. The literature documents various methods for MAR implementation; however, the appropriate method and its feasibility in Qatar remain unexplored.

This paper establishes key indicators to develop MAR in Qatar, in light of the successful implementation of MAR in arid regions and taking into consideration the current technical and socio-economic factors. The four MAR methods considered are (1) aquifer storage and recovery, (2) in-channel modification, (3) rainwater harvesting, and (4) spreading methods. Results show that using the harvested rainfall and desalinated water to feed MAR is the optimum scenario to increase water security and sustainability in Qatar. In addition, rainfall harvesting will contribute to flash flood protection, which adversely impacts the environment. Specific recommendations are embarking on field-scale tests and theoretical models for subsurface dams and rainwater harvesting methods.

**Keywords:** Qatar, managed aquifer recharge, water resources management, desalinated water.

## IEEES12- P162

## Microwave Melting Salt Slurries by Serpentinite Granule for Thermal Energy Storage

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Heated Ca-ferrite pellets in microwave radiated molten slurries are one of the most promising technologies for advanced fuel energy storage with favorable economic potential and intrinsic properties. The development of solid pellet technology for molten salt is a key issue in heat transport processing. As for pure molten $MgCl_2$-$CaCl_2$-NaCl eutectic salt at approximately 473-500°C, we have already reported the successful results of transport using gravity and a centrifugal pump. However, molten salt in the carbon pellet/ metal-salt mixes with insoluble fines dissolved in a porous basket. The insoluble consists of noble metal fission products, such as Pb, Zn, Cu. In this study, there have been very few transport studies of molten salt slurry (metal fines-molten salt mixture).

**Keywords:** Microwave melting, pellets, heat storage, molten salts, pellet granules, active carbon.



## IEEES12- P164

## Production of Zeolite/ Biochar Active Carbon Composite Pellets for Hydrogen Sorption

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The packed bed sorption of Hydrogen gas was carried out over 100 microns on active carbon char and activated zeolite clay pellets. Microwave leached char was activated and in order to enhance this packed flow manner of that compost, clay pellets were put in the barrel chamber and leached by 0.1 M HCl solution for 20 min. Extruded biochar pellets pressed with 40%,60%, and 80% bio-active carbon, active clay mixtures, and microwave leached activated forms were used in our absorption experiments at 1- 2rnrn sized pellets. The cycles of gas transport were managed until saturation of carbon pellets. The simulated sorption on solid carbon porous structure and capturing for Hydrogen gas on active carbon or char developed mechanical separation used. The pellets size-sorption simulation was provided a 7-8% Hydrogen gas sorption and also 14-15% soot addition provided highly developed compressibility. The waste organic oil and soot improved briquetting quality at coarse-grained structure extruding. The clay samples were thought to be subjected to homogenization in microwave leaching and acid treatment.

**Keywords:** Microwave activation, active carbon, hydrogen sorption, hydrogen, storage.

## IEEES12- P165

## Comparative Study for Solar Powered Systems in Pakistan

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Pakistan receives 1kW/$m^2$ of solar energy for 6-7 hours a day, with 3000-3300 hours of average sunshine hours in the country. This potential can be harnessed to produce off-grid electricity to power rural areas in the western, northern regions and urban city centers in order to meet the power shortfall. This paper presents the performance of various solar-powered electricity generation systems. The power plants comprise a solar system integrated with a steam Rankine cycle. The solar systems considered are; Heliostat Solar Tower Plants, Parabolic Trough Collector Plants, Photo Voltaic Plants. The cumulative yearly electrical output affiliated with each type of plant, for a solar field size of 10,000$m^2$, is evaluated for ten major cities, and a comparative analysis is performed. The conducting fluid used in the heliostat solar system is molten salt and Therminol VP-1 in parabolic trough collector system. Apart from the thermal and electrical performance of each type of solar system, the effects of parameters like Direct Normal Irradiation (DNI) that vary for each city, is analyzed. For all systems, heliostat, parabola, and PV systems, the max output power is available during the summer season, i.e., June, July, and August. The output of heliostat exceeds the output of Parabolic Trough by 24% and PV system by 42% due to higher attainable steam temperature, which results in a more efficient power cycle. The solar power output in western areas and northern regions, typically in Quetta, Skardu, Peshawar, and Islamabad is comparatively less than areas situated in Sindh and Punjab. Karachi has the highest solar potential for all Solar based systems. The Heliostat integrated Rankine cycle's cost analysis presents the least payback period of 4.4 years, while that of Parabolic Trough collector and Photo Voltaic is of 6 years and seven years, respectively.

**Keywords:** Solar, Pakistan, parabolic trough, heliostat, PV.



## IEEES12- P166

## Assessing the Environment Impacts of Grocery Bags

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In this paper, the environmental feasibility of three types of grocery bags (paper, plastic, and cotton) is assessed. Data for these bags are collected, and Life Cycle Assessment (LCA) carried out, using the cradle-to-grave approach. The results obtained depict that LDPE bags have a greater environmental impact index (EI) and lower ecological sustainability index (ESI) compared to the other two. This is certain as the production of plastic involves the use of non-renewable sources - petroleum. According to the survey conducted, the most preferred choice is cotton bags; however, the results indicate that they contribute more to global warming.

**Keywords:** Life cycle assessment, environmental impact index, environmental sustainability index.

## IEEES12- P167

## Comparative Economic and Exergoeconomic Analysis of a Hybrid Cascade Refrigeration System using Ammonia-Propane, Propane-Propylene, and Isobutane-Propane Refrigerant Pairs

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In this paper, a comparative economic and exergoeconomic analysis of a cascade refrigeration system incorporated with a flash tank in its higher temperature cycle and a flash intercooler with indirect sub-cooler in its lower temperature cycle is done using ammonia-propane, propane-propylene, and isobutane-propane refrigerant pairs. The system is modeled on EES software, and the analysis of the total system cost rate is done followed by the evaluation of exergoeconomic factors for different system components for the three natural refrigerant pairs. The results show that Ammonia-Propane is the most economical refrigerant pair while Isobutane-Propane possesses the maximum system cost rate.

**Keywords:** Cascade refrigeration system, flash tank, economical analysis, exergoeconomic factor, Natural refrigerant pairs.



## IEEES12- P169

## Exergoeconomic Performance Evaluation of a PV/T Assisted Wastewater Source Heat Pump System

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In this study, the exergetic and exergoeconomical performance of a PV/T assisted wastewater source heat pump (WWSHP) system has been investigated. The system has been installed at Yasar University, Izmir, Turkey and the experiment was conducted in heating mode. In the first part of the study, conventional exergy analysis was employed using the gathered experimental results, where exergy destructions, efficiencies, relative irreversibilities, and improvement potentials are obtained. After that, an economic analysis was conducted to get the economic data related to each component of the system. Finally, the results of exergy and economic analysis were combined by using exergoeconomic methods. The highest relative irreversibility among all components occurred in the PV/T unit and is followed by the compressor. The functional exergy efficiencies of the WWSHP and whole system were found to be 0.10 and 0.15, respectively. The exergoeconomic factors of the condenser and WWHE were found to be considerably high among all components, which shows that the main driver of the cost associated with them are related to investment costs. On the other hand, the highest exergy loss per-unit price is obtained in the PV/T system. Exergoeconomic factors for each equipment and the entire system tended to decrease with increasing yearly working periods and decreasing interest rates. The same trend was also observed in the specific cost of exergetic products.

**Keywords:** wastewater, wastewater source heat pump, waste heat recovery, exergy, exergoeconomic.

## IEEES12- P171

## Experimental Study on a Thermoacoustic-Stirling Engine with Acoustic Field Adjustment

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The design, construction and experiment of a thermoacoustic Stirling heat engine with a phase-adjuster are the main scopes of this invention. The acoustic field can be adjusted by using the phase-adjuster, therefore the thermoacoustic engine could maintain a good performance. The core components of prototype comprise of an ambient heat exchanger, a regenerator, a hot heat exchanger and a feedback pipe, where are located in the torus section. Besides, there is a resonator pipe, connecting to the torus section, which acts as compliance to maintain the system stability. The phase-adjuster is installed at the end of the resonator. Firstly, the thermoacoustic Stirling engine is modelled with DeltaEC to search for the optimal configurations of the prototype. The thermoacoustic engine with the enlarged diameter at the end section of resonator provides a higher energy conversion efficiency compared to the constant diameter resonator. In the experiments, the onset temperature of the thermoacoustic Stirling engine is around 481.6°C, and then the hot-end temperature of the regenerator at the steady-state is 397.3°C. The pressure amplitude of 17.33 kPa and the resonance frequency of 38.31 Hz is observed. The acoustic power of 39.75 W is generated by the regenerator. The thermo-to-acoustic efficiency of 12.03%, corresponding to the Carnot efficiency of 22.56% is achieved. The measured results are in reasonably good agreement with the DeltaEC simulated results. This shows the preciseness of the developed model. Furthermore, the effects of the acoustic load, heat supplied to the system, porosity of the regenerator, length of the resonator (phase-adjustor), and gas pressure in the system are examined. It is found that the porosity of the regenerator, heat supplied, and gas pressure in the system has a significant effect on the energy conversion efficiency. The phase-adjuster can adjust the resonance frequency of the system as expected.

**Keywords:** Heat engine, oscillating flow, phase-adjuster, Stirling, thermoacoustic.



## IEEES12- P172

## Exergy Analysis of MgO-Water Nanofluid as a Coolant for Sinusoidal Mini-Channel Heat Sink

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The cooling of mini-channel heat sink via nanofluid has been anticipated to be an effective technique for heat dissipation from contemporary electronic devices. The evaluation of the exergetic performance of the mini-channel heat sink can play an important role in the evolution of improved heat sink with better cooling characteristics. The main aim of the present study is to experimentally analyze the exergy of distilled water and MgO-water nanofluid as a coolant in a sinusoidal mini-channel heat sink. The MgO-water nanofluid having a concentration of 0.01 vol.% was prepared using the two-step method. The coolants (distilled water and nanofluid) were passed through the mini-channel heat sink under the heating power of 45W and Reynolds number ranging from 517 to 914. From the results, it can be inferred that the exergy gain for nanofluid was higher than the base fluid (distilled water). This gain in exergy deteriorated with the rise in flow rate for both water and nanofluid. The outlet exergy was found to be enhanced with an increase in Reynolds number for coolants. The augmentation in outlet exergy of 44.51% was obtained for nanofluid at the highest Reynolds number as compared to distilled water. The exergy efficiency showed an increasing trend with an increase in Reynolds number for coolants. The maximum 2nd law efficiency of 35.01% and 26.65% were attained for 0.01 vol.% concentration of MgO-water nanofluid and distilled water, respectively, at Reynolds number of 914.

**Keywords:** Nanofluid, mini-channel heat sink, exergy efficiency, exergy gain.

## IEEES12- P174

## A Predictive Model for the Thermal Conductivity of Nanofluids using Machine Learning Algorithms

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Nanofluids are novel fluids that are gotten from the colloidal suspension of nanoparticles in base fluids. They are experimentally known to have vast potential in heat transfer applications due to their high thermophysical properties. The determination of thermal conductivity, which is an important parameter for analyzing the convective heat transfer of nanofluids is usually done by experimentally methods that are time-consuming and expensive. Theoretical models have been used to resolve this limitation; however, literature reviews have reported that most of the classical and empirical models have discrepancies in making accurate predictions. Therefore intelligent techniques have been proposed to cover the gaps in making more precise predictive analysis. In this study, the thermal conductivity of hybrid nanofluids is predicted using input variables of volume concentration, temperature, the acentric factor of the base fluid, nanoparticle bulk density, specific heat capacity, and particle size. Six hundred experimental data points using from studies using nanoparticles and base fluids are used in developing an artificial neural network (ANN) model. A feed-forward backward propagation is developed with different hidden layers and neurons in computing the training algorithm for predicting the output parameter (thermal conductivity). The performance validation of the models is computed using the root mean square error (RMSE) and the mean absolute percentage error (MAPE).

**Keywords:** Nanofluid, prediction, thermal conductivity, artificial neural networks, nanoparticle.



## IEEES12- P175

## Turkeys Industrial Waste Energy Recovery Potential Via Power and Hydrogen Conversion Technologies

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The need for energy in the world is increasing day by day. In particular, this situation will increase the demand for energy in developing countries with population growth, industrialization, and technological developments. Turkey is a country dependent on foreign energy by 70%. Fossil energy sources are being depleted day by day, and they cause irreversible damages to our world and threaten the life areas of future generations. The industrial sector affects the amount of energy used in Turkey considerably. Given that energy resources are limited, and demand for industrial products continues to increase, meeting the industrial energy demand and minimizing the economic impact in the future will be a major challenge. In this study, the energy consumption potential of Turkısh low to high-grade industrial waste energy over the years has been calculated and projected. Based on the grade of the heat some selected power systems are adapted to evaluate the potentially available energy production. In addition, electrochemical and thermochemical hydrogen generation technologies are considered for hydrogen production from waste heat. Many case studies are performed based on the temperature range of the waste heat. The annual waste energy amount is around 974 PJ and between 9-18% of this energy is recoverable with selected power and hydrogen technologies. The highest amount of power recovery is possible with Gas turbines, while HyS is eligible to recover the highest amount of hydrogen.

**Keywords:** Industrial waste heat, cement industry, glass industry, iron-steel industry, power, hydrogen.

## IEEES12- P176

## Energy-Enviro Investigation of Solar Powered Self-Sustainable Minimal Liquid-Solid Discharge Toilet

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The sewage waste treatment is essential to reduce the concentration of pollutants, which can pose a severe threat to the environment. In the present energy-environmental study, the sewage waste is treated in small scales at their source for minimal waste discharges. The proposed system is designed for treatment capacity of 2.4 kg solid waste and 55 liters of black water, which is an average discharge from a family of 5 persons (2 adults and 3 children). This system operates for 8 hours under varying solar irradiation during March. This treatment process consists of the separation of black water from solid waste and their treatment in a multi-stage distillation unit and solar dryer. This is a completely self-sustainable process powered by solar renewable thermal and PV technologies. For equal flow distributions in MSD, the maximum distillate yield of 12.4 liters when operated under ambient pressure, whereas a maximum of 19.4 liters can be obtained when operated under lower pressures. In the case of half of the blackwater supplied to stage 4 and rest is equally distributed to other stages of MSD, a maximum distillate yield of 16.6 liters when operated under ambient pressure whereas a maximum of 23.8 liters can be obtained when operated under lower pressures. The distilled water obtained from multi-stage distillation is used for the non-contact human requirements whereas the dried biomass from the solar dryer can be used either for power generation or as a natural fertilizer.

**Keywords:** Solar energy, black water treatment, sewage treatment, solid waste, multi-stage distillation.



## IEEES12- P177

## Supply Security in Critical Energy Infrastructures for Reliable Energy Grids

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Energy is an indispensable building block of all countries and has an impact on the entire economy. Disruptions in the energy supply chain threaten health and welfare and directly affect the economy, which prevents continuous and regular energy distribution to consumers. Smart grids and cities in critical energy infrastructures have become one of the most important topics researched around the world in recent years. In this study, we aim to show the increase in the amount of energy supply from the past to the present and draw attention to the importance of this increasing energy supply in terms of security in critical infrastructure. Energy supply security has now become a priority for many critical infrastructure institutions. The consumption of energy supplies is expected to increase more in the coming years due to the increasing population. Renewable energy resources consumption is estimated to be 100 quadrillions in 2020, while consumption in 2050 is 250 quadrillions, and consumption in natural gas resources is estimated to be 200 quadrillions in 2050. Key factors of energy supply security are investigated in electricity, natural gas, coal, oil, renewable energy, nuclear energy. In this study, cybersecurity, which is one of the high risks, has been drawn attention to its importance due to the increase in attacks on energy resources in recent years. Especially in this study, an energy supply security framework is proposed for energy supply security and shows the importance and reliability of renewable energies in energy supply security in critical infrastructures.

**Keywords:** Energy supply security, smart grid, critical energy infrastructures, renewable energy reliability.

## IEEES12- P178

## Recovery of the Cubic Structure in Mixed Cation Perovskite Thin Films via Machine Learning Assistance

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In this work, our developed machine learning (ML) model inspired us with the revelation of the cubic perovskite structure at room temperature (RT). Here, we report that how large cation (dimethylammonium, DMA) incorporation induce distortion variation in methylammonium lead triiodide (MAPbI3). Due to this severe distortion, perovskite structure formation is inhibited. A recovery mechanism to regain the cubic phase, which is more stable is adopted from the ML model. It is observed that by insertion of the small cation (Cesium), the cubic perovskite structure has recovered, despite the high concentration of DMA. Remarkably, it is observed that there is a threshold to the addition of small cation cesium for which the phase of the perovskite is favorably cubic rather than tetragonal or orthorhombic even at RT. In addition, the large grains as MAPbI3 are achieved in contrast to the typically small grains when large cations are incorporated. This restoration is confirmed by X-ray diffraction and scanning electron microscopy. Besides, UV-Vis measurements were performed in order to determine the relationship between the cation replacement and the bandgap of the deposited material. Our conclusions highly support the possibility of cubic-phase stabilization at RT by controlling the stoichiometric ratio of various-sized cations. These findings will pave the way for the fine-tuning of bandgap by manipulating not only the lattice parameters but also through the phase control.

**Keywords:** Triple-cation perovskites, XRD, machine learning, phase stability, bandgap.



## IEEES12- P180

## Life Cycle Assessment of Ammonia Synthesis from Thermo-Catalytic Solar Cracking of Liquified Natural Gas (LNG)

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Ammonia is considered as a sustainable energy storage medium. Although ammonia has low gravimetric energy intensity compared to fossil fuels (e.g., natural gas), it is regarded as one of the critical and green energy storage fuels with zero carbon content. In this work, thermal catalytic cracking of liquefied natural gas (LNG) at elevated temperatures employing concentrated solar tower is considered to produce clean hydrogen (CO2-free) is studied. Then, the generated hydrogen is utilized for ammonia synthesis in a Haber-Bosch reactor. The proposed system is initially assessed from a thermodynamic point of view, considering energy and exergy analyses with emphasis on the optimization of operating conditions. Then, life cycle assessment (LCA) of the proposed system is performed to analyze the environmental impacts of ammonia synthesis. Although solar energy is a clean and abundant source of energy, the employed conversion systems bear some environmental impacts. Aggregate environmental impact of the proposed system is quantified and compared with conventional hydrogen and ammonia production processes. Through the utilization of renewable energy resources, the production of ammonia can be attained, avoiding high emissions. The LCA study is carried out in GaBi software, and the selected impact assessment methodology is ReCiPe. The impact categories studied in this work are global warming potential, acidification, fossil and metal depletion, human toxicity, and particulate matter formation potential. Results are analyzed by dominance, break-even, and variation analyses.

**Keywords:** Methane decomposition, life cycle assessment, solar energy, solar hydrogen, ammonia.

## IEEES12- P181

# Synthetic Natural Gas Production in Power-to-Gas Approaches Involving Biomass Gasification and Anaerobic Digestion

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Power to gas (PtG) technology allows obtaining liquid and gaseous fuels, such as hydrogen, synthetic natural gas (SNG), methanol, etc., that might be stored, used locally for the purpose of energy generation or chemical industry needs, or injected to the natural gas grid. The main goal is to assess and compare two-hybrid systems for the production of synthetic natural gas from electrolytic hydrogen through a methanation process. The first case is a technology consisting of a source of renewable energy (wind or solar), electrolyzers for the production of hydrogen (and oxygen), the oxy-gasification unit as a source of carbon monoxide and dioxide for the methanation reactor, which can optionally be equipped with tanks for hydrogen, oxygen, and SNG storage. The second case differs from the first one in the source of carbon for methanation, which in this solution comes from an anaerobic digestion process. Thus, the main difference between the two proposed cases is the type of biomass used and its thermal conversion technology, resulting in a significantly different composition of the raw gas bearing the source of carbon for methanation. It was assumed that in both cases, a 2 MW renewable source is supplying power to the electrolyzers, and the produced hydrogen is fully utilized in the methanation processes. To make the assessment of the proposed solutions mathematical models were built, and a parametric analysis was made. It allowed determining the main performance indicators of the proposed solutions, such as mass and energy flows, and gas composition in characteristic points of the systems as well as the efficiencies of the full chains. The results show that both cases may be an interesting option for SNG production and energy storage. The overall efficiency of both solutions can reach a value exceeding 55% and is slightly higher in the second case.

**Keywords:** Electrolysis, methanation, SNG production, thermodynamic assessment.



## IEEES12- P188

# Al Rayyan's Wind Energy Potential to Satisfy Ahmed Bin Ali Stadium's Energy Demand During the 2022 FIFA World Cup in Qatar

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Considering the 2022 FIFA World Cup, and the Qatar National Vision 2030, this study analyzes the possibility to use the wind's kinetic energy to produce electricity to satisfy the demand of the Ahmed Bin Ali Stadium located in Al Rayyan, Qatar. An evaluation of the wind potentiality is performed, based on a thorough analysis of environmental parameters and further computation of the wind power density of the district. Furthermore, a commercial wind turbine is chosen, and a case study is carried out to quantify the capacity that wind energy offers to satisfy the maximum energy demand of the stadium. The results indicate that the environmental conditions of Al Rayyan enable energy production to implement wind turbines, based on a 4.63 m/s wind speed mean and a wind power density of 150.96 $W/m^2$. In addition, a single wind turbine with 3.4 MW of nominal capacity and 130 m hub height is capable of generating an average of 5955.02 MWh of energy in a year while a wind farm composed by ten turbines could produce 59550.19 MWh/year. From the demand point of view, the maximum energy consumption of the stadium during a football match is in the range of 28-30 MWh which means that, in order to satisfy this demand, a single wind turbine should generate electricity for a period of 44.1 hours, while the wind farm requires 4.41 hours to provide the energy needed. Moreover, to prevent the use of a storage system, the electricity generated by the wind turbines will be tied to the grid, lowering the energy production quota of fossil fuel power plants. By applying this approach, Qatar could reduce its environmental footprint by saving about 5.84 tons of $CO_2$ per match compared to conventional grid supply during the FIFA World Cup 2022.

**Keywords:** Wind energy, carbon footprint, wind turbine, supply, demand.

## IEEES12- P193

## MOPSA and SPECO Approaches for Thermoeconomic Assessment of a Combined Power Cyle using Renewable and Conventional Fuels

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MOPSA and SPECO methods are considered as two of the most powerful tools for thermoeconomic analysis of thermal systems. Both tools provide distinct approaches, and both have superiorities and shortcomings over each method. SPECO proposes calculation of unit specific exergy cost of each stream that belongs to the studied systems while MOPSA is based on exergy costing without flow stream cost calculations, and thermomechanical exergy is divided into its thermal and mechanical components. This study aims to comparatively assess both tools for a combined power cycle using renewable and conventional fuels. Biogas and natural gas are considered for the gas turbine combustion, and exhaust gases are utilized for energy recovery through a regenerative steam cycle. Combustion characteristics and air/fuel ratios are taken into account to specify combustion chamber exit properties considering the contribution of exhaust gases to stream exergy values. Unit costs of electricity generated from both gas and steam turbines are calculated separately. Exergy destruction cost rates of components using each tool are calculated. Both tools represent certain differences in the cost of exergy destruction rates, while unit costs of products are similar.

**Keywords:** MOPSA, SPECO, combined cycle, exergy, thermoeconomics.



## IEEES12- P201

## Exergy Analysis of Tunnel Furnace and Tunnel Dryer

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With Specific Heat Energy Consumption (SEC) of 1.463 kJ, 90% of the total power need of the sample brick factory is consumed at the tunnel furnace. Being the energy-dense production systems, the tunnel furnace and the tunnel dryer are chosen as the control volume of the exergy analysis. This is the first time of an exergy analysis on a control volume, including the tunnel furnace and the tunnel dryer. Lignite coal, with an LHV of 17.573 kJ, is used as the fuel of the control volume. The waste energy of the tunnel kiln with 116 meters in length is recovered and sent to tunnel dryer with 80 meters in length to dry the wet bricks. The real data are measured at a working brick factory with a daily production of 392 tons of fired bricks with an installed heat power of 6.7MW. The production data for a whole year are used in the analysis. The flue gas composition of the coal combustion is determined by making measurements with a flue gas analyzer. Differential-Thermo- Analysis (DTA) analysis is performed to understand the firing process of bricks. After making a mass balance with a deficiency of 0.15%, the heat energy efficiency of the control volume is calculated as 49.35%. With the input of 372 kW electric power for running the fans in the control volume, the exergy efficiency of the control volume is found out to be 37,50%.

**Keywords:** Brick factory, tunnel furnace, tunnel dryer, energy analysis, energy efficiency, exergy analysis, exergy efficiency.

## IEEES12- P203

## Enhancements in Coal Burning in a Tunnel Furnace

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It is always hard to burn coal. Since climate change is an energy problem and burning fossil fuels to produce electricity or heat is responsible for roughly half of global warming pollution, it becomes a challenge to burn the coal efficiently. In this research; the effects of particle size distribution, coal humidity, coal crusher system, and excess air are investigated in terms of burning efficiency and cost-saving. It is found out that the amount of unburnt coal is directly proportional to the coal particle size. Particle size reduction is related to the performance of the coal crusher. It is experienced that the more the coal is crushed, the faster the hammers of the crusher wear. The compromise in increasing wear and labor is exceeded by coating the hammers. The return on investment (ROI) of an energy-efficient coal crusher system is found out to be 6, 7 months. The burning efficiency is inversely proportional to the coal humidity. It is experienced that reducing the humidity by 1% reduces the Specific Energy Consumption (SEC) by 3.5%. By calculating the required theoretical air for burning, the heat loss by excess air is simulated. Up to 18%, practically 15% of energy saving can be achieved by the enhancements mentioned in this research paper.

**Keywords:** Coal burning, tunnel furnace, coal crusher, coal humidity, excess air, return on investment, energy efficiency.



## IEEES12- P204

## Effects of Microstructure Shape Parameters on Water Removal in a PEMFC Lotus-Like Flow Channel

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Water management is significantly important to the performance and lifetime of proton exchange membrane fuel cell (PEMFC). Effective water removal from the flow channel wall in PEMFC can prevent the water flooding and reduce the wall corrosion, hence improving the PEMFC performance. In this study, the chief object is to improve the anti-corrosion and drag reduction performances of the flow channel wall. A 3D numerical investigation of water removal in a PEMFC lotus-like flow channel by using the volume-of-fluid method was carried out. The effects of the microstructure shape parameters (height, radius, and spacing) on the water removal were investigated. The investigation carried out has revealed that compared with the conventional straight flow channel, the lotus-like flow channel can not only effectively remove the water droplets on the channel wall surface, but also accelerate their transport because the air exists at the bottom of the flow channel. With the increase of height, the velocity of the water transport increases. However, excessive microstructure height contributes to the water accumulation at the bottom of the microstructure. The pressure drop of the lotus-like flow channel is higher than that of the conventional straight flow channel, which leads to a higher requirement for the air compressor. In addition, the pressure drop shows an upward trend as the height increases. As the radius increases, the velocity of the water transport increases slowly. The variation of the radius brings out a bulge in the front of the water droplet. The spacing has an obvious influence on water accumulation while it has an inapparent influence on water removal and water transport. The lotus-like flow channel has good anti-corrosion and drags reduction performances with the microstructure height of 50 μm, the radium of 50 μm, and the spacing of 200 μm.

**Keywords:** PMFC, flow channel, lotus-like microstructure, water removal.

## IEEES12- P207

## Parametric Study and ANN Modeling of Liquid Feed Direct Ethanol Fuel cells

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Direct ethanol fuel cells (DEFCs) have emerged as an attractive solution to the present-day energy crisis. As a fuel, ethanol shows great promise in the field of Alcohol Fuel Cells. In this research endeavor, the experimentation of a liquid fed ethanol fuel cell was carried out to study the effect of various parameters on the performance of the fuel cell. The effect of operating parameters such as cell temperature, ethanol concentration, anode and cathode flow rate, humidity were studied. An artificial neural network (ANN) was also employed to model the performance of the DEFC. The model employed a feedforward topology with backpropagation. The neural network was trained using the experimental results obtained. The model is able to sufficiently predict the performance of the DEFC and the predicted target values are in good agreement with the experimental output values. The regression coefficient value was 0.992. The maximum performance was obtained at a cell temperature of 80ºC. The optimum power density was obtained at a concentration of 2M beyond which ethanol crossover decreases the cell performance. Anode and cathode optimum flow rates were obtained as 1.5ml/min and 2000ml/min, respectively.

**Keywords:** Direct ethanol fuel cell, artificial neural network, modeling, power density.



## IEEES12- P208

## Potential of Biocrude Production from Camel Manure via Hydrothermal Liquefaction: A Qatar Case Study

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Livestock manure is a significant contributor to methane emissions which are released upon the decomposition of manure under anaerobic conditions. Besides, the mismanagement of manure may lead to serious water and soil contamination. In Qatar, camels are commonly domesticated for their meat and milk. Its camel population generates around 120,000 tonnes of manure annually, resulting in nearly 4 kilotonnes of $CO_2$-e emissions. Meanwhile, Hydrothermal Liquefaction (HTL) has emerged as a promising technology for the valorization of wet wastes, as it does not require the energy-intensive drying step as in gasification and pyrolysis technologies. As such, this study investigates the potential of biocrude production from camel manure in Qatar, and potentially other similar areas, using HTL. Proximate and elemental analysis of manure samples is conducted, while the process is simulated using Aspen Plus® software with an optimal feed capacity to completely utilize most of Qatar's camel manure. Moreover, an economic assessment is conducted using Aspen Process Economic Analyzer (APEA). The demonstrated results are encouraging; whereby, a biocrude yield of 37.9% (dry, ash-free basis) is achieved, with a minimum selling price of 72 US$/bbl. Nevertheless, the presence of well-established oil refineries in Qatar makes it feasible to upgrade biocrude into drop-in transportation fuels via co-processing with petroleum crude, which has been recently certified by the American Society for Testing and Materials.

**Keywords:** Hydrothermal liquefaction, camel manure, Qatar, biocrude.

## IEEES12- P213

## Potential Carbon Reduction from Atmosphere via Urbanized Local trees in Qatar

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Carbon capturing and sequestration are of great interest to reduce the carbon dioxide $CO_2$ emissions from the atmosphere. To achieve this, forests, grasslands, and vegetation areas, in general, should be planted and conserved. However, for cultivating a landscape, water resources become an issue for some regions specifically in the arid areas where they have water scarcity and use desalination of seawater for life amenities. Even with using a relatively clean energy source (natural gas), desalination is responsible for 12 kg of $CO_2$eq m-3 with high consumption of electricity and energy resources. Alternating this with treated wastewater with good purity can help reuse of treated sewage effluent TSE, abate the consumption of resources, and mitigate the emissions of $CO_2$. This scenario was applied in the middle east region, particularly in Qatar, where the 2022 world cup event will be held. An intensive project was established near Doha north TSE with the potential of reducing the massive amount of $CO_2$ by natural sequestration through planting trees and grasslands. Efficiently, TSE exclusively was used to cover the need of the whole landscape. In this study, the focus was on studying the potential mitigation of carbon by measuring the operational carbon footprint from facilitating and planting the landscape, the carbon captured by the whole landscape (trees, grassland, soil, etc.), and the net carbon storage and neutralization. Initial results showed that the usage of TSE was able to reduce the $CO_2$ by approximately 12 times compared to desalinated water. With further investigation, the value of carbon sequestration through the landscape can provide positive net carbon storage helping in neutralizing carbon emissions with sustainable and natural facilities.

**Keywords:** Carbon sequestration, carbon capturing, recycled wastewater, desalination.



## IEEES12- P214

## Impact of Energy Subsidies on the Economic Viability of Rooftop Photovoltaic Systems in Qatar

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Renewable energy sources and sustainability have been attracting increased focus and development worldwide. Qatar is no exception, as it has ambitious plans to deploy renewable energy sources on a mass scale. Qatar may also look into initiating and permitting the deployment of rooftop photovoltaic (PV) systems for residential households. As a result, a research gap has been introduced regarding the system design, grid compatibility, economic viability, and consumption of energy produced from household rooftop PV systems. Additionally, the lack of supporting policies and a feed-in tariff creates further research and development topics. Therefore, using empirical research done using data collected from 10 houses over a year-long period, data collected from a solar testing facility and a developed PV payback model used to determine the feasibility and economic viability of using rooftop photovoltaic and energy storage systems. The purposes of this research study are as follows: (1) determining the economic viability of rooftop PV systems under different policies and electricity rate schemes; (2) evaluating the impact of energy subsidies on the application of rooftop PV systems in Qatar. The insights of the results of this study can serve as a stepping stone for decision and policymakers with regards to the application of rooftop PV systems in Qatar.

**Keywords:** Solar energy, economic viability, electricity prices, energy subsidies.

## IEEES12- P217

## Comparison of Multi-Input Single-Output Isolation-free DC-DC Converter Topologies for Hybrid Power Plants

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Today it is an obvious fact that energy consumption tends to increase due to technological developments, population growth, and increasing living standards. In last two decades, renewable energy sources are accepted the most convenient way. However, most of these alternative systems are not considered sufficient to supply whole demand alone. But hybrid systems with some of alternative energy sources, such as solar, wind and biomass appear to be a solution to supply the energy needs in the future. In hybrid systems, the dc-dc converter structure is the main device when converting energy for the proper loads. Single / multiple input single / multiple output dc-dc converter topologies vary in design according to the energy demand of the load. Particularly, topologies with bi-directional power flow and less circuit elements come to the fore. In this study, the simulation of multi-input single output dc-dc converter topologies was performed in Matlab / Simulink software. Induction current and voltage, output current and voltage, as well as output power used in the determined topologies were analyzed.

**Keywords:** MIC topologies, hybrid systems, Matlab / Simulink, two-input converters, V-I characteristics.



## IEEES12- P219

## Sustainable Energy use and Decarbonization Potential in the Hungarian Residential Building Sector

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The residential buildings form a crucial sector of climate change mitigation in Hungary. Household heating is responsible for almost 25% of the overall $CO_2$ emissions and represents significant potential for future emission reductions. The primary objective of the paper is to identify the long term tendencies and future perspectives of decarbonization of household's heating energy use in Hungary. Methodology for spatial and temporal analysis of GHG emissions from household heating is developed; moreover, the essential characteristics of the residential building stock and structure of household heating fuel use are summarized. The comparative analyses of carbon-intensity of the household's heating among the EU member states are presented as well. The paper provides a detailed assessment of energy use and $CO_2$ emissions related to district heating of multi-dwelling residential buildings and heating fuel mix in detached houses, separately. Driving factors (such as fuel switch, energy efficiency improvements, housing's retrofit) in historical emission reductions are identified, as well as future decarbonization potentials and options in household heating are estimated. Results suggest that significant $CO_2$ emission reduction has been realized in heat production and district heating consumption and moderate future decarbonization potential can be expected. Nevertheless, in the case of detached houses (more than 2 million in Hungary), the primary source of decarbonization is the fuel switch to solid biofuel (fuelwood), and emission reduction options in housing energy efficiency improvement are still not adequately exploited. Finally, the paper focuses on the sustainability context of fuelwood use in household's heating, especially in rural regions, since fuelwood use leads to local air quality problems and related respiratory health risks. Furthermore, fuelwood use is strongly interlinked with energy poverty and other social circumstances. Concluding remarks and suggestions are summarized to achieve sustainable energy use.

**Keywords:** Residential buildings, decarbonization potential, sustainable energy use.

## IEEES12- P222

## Reactivity of Iron Powder Fluidized Bed for Solar Hydrogen Production

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Thermochemical hydrogen production utilizing iron reduction oxidization (Redox) reactions is a promising high-efficiency route to renewable fuels. This work considers oxidation of iron by steam to produce hydrogen using a fluidized bed reactor. The oxidation of fluidized iron powder results in sintering and deactivation. Sintering adversely affects the hydrogen production process and inhibits the recycling of the iron/iron oxide. Therefore, an investigation has been taken to develop a means to hinder sintering during repeated Redox cycles so that the reactivity of the iron powder remains stable for hydrogen production in solar thermochemical reactors.

Elemental iron is used for experimental investigations. A laboratory testing facility is constructed. Bed temperature varied between 630 – 970°C, and the steam mass flow rate is 2 g/min. To inhibit sintering, crystalline, and amorphous silica are utilized. The incorporation of inhibitors within the iron sample involved mixing the iron powder with silica. Mixing iron with silica hinders the sintering but reduces the hydrogen yield. Mixing iron with crystalline silica with apparent volume fraction to 0.5, 0.67, and 0.75 reduces the hydrogen yield compared to pure iron by 20%, 30%, and 45%, respectively. Mixing iron with amorphous silica reduces the hydrogen yield 35% and 45%, as compared to pure iron, for iron (0-250 μm) and 125-355 μm particle distributions, respectively. The hydrogen production rate for Iron/amorphous silica mixtures surpassed that of the crystalline silica.

**Keywords:** Redox, sintering, hydrogen, water splitting.



## IEEES12- P224

## Enhanced Thermal Conductivity of Polyethylene Composites using Granulated Graphene

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Polyethylene based heat exchanger may offer replacement to metal evaporators in Multi-Effect Distillation (MED) desalination units because of their better resistance to corrosion, fouling, and scale formation. However, the low thermal conductivity of polyethylene (PE) is a bottleneck for its application as heat transfer surfaces, which require high thermal conductivity along with improved mechanical properties and wettability. Nevertheless, the Thermal conductivity, mechanical properties, and wettability of polymers can be enhanced through the addition of graphene-based fillers of very high thermal conductivity. The thermal conductivity of PE-graphene composites is controlled by several filler characteristics such as size, inherited thermal conductivity, loading, directionality, number of polymer-filler interfaces, etc. In this work, nanocomposites of high- and low-density PE with granulated graphene having lateral dimensions in the range of 100s of nm to few mm were prepared by melt mixing using different volume ratios of fillers followed by hot pressing. The morphological analysis of the composites' fractured surface releveled the random oriented of the graphene in the PE matrix. However, melt processing greatly reduced the filler lateral size. At ~20 vol. % of granulated graphene, the thermal conductivities of the composites were 2.9 and 3.2 W/m.K, indicating the very high enhancement of ~950% and ~800% for low-density and high-density polyethylene respectively. Moreover, the stiffness of PE was improved significantly, but the ductility was reduced drastically. Finally, the impact of the composite processing time and extrusion speed on thermal conductivity and mechanical properties were investigated to establish the structure-processing-properties correlation.

**Keywords:** Composites, Polyethylene, Thermal conductivity, granulated graphene.

## IEEES12- P225

## Evaluation of Regional Climate Innovation Potential in Hungary

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Climate change can have extremely diverse impacts on different spatial levels depending on regional characteristics, adaptive capacity, and vulnerability of a territory. Nowadays, it is pivotal to be able to tackle climate change in a sustainable way on regional level, also considering the UN Sustainable Development Goals (SDGs). Hungary is located in the center of the Carpathian Basin with special spatial and natural environment-related characteristics that also influences the possible impacts of climate change according to socio-economic development perspectives. Among several different regional development pathways, climate oriented spatial planning at the regional level can play a pivotal role in enhancing long-term sustainability. Climate innovation-related activities can foster the effectiveness of both mitigation or adaptation-oriented tasks and interventions on a regional level. Based on the international scientific literature review, several different types of innovation can be found, and some of them also can consider climate change-related issues. This paper gives an overview and a typology about climate innovation options from the regional development perspective considering the recent state of climate planning on the NUTS-3 level in Hungary. There is a lack of knowledge related to the comprehensive climate oriented spatial planning assessment on the county level in Hungary mainly in connection with climate innovation; however, all of the 19 Hungarian counties and also the capital has accepted climate strategies. Among examined climate innovation-related solutions, this evaluation also highlights the crucial role of environmental education and training. Recent research focuses on climate innovation potential on the regional level and evaluates the current status of climate strategies, tools, and practices in Hungary considering the potential pathways according to the forthcoming activities. Based on the in-depth analysis mitigation, adaptation, and awareness-raising related climate innovation interventions can be distinguished in different sectors. The results of the evaluation show state-of-art knowledge concerning climate innovation as a support tool for sustainable regional development.

**Keywords:** Climate innovation, regional development, sustainability management, environmental education, awareness-raising.



## IEEES12- P226

## Direct synthesis of formic acid energy carrier from captured carbon dioxide and utilization in a direct formic acid fuel cell

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The objective of this work is to develop a process flow modeling for the synthesis of formic acid from $CO_2$ and hydrogen for energy storage and transport purposes. The use of formic acid as an energy storage medium is promising due to difficulties in hydrogen storage, where formic acid can be stored for a longer time with minimal losses, and then can be utilized in a direct formic acid fuel cell for cleaner power generation. The process flow is developed using Aspen Plus and Engineering Equation Solver to obtain the energy and mass balances, efficiency, fuel utilization, and Nernst voltage of the direct formic acid fuel cell. The model is validated against data available in the literature for operating parameters. The results show that the operation parameters such as formic acid formation rate, heat duty, and work values, fuel cell efficiency and Nernst voltage have a significant influence on the overall performance. The proposed system forms formic acid from gaseous $H_2$ and $CO_2$ with an energy efficiency of about 19%. The formed formic acid is initially stored in a tank for energy storage and then used in a direct formic acid fuel cell to produce about 157.5 kW power with an energy efficiency of 15% at 0.7 V, 25 $^{o}$C and 1 bar.

**Keywords:** Formic acid, direct formic acid fuel cell, carbon capture, hydrogen, energy storage.

## IEEES12- P230

## Kinetic Studies of Camel Manure using Thermogravimetric Analysis

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The kinetic studies on Camel manure degradation are limited. In this study, the thermal degradation of Camel Manure was studied using a Thermogravimetric Analyzer. The analysis was performed in an inert nitrogen atmosphere from ambient temperature to 950°C at a heating rate of 10°C/min. From the TG-DTG curve, three distinct reaction zones corresponding to dehydration, hemicellulose–cellulose degradation, and lignin degradation were observed. The kinetic parameters- activation energy, pre-exponential factor, and order of the reaction for the above zones were determined using a modified form of Arrhenius Equation. The activation energy was calculated to be 34.45, 58.34, and 9.77 kJ/mol for Zone I, Zone II, and Zone III respectively. The order of the reaction was determined to be 0.65, 0.95, and 0.33 for Zone I, Zone II, and Zone III respectively. The knowledge of the kinetics of Camel Manure degradation will be helpful for the design and fabrication of pyrolysis/gasification reactors.

**Keywords:** Camel Manure, thermal degradation, thermogravimetric analysis, Arrhenius equation, kinetic parameters.



## IEEES12- P231

## Thermodynamic Optimization of a Biomass-based Integrated Gasification Combined Cycle with Post Combustion Carbon Capture using Potassium Carbonate

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Biomass showed promising results for efficient energy production by means of mature technologies, best practices, and performance optimization models. With the growing demand for energy and the mounting concerns on the environment, the search for new biomass resources and the development of efficient technologies and processes for their exploitation has become a necessity. Gasification has been found to be an efficient and environmentally friendly thermochemical process, producing a valuable fuel called syngas that can be fed to gas turbines for electricity generation. Combining a steam turbine in the process by using the exhaust waste heat from the gas turbine significantly increases the efficiency of the system. In this study, a novel biomass-based integrated gasification combined cycle (BIGCC) with post-combustion carbon capture using potassium carbonate has been modeled, simulated, and optimized. The proposed system is producing valuable energy from date pits at a net negative carbon emission cost. As such, the proposed system is serving the concept of sustainability by reducing waste, diversifying the energy portfolio, and reducing GHG emissions in the generation of energy. The integrated system is simulated using the Aspen Plus software under thermodynamic equilibrium for the BIGCC and a rate-based model for the carbon capture unit. Overall energy and exergy efficiencies are calculated and optimized by finding the optimal operating parameters in which the electricity generated, and the amount of carbon captured are maximized whilst minimizing the use of resources. Several sensitivity analyses are conducted to select impactful operating parameters and determine their ranges for optimization. Results show that the system is generating approximately 420kW of electricity and capturing around 80% of $CO_2$, with maximum energy and exergy efficiency of 54% and 61% respectively.

**Keywords:** Biomass, BIGCC, carbon capture, $K_2CO_3$, simulation, optimization.

## IEEES12- P232

# Environmental Assessment of Qatar's National Development Strategy associated with Solar Energy Production and Decreasment of Automobiles

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As part of the Qatar National Vision 2030, the government of Qatar is conducting reviews for the National Development Strategies to observe the progress of the Qatar National Vision for each period. However, the second National Development Strategy revision showed some targets for Qatar that needed to be achieved in order to achieve the desired sustainable goals. Two main objectives are illustrated which are the installation of a solar plant of 200 MW capacity by Kahramaa to satisfy the renewable energy production, and energy mix targets to ensure electricity security. In addition, the National Development Strategy is indicating that air pollution is carrying the most weight of pollution in the country of which it was responsible for spreading Particulate matter (PM) 10 and 2.5. Still, maintaining and lowering the ozone safe levels target failed. This was claimed due to the increasing number of automobiles, which is currently should not be the case as the operation of the Doha Metro started. This paper assesses the environmental impacts associated with the production of the newly developed 200 MW solar plant and the operation of the Doha Metro network that can contribute to lower the air pollution of which was claimed due to the increase of automobile number. This paper depend on developed framework of which Collecting emissions data associated with both natural gas burning for energy, for Doha metro trains, and automobiles usage in order to compare illustrate the results to examine the feasibility of the targets that needed to be achieved in the National Development Strategy of Qatar based on Life Cycle and Environmental Impact methodology. The outcomes are believed to be suggestive to the organizations to take the steps needed to comply with the lowest requirements to achieve the targets to contribute toward a sustainable environment for the country for the National Vision 2030.

**Keywords:** Environmental assessment, air pollution, solar plant, automobiles



## IEEES12- P235

# Fuel Cell Electric Vehicles: Current Prospects and Challenges Beyond 2020

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Both academic and industrial R&D motivation for fuel cell electric vehicles (FCEV) has lagged behind the immense momentum increase for battery electric vehicles (BEV) in the last decades. Even though there are quite important challenges that need to be addressed for both technologies, the problems with BEV technology can be tackled relatively easier. This study aimed to review current important challenges for FCEV technology which can be summarized under at least four different categories such as 1) Hydrogen production: Even though the byproducts of the reaction takes place in FCEVs are just water and electricity, the hydrogen production from natural gas or other hydrocarbons is not cost-effective and environmentally friendly as it is thought. Global daily consumption of hydrogen, mostly by oil refineries and chemical industry, is about 70 million tonnes and significantly associated with $CO_2$ emissions. 2) Storage and distribution: Hydrogen storage is still regarded as problematic due to several reasons including liquefication of hydrogen at high pressures, safety measures for compressed hydrogen storage tanks, leakage/storage challenges, gravimetric and volumetric inefficiency, etc. Due to the paradigm shift to autonomous driving which enables passengers to free movement inside vehicles, the energy storage should be located at the bottom of vehicles in flat form. Therefore, current cylindrical type IV pressure vessels are needed to be replaced with rectangular shaped ones. 3) Distribution: Transportation of hydrogen in mass scale is quite expensive and it also requires relatively complicated infrastructure for refueling FCEVs. 4) Economy: Compared to BEV, FCEV infrastructure is more expensive. Scenario analysis showed that FCEVs would be more economical over BEV if a fleet size of one million cars are on the road. On the other hand, durability and degradation issues of stack components should be addressed. Despite these challenges, FCEV shows a slow but consistently increasing trend.

**Keywords:** Fuel cell electric vehicle, challenges, projections, cost-effectiveness, storage, distribution.

## IEEES12- P236

## Assessment of Three Electrochemical Energy Storage Methods for Residential Applications in Hot Climates

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Global warming plays an increasing role in our world, as the share of renewable energy sources in the overall production of electricity has witnessed exponential growth over the past years. Consumer demands are required to be met at any moment at a feasible price. Therefore, sources of renewables, e.g., solar and wind power are potential options; however, production strongly relies on weather and is not fully capable of tracking the demand peaks. The need for high capacitive techniques of energy storage is strongly required to fill up the production deficiency of green energy at a convenient time of a given period. Storage is a significant issue with the advancement in renewable energy because of promoting decentralized energy production. Countless solutions exist to enhance system security, but they vary in terms of specifications. Thus, introducing a group of technical criteria can assist in understanding the performance of each storage technique. Such criteria can serve in proper comparison of different storages where the most suited technique is determined. Specifically, storing energy in hot arid climate regions is a sensitive matter as it is critical to consider appropriate technologies to implement to avoid unnecessary causalities caused by extreme temperatures. Most researches have primarily focused on understanding and defining how each storage system behaves and identifying the main specification of each system, e.g., capacity and energy density or efficiency of the whole system. In addition to the literature, this study compares three different storage methods, namely, flow batteries, lithium-ion batteries, and reversible fuel cells for a residential application located in hot arid regions in terms of water usage, energy density, location dependency, and temperature degradation. A selection approach regarding prior criteria was carried out among the three storage methods: lithium-ion batteries, flow batteries, and reversible fuel cells and obtained rankings were: 6.45, 6.43, and 6.13, respectively. Lithium-ion concluded to have the leading ranking in comparison with the other two methods, whereas the rankings are very close to each other and over the average, implying the potential application of these methods in hot climates.

**Keywords:** Electricity storage, renewable energy, fuel cell, battery, chemical storage.



## IEEES12- P237

## Physical and Electrochemical Analysis of Calcium Co-Doped GDC and its Use as Electrolyte in IT-SOFC

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Calcium co-doped GDC electrolyte (Ce0.8-x Gd0.2 Cax O2-δ) was synthesized by the sol-gel method. Ca Co-doped GDC was mixed with $(LiNa)_2 CO_3$ carbonate mixture to form a composite electrolyte. The optimization study in terms of high ionic conductivity and thermal stability of the Ca dopant in the GDC was carried out. These show very high ionic conductivity due to fast interfacial transport. Physical and electrochemical characterizations were carried out on these electrolytes using thermogravimetric analysis (TGA), X-ray diffraction (XRD), scanning electron microscopy (SEM), Transmission electron microscopy (TEM), Energy-dispersive X-ray spectroscopy (EDX), electrochemical impedance spectroscopy (EIS), Linear sweep spectroscopy (LSV) respectively. TGA was used to determine the calcination temperature of the electrolyte powder. XRD results show that the powders are phase pure with no new peaks. The Ca co-doped GDC exhibited high conductivity and performance, as it combines both the advantages of co-doping and the composite effect. 5% calcium doped GDC showed the maximum conductivity of 0.3 $Scm^{-1}$. These materials show promising fuel cell performances and can be used as electrolytes in the low-temperature solid oxide fuel cells.

**Keywords:** Electrolytes, low-temperature SOFC, co-doped ceria.

## IEEES12- P239

## Energy use Identification for Adapted Production in Africa Frameworks

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This paper is a contribution to the analysis of the current energy access situation in sub-Saharan African regions. More precisely, the study concerns the areas remote from the main grid connection. The goal is setting up a large-scale electrification strategy to satisfy the load required and thus meet the minimum daily energy demand. Besides, the system must be technically and economically feasible according to the energy resources available in the considered area. The paper presents first the Sub Saharan African population's energy demand according to their daily life habits. Demand priorities depend on the locality. Hence, this study is dedicated to a specific area constituted of five countries that are Ghana, Djibouti, Kenya, Ethiopia, and Mozambique. Studies show that the demand is mainly residential, and accounts for about 30% of the total electricity consumption. This demand generally relates to cooking, lighting, and powering devices like TV, radios, and phones. Secondly, on the one hand, the paper evaluates the installed capacity generation relative to available resources, on the other hand, it assesses the satisfaction with the energy supply, which is characterized by two specificities. First, the demand is continuously growing with the development of air conditioning and cooling systems and the increasing of domestic refrigerating appliances usage and then being more difficult to be satisfied by the existing supplying electricity capacity. Second, most of the appliance's energy consumption is inefficient because of their seniority or their non-compliance with the region's standards and labels. Finally, the paper presents some policies and recommendations to improve sustainable energy access for all.

**Keywords:** Energy use, Sub-Sahara Africa, remote areas electrification, total capacity produced.



## IEEES12- P243

## Evaluation of Oxygen and Steam Fed Biomass Gasification within Energy, Water, and Food Nexus

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With the anticipated growth in population to reach 9 billion by 2050, the demand for energy, water, and food (EWF) resources will continue to rise. This has encouraged the deployment of alternative energy sources to limit resource depletion and enhance system efficiency. Biomass is a promising substitute for fossil fuels that can support sustainable development. It can be processed through gasification to generate high-energy syngas that has the potential to produce sustainable energy and chemicals. Sustainability assessment of the biomass gasification strategy is crucial to quantify the impacts of the different pathways on the EWF resources. This study benchmarks the effects of oxygen, steam, and oxygen/steam fed biomass gasification on EWF resources against economic performance through a sustainability optimization metric. The approach enables the maximization of sustainability indices while ensuring a positive generation of EWF resources. The results demonstrate the excellence of steam-only gasification in supporting EWF nexus.

**Keywords:** Biomass gasification, EWF nexus, gasifying agent, sustainability.

## IEEES12- P246

## Cost and Thermal Aspects of Solar Driven Heating Assistance Options for Residential Buildings

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Turkey is a country that imports energy, and its annual natural gas (adopted in the cleanest of fossil fuels) consumption is over 50 billion $m^3$. Every year 12-15 billion $m^3$ of natural gas is used in residential heating. Energy from renewable energy systems can reduce both $CO_2$ emissions and national energy imports. In this study, the storage of sensible heat, hydrogen, and electricity are compared in four different systems to be integrated into existing heating systems utilizing solar energy for heating assistance. Vacuum tube collector system and parabolic thermal collector (PTC) system are selected for sensible heat storage, and photovoltaic (PV) panel system is selected for hydrogen storage and electrical energy storage via batteries. According to calculations for an area where 300 kW of solar energy falls for 8 hours, the highest heating support is PTC with approximately 5800 MJ. Its natural gas equivalent is approximately 160 $m^3$/day. PTC system is followed by thermal energy storage with a vacuum tube, battery, and hydrogen storage respectively. While the PTC system requires an additional power generation system for power to the grid when there is no thermal energy requirement. Cost aspects of the study cases are also taken into account where the hydrogen storage system represents the highest capital costs and increases the thermal energy cost for heating assistance.

**Keywords:** Energy storage, renewable energy, solar energy, heating system.



## IEEES12- P250

## The Energetic and Environmental Parameters' effect on The Valuation of Bulk Carriers

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Depending on the weather and the sea condition, all duty processes of dry cargo vessels consume energy depending on the device/system configuration that is either activated or deactivated. These processes affecting energy consumption can be defined as maneuvering in the port with a full load on the port, open coastal waters and narrow waters, succession on the open sea, approaching the port of arrival, piloting the ship, pocketing or hoisting abdomen with pushing and pulling means and finally load handling. However, there is also a loss of energy wasted in direct proportion to the abilities of the ship's personnel. As a result of the development of environmentally sensitive systems and the regulations imposed by regulatory authorities such as the International Maritime Organization, Flag and Port State, shipping companies are under severe conditions for developing environmentally sensitive behavior as well as coping with low freight rates. This study is based primarily on the energy analysis and environmental effects of the power transmission system used in a dry bulk carrier, based on the operating parameters. Then, considering the performance data, the effects on the ship's valuation processes are also questioned. At the end of the study, taking into account the fuel cost, which is the biggest impact on the Operational Expenditure costs, the relationship between the ship operation processes and valuation is presented. As a result of the study, it has been found that the total amount of fuel at 20°C has a value of 31.54% when 30 voyages are considered. A one-degree savings rate in this load distribution has yielded a 5.27% savings, with 510.31 tons. These savings increase the ship's value of up to 2.7 million USD at the end of economic life.

**Keywords:** Dry cargo carriers, ship, energy, efficiency, ship valuation.

## IEEES12- P254

## Economic Analysis of Generated Boil-Off Gas of Various Liquefied Energy Carriers During Energy Storage and Transport

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The energy of natural gas can be transported in forms of liquefied energy carriers (chemicals), pipelines, hydrates, compressed natural gas, and others. For large scale energy transport, forms of liquefied chemicals can be used to transport the energy of natural gas due to a reduction in volume compared to gaseous forms. However liquefied energy carriers have commonly low boiling temperatures. Therefore, some portion of liquefied energy carriers' mass is lost continuously due to the temperature difference between the storage and the ambient temperature, these losses are called boil-off gas (BOG). BOG is an obvious problem when the energy of natural gas is stored and transported in a liquefied form. These losses reduce the quantity of the liquefied energy carrier, which directly affect their economic value. Therefore, this study presents an economic analysis of three liquefied energy carriers produced from natural gas, namely; liquefied natural gas (LNG), methanol, liquid ammonia ($NH_3$). The economic approach focuses on determining the total ocean transport costs, which are dependent on capital costs, operational costs, and BOG costs. The transport distance (km) and ship capacity ($m^3$) are fixed for the three energy carriers for a fair comparison. The total transport costs of LNG, liquid ammonia, and methanol are 0.75 $/GJ, 1.10 $/GJ, and 0.76 $/GJ, respectively. Liquid ammonia yields a lower cost of transportation per unit mass (kg) but due to lower calorific value, it has a slightly higher cost of transportation per unit energy (GJ). BOG generated during LNG transport contributes to 12% of the total costs whereas, BOG generation during methanol transport does not exceed 1%. To reduce the total costs of transporting the energy of natural gas, proper handling of BOG by economical methods is required during transporting the energy as LNG or transporting the energy of natural gas as methanol can be more economically efficient.

**Keywords:** Economic analysis, boil-off gas, energy carriers, natural gas, storage, transportation.



## IEEES12- P256

## A Survey of International Security Standards for Smart Grids, Industrial Control System and Critical Infrastructure

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International security standards used in smart grids, Industrial Control Systems, and critical infrastructures have become important for institutions and organizations. Within the framework of these standards, it is aimed to increase the security and durability of smart networks, Industrial Control Systems, and critical infrastructures. When determining the most useful best practice standards and guidance for implementing effective cybersecurity and information security, it is important to determine the role and scope of each, and how it will interact with other standards and guidance. Cybersecurity and information security standards are applied to all organizations in which they operate, regardless of sector and institution, regardless of their size. This study provides general information about international information and cybersecurity standards used and referenced in the detection and protection of security vulnerabilities in smart grids, Industrial Control Systems, and critical infrastructure systems. In this study, we investigate 26 international security standards in smart grids, Industrial Control Systems, and critical infrastructures and in which country it was developed and years of development. The research study covers the years from 1971 to 2020. According to our research results, 19 security standards were developed in the USA. It also provides general information on smart grids, Industrial Control Systems, and critical infrastructures.

**Keywords:** Smart grids, industrial control systems, critical infrastructures, security standards, cybersecurity.

## IEEES12- P259

## Architecture Design and Energy Performance of a Modular Nearly Zero Energy Building

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After launching its national energy strategy, energy efficiency along with the development of renewable energy become a top priority of Morocco. The strategy aims at reducing energy consumption by 20% by 2030. In this context, we challenged to design and build highly efficient and innovative buildings powered by solar energy. The building design strategies are based on: bioclimatic architecture, free-concrete building, passive cooling, active solar technologies, VRV HVAC System, Heat Recovery Ventilation, high-performance appliances, LED lightings, etc., to achieve a positive energy balance. Based on the EnergyPlus simulation, we studied first the influence of the Envelope composition, the Cool Roof, the Natural Ventilation, the Patio opening, on the interior temperature variation without an HVAC system. To make TDART project a modular house that can be assembled and dismantled, we were forced to use materials with low thermal inertia. In order to improve the thermal comfort and reduce the energy consumption, thermal insulation materials were added to walls, roofs, and floors, which has proven its efficiency when combined with adequate HVAC systems. Our system has a capacity of 14 kW for cooling and 16.5 kW for heating, an energy efficiency ratio (EER) of 3.9, and a coefficient of performance (COP) of 4.18. Regarding domestic hot water production, it has found that the use of a heat pump as a technology for producing hot water, has the lowest primary energy consumption, compared to an electric boiler. We have adopted a photovoltaic installation of 9.8 kWp, with a special electrical configuration. The installation consists of 27 monocrystalline solar panels with a capacity each of 360 w, three inverters with a total capacity of 12.2 kW, and a storage capacity limited to 4.8 kWh. TDART house performed well by guarantying an electrical energy production of 712 kWh while our consumption was about 214 kWh.

**Keywords:** Bioclimatic architecture, thermal building performance, PV, VRV system, heat recovery, ventilation, heat pump, energy plus.



## IEEES12- P261

## Thermodynamic Comparison of Cooling Options for Clean SOFC-Powered Locomotives

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In this paper, an energy and exergy efficiency based-comparison of two space cooling options for locomotives, powered by an integrated SOFC system, is presented. System 1 uses a reversible heat pump that has space and operating weight advantages, while System 2 uses an absorption chiller to recover waste heat for providing space cooling that is more exergetically efficient. Both energy and exergy analyses are employed to model the present systems. The obtained results show that the energy and exergy efficiencies of System 2, with an absorption chiller operating at a cooling load of 105 kW, have slightly higher values than System 1 by a difference of around 1%. Therefore, using an absorption chiller as a cooling option is less attractive compared to a reversible heat pump due to the space requirements advantages of using a reversible heat pump.

**Keywords:** Energy, exergy, efficiency, cooling, locomotives, solid oxide fuel cell.

## IEEES12- P262

## An Experimental Study on Gas-to-Liquids (GTL) and Biogas Dual Fuel Operation of a Diesel Engine

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In the pursuit of a substitute to fossil fuels, many alternatives have been suggested in the last few decades. It has been felt that if the conventional engines can be modified to operate with alternative fuels, a smooth transition to renewable technology will be realized. In this context, an experimental study of dual fuel operation of a conventional diesel engine with GTL (gas-to-liquids) as the pilot fuel and biogas as the main fuel is presented in this work. In this study, the pilot fuel (GTL) was directly injected in the engine cylinder with the help of a conventional diesel injector, and the main fuel (biogas) was inducted in the intake manifold. The engine operations were studied at steady-state and maximum pilot fuel substitution conditions at varying engine loads. The performance of the engine was studied based on energy and exergy analyses. On the emission side, oxides of nitrogen ($NO_x$), hydrocarbon (HC), carbon monoxide (CO) and smoke emissions were analyzed. The results were also compared with the standard single fuel operations of the diesel engine. It was found that the engine efficiency with GTL fuel was slightly higher as compared to diesel in single fuel operation. The dual-fuel operation showed up to 80% pilot fuel replacement by biogas; however, some reduction in engine efficiency was observed. The major reason for the loss in efficiency with biogas is its lower calorific value. At the full load, the exergy efficiencies with diesel, GTL, and GTL-biogas operations were 28.4%, 30.2%, and 23.6%, respectively. At these operating conditions, the exergy destructions were 36.5%, 33.4%, and 47.7% of the total input fuel exergy, respectively. On the emissions side, GTL showed slight improvements in $NO_x$, HC, and CO emissions as compared to diesel. The dual-fuel operation showed a significant reduction in $NO_x$ and smoke emissions, though the HC and CO emissions were increased.

**Keywords:** Dual fuel, GTL, biogas, diesel, exergy, irreversibility.



## IEEES12- P266

## Catalytic Hydrolysis of Mixtures of Sodium Borohydride and Ammonia Borane for Hydrogen Generation

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Catalytic hydrolysis of mixtures of sodium borohydride (NaBH4) and ammonia borane (NH3BH3) was studied for hydrogen production. For hydrolysis, novel tri-metallic (Ni-B-Zr) and bimetallic (Ni-B) catalysts was prepared and used. Experiments conducted at different reactant molar ratios and temperatures. Comparing Ni-B and Ni-B-Zr for pure NaBH4 and pure NH3BH3 reactions, positive effect on hydrogen production provided by Zr on Ni-B catalyst was obtained. SEM, BET Kinetic analysis for hydrolysis reactions were carried out and activation energies of hydrolysis reactions of pure NaBH4, pure NH3BH3, and NaBH4/NH3BH3 molar ratios were calculated

**Keywords:** Hydrogen production, Dehydrogenation, catalytic hydrolysis, ammonia borane, sodium borohydride.

## IEEES12- P267

## Investigation of $Ni_2B$ as an Additive in the Molten Carbonate Fuel Cell Anode Materials

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Molten carbonated fuel cells are notable as power generation systems because of its high efficiency and relatively clean conversion of chemical energy into electrical energy. In this work, the anode electrode for molten carbonate fuel cell was synthesized. The positive effect of nickel boride as an additive in nickel anode electrode was investigated. Nickel boride was synthesized by chemical reduction with solvo-thermal route. Reduction reaction of nickel chloride hexahydrate salt with sodium borohydride was performed for nickel boride synthesis. Result of reaction, both nickel boride and hydrogen were produced and then nickel boride was put into reactor kept at 350°C for 12 hours to provide solvo-thermal conditions. Obtained nickel boride was added to green sheet. Green sheets were subjected to sintering operation to get anode electrodes. As a result of SEM analysis, average particle size for without and with additive anode electrodes were calculated as 4,4 µm and 3,4 µm respectively. According to EDAX results, atomic percent of nickel for without/with additive anode electrods were found %44,34 and %83,13 respectively.

**Keywords:** Plastic material, Anode, metals, molten carbonate fuel cell, nickel boride



## IEEES12- P268

## Exergetic Investigation of a New Integrated Ammonia Based System

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In this study, a newly developed integrated ammonia synthesis and fuel cell system is presented for hybrid solar and wind power plant applications. The system is incorporated with a novel type of three-way thermal energy storage, electrochemical ammonia synthesis, and direct ammonia fuel cell subsystem operating with single alkaline molten electrolyte salt. The excess solar thermal energy is stored in this subsystem, and the molten salt acts as both the storage medium and electrolyte for electrochemical ammonia synthesis as well as power generation through direct ammonia fuel cells. The energy and exergy efficiencies of the electrochemical ammonia synthesis system are evaluated to be 38.2% and 41.1%, respectively. Further, the direct ammonia fuel cell entails an energy efficiency of 61.5% and an exergy efficiency of 57.8%. Several parametric studies are also conducted to investigate the effects of varying operating conditions and system parameters on system performance.

**Keywords:** Ammonia synthesis, ammonia fuel cell, integrated system, energy, exergy, efficiency.

## IEEES12- P269

## Performance Investigation of the Reactor Cascading Effect on Ammonia Synthesis

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This study develops the concept of cascaded ammonia synthesis and investigates the three different configurations of ammonia synthesis, including single-stage, double-stage, and triple stage cascaded systems. The concept of using multiple cascaded reactors in series is investigated in this study, which can eliminate the cost of reheat and re-pressurizing the unreacted gases to recycle back in the synthesis reactor and to reduce the number of recycle loops. All three proposed configurations are simulated using Industrial software Aspen Plus V11. The results revealed that the exergetic and energetic efficiencies increase with the reactors cascading ammonia synthesis. The exergetic and energetic efficiencies for the single-stage configuration are found to be 20.2% and 18.6%, for double- stage configuration, 35.35% and 32.6% and triple-stage configuration, 46.71%, and 43.09% respectively. Furthermore, sensitivity results are presented and discussed.

**Keywords:** Cascaded reactors, ammonia synthesis, energy, exergy, efficiency.



## IEEES12- P274

## Reliability Analysis of V- Trough Solar Air Heater (VTASH) with Thermal Storage using Hourly Average Solar Radiation Data

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This paper presents the hourly average solar radiation data and standard deviation as inputs to study the reliability performance of VTASH over a year using the Monte Carlo simulation (MCS) technique with the help of MATLAB package. This paper is organized as two sections; the first section deals with the various solar radiation prediction models along with the hourly average solar radiation (HASR) method are compared. The comparison is carried on the basis of predicted hot air generation by solar air heater. Estimation of heated air using the HASR method is close to the actual heated air generated by solar air heater. The deviation in monsoon months is due to the cloud cover. In the later part of the paper, various reliability indices are obtained by the HASR method using the MCS technique. Reliability indices, additional energy hours and additional thermal energy reduce exponentially with an increase in load indicates that a solar air heater with thermal storage system, the source will offset maximum fuel when all of its generated energy is utilized. The fuel-saving calculation is also investigated. Case studies are presented for ACS College of Engineering in Bengaluru, Karnataka State, India.

**Keywords:** Hourly mean solar radiation, Monte Carlo simulation, MATLAB, reliability indices, solar air heater.

## IEEES12- P278

## Borohydride Oxidation on Copper alloys deposited on Carbon by Electroless Coating

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DBFCs are seen as alternative power sources for portable and mobile applications since they eliminate hydrogen storage problems and due to liquid fuel usage can be used safely. Among low-cost, non-noble metals, the 3d transition metals – nickel, copper, cobalt, iron, zinc – with unoccupied 3d orbitals are expected to enhance the electrocatalytic activity on alloy electrodes for BOR. Copper alloys such as Copper Cobalt, Copper Zinc with varying percentages were coated on Torray carbon paper by an electroless method. Coatings were characterized by XRD, SEM/EDAX. Cu alloys coded as A1, B1, C1 (Cu-Co) and D1, E1, F1 (Cu-Zn) were evaluated as a negative electrode for the direct electrochemical oxidation of sodium borohydride (NaBH4). Steady-state galvanostatic measurements, cyclic voltammetry, linear scan voltametry were used to characterize the electrode behavior; namely, the oxidation reaction at the Cu/borohydride interface, and a possible working mechanism was proposed. The most effective Cu alloy composition for the oxidation of sodium borohydride was found to be A1 and B1, i.e., 70% Cu - 30% Co and 60% Cu 40% Co. Other electrodes, such as C1, D1, E1, F1, were not effective. NaBH4 was observed to be oxidized at 0.21V for A1 and 0.25Vfor B1 (Cu-Co) alloy electrodes at the scan rate (50 mV/s).

**Keywords:** Borohydride oxidation, copper alloys, electroless method, Direct borohydride fuel cells.



## IEEES12- P284

## Synthesis and Testing of Hybrid Micro-Nano Coatings for Advance Nucleate Boiling

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CPV technology provides a sustainable solution for the practical implementation of the multi-junction solar cell; however, thermal management of CPV is still challenging to overcome. Thermal management of concentrated photovoltaics (CPV) is also an important parameter that affects the cell efficiency and maximum possible concentration ratio of CPV, which resulted in a significant effect on its price and required installation area. In this study, new hybrid micro-nano surfaces have been applied to enhance the performance of nucleate pool boiling heat transfer as a thermal management technique for CPV. Synthesis of the micro-nano scale surface is performed by two-step hot thermal compaction and nanofluids boiling. The performance of three different types of surfaces, i.e., micro, nano, and hybrid micro-nano surfaces, has been prepared and tested and comparatively analyzed with the standard unmodified surface. Micro-surfaces resulted in maximum enhanced performance to critical heat flux (CHF) and the heat transfer coefficient (HTC). Compared to the standard plain surface (P), CHF of the microsurface has been increased by 62 %, from 690 kW/m$^2$ up to 1120 kW/m$^2$. While the average increase in HTC was 101%. Hybrid micro-nano surfaces resulted in lower performance of microporous surfaces. The deposition of nanoparticles over microporous surfaces resulted in the disturbance of the original enhancing phenomena of microporous surfaces by blocking the micropores. The decrease in performance is observed with the increase in the concentration of nanofluids for three different concentrations of 0.0001%, 0.001%, and 0.01%. Since the reduction in the required installation area and low cost are the main requirements for the successful installation of renewable energy technology in urban infrastructure. At the end of this study, the effect of these results has been studied for efficiency, maximum concentration ration, and the required installation area of CPV technology in urban infrastructure. The overall decrease in the surface area observed is the study is more than 24%.

**Keywords:** Heat transfer, energy efficiency, CPV, green building.

## IEEES12- P287

## Economic and Social Sustainability in Low-Carbon Energy Transitions: Computer Simulations of a Proof-of-Concept Study

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Global efforts have considerably raised in the low-carbon energy transition to reduce $CO_2$ emissions for the last decade, hence protect the nature of the world. The transition from fossil fuels to renewable resources has broadly investigated in many studies in terms of environmental sustainability and technological development. However, economic and social outcomes of clean energy investment have been usually overlooked in the energy literature, whereas sustainable development requires a holistic approach by considering the economy and society along with the environment. There is a dramatic financing gap in energy investment, and conventional financing models fail to fill the gap. The financing tools depending on excessive debt ultimately and negatively affect social welfare by increasing wealth inequality. This study proposes an innovative proof-of-con-cept financing model for building solar powerplants that provides insights into wealth inequality and social welfare. To this end, a closed economic system is designed as an agent-based computational model with the proposed policy rules and the equity-foun-dation-based financing model. Then, the proposed model is simulated for fifty years to evaluate and compare the wealth inequality with a conventional financing mechanism. As a proof-of-concept, the key finding shows that the proposed policy settings radically reduce wealth inequality to 0.434 throughout simulation time, which is lower than the lowest value in the world. In conclusion, there is a need for innovative financing models to achieve environmental sustainability together with economic and social pillars.

**Keywords:** Sustainable finance, solar powerplant, wealth inequality, agent-based modeling.



## IEEES12- P289

## Simulation Model for Designing an Optimal Site-Specific Renewable Energy Based Electric Vehicle (EV) Charging Station – A Case Study in Qatar

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E-Mobility has become of great interest during recent years for many countries around the world where the main objective is to decrease the dependency on fossil fuel-based transportation means and reduce the $CO_2$ emissions generated from the transportation sector. However, to meet the additional electricity demand to fulfill the electrical charging requirements for Electric Vehicles (EVs) without expanding on conventional fossil fuel-based power generation systems nor expanding or overloading the exiting electricity infrastructure, grid-independent renewable energy-based charging stations are considered as an ultimate solution for securing the electricity needed for EV charging. Since renewable resources are site-specific, this study investigates the modeling, simulation, and optimization of a proposed grid-independent multigeneration charging station consisting of hybrid solar, wind and biomass sub-systems with battery, hydrogen, ammonia and thermal storage units in the State of Qatar where real metrological data inputs associated with the incorporated renewable energy subsystems are used. The objective of the proposed design is to fast charge minimum 50 EVs per day and produce sufficient mass of $H_2$ and $NH_3$ to produce 200 kW power considering multiple constraints such as site-specific metrological conditions for the power generated by solar system and wind turbine and their intermittent nature as well as restricted land area not exceeding 1,500 $m^2$ to equate typical fuel station land requirement. The results showed that the selection of 1,728 kWh/day CPV/T system and 250 kW rated wind turbine along with 650 kW Li-ion battery storage system and 34 kW biomass-driven steam turbine can achieve the desired target with operational consideration of shutting down $H_2$ and $NH_3$ production 25% and 50% during May and July respectively and total shutdown during June, September, October, November, and December.

**Keywords:** Grid-independent, fast-charging station, electric vehicle, modeling, simulation, optimization.

## IEEES12- P291

## Preliminary Investigation of the Experimental $CO_2$ Cascade Heat Pump System from Exergetic Point of View

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Thermodynamic properties and heat transfer characteristics of $CO_2$ is essential to investigate for new refrigeration systems. This study presents a preliminary investigation of a $CO_2$ cascade heat pump system that can achieve the ultra-low temperature below the $CO_2$ triple-point temperature of -56°C and thermal energy above 100°C. It is known that the system performance of this heat pump system can be optimized by an exergy analysis of the system. Exergy can be considered as an indicator to measure how nearly the efficiency of a process approaches the ideal condition. Therefore, this study has pointed out the specific weakness of the heat pump with an exact method over the system to evaluate the inefficiencies. The main purpose of this study is to apply the conventional exergy analysis to the $CO_2$ cascade heat pump system in order to improve our understanding of the system components and to provide useful information for optimizing the heat pump performance. The results show that the exergy efficiency of the Cool Water Gas Cooler is very low in both the high-pressure and low-pressure sides. However, it has seen that the efficiency of the Cool Water Gas Cooler increase when the inlet water temperature increase. Therefore, the performance of this $CO_2$ cascade heat pump system can be optimized with an appropriate inlet water temperature of the cold water gas cooler.

**Keywords:** Carbon dioxide, exergy analysis, cascade heat pump, system performance.



## IEEES12- P297

## Natural vs. Synthetic Phosphate as Efficient Heterogeneous Eco-Catalysts for Synthesis of Quinoxalines

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Hydrogen enriched syngas production from solid waste through CSP hybrid staged gasification is an attractive technology. In this study, ASPEN Plus was used to develop a simple model for gasification followed by the reforming of syngas. It is a powerful process simulation tool to investigate the production of hydrogen-enriched syngas through staged-gasification with two configurations; gasification followed by syngas reforming and gasification with co-production of bio-char followed by syngas reforming. The model has consisted of gasification followed by a reformer. The heat load of a gasifier was balanced by the injection of solar energy while the heat load of a reformer was balanced by the combustion of produced syngas. The main objective of this study was to compare the benefits of reforming of syngas and the incorporation of solar energy. Simulation results showed that an increase in temperature of a gasifier and steam flow rate to a gasifier significantly increased the carbon conversion, yield of hydrogen, and yield of syngas, but higher pressure did not favor the production of more syngas. Simulation results revealed that gasification of 1000 kg/h feedstock at 600°C @ 1 bara with a steam flow rate of 540 kg/h; resulted in 8640 kmol/h of syngas having hydrogen fraction of 0.38. By reforming of this produced syngas at 900°C @ 1 bara, will resulted with 9720 kg/h of syngas and hydrogen boost up by 26%. Gasification of the same amount at 600°C @ 1 bara in the absence of steam; resulted in 4428 kg/h of syngas having a hydrogen fraction of 0.38 and co-production of 174 kg/h of bio-char. By reforming of this produced syngas at 900°C @ 1 bara, will result in a production of 4968 kg/h of syngas and hydrogen boost up by 26%. Simulation results of both types of configuration integrated with steam reforming of syngas is a promising technology to produce hydrogen-enriched syngas.

**Keywords:** Solid waste, gasification, pyrolysis, reforming, hydrogen-enriched syngas.

## IEEES12- P299

## Development of an Assessment Methodology for Smart Cities: Canadian Cities as Case Studies

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The urge to develop and innovate net-zero energy systems for smart city applications has never been more pressing. As the world population is rapidly growing, the global energy demand expands exponentially. The setback with higher energy consumption is the substantial greenhouse gas emissions associated with using fossil-based fuels, which make up the primary energy sources in the world today. The concept of net-zero energy has been investigated for various applications, including homes, farms, and communities. However, the concept of net-zero energy city is seldom explored in the literature, making this paper more valuable and addressing an important research gap. This paper introduces a novel concept to assess cities for their smartness. A smart city is characterized by assessing the economy, environment, society, governance, energy, infrastructure, and transportation aspects. Each domain is evaluated by assessing a number of key parameters that reflect the condition of that domain in any given city. All indicators can be numerically evaluated and assessed, which gives this approach more credibility and accuracy. Toronto achieved the highest in smart governance and smart energy with 92.7% and 77%, respectively, while it was the lowest in the smart environment with 71.6%. On the other hand, Montreal's smart governance and smart energy were the second highest with 90.1% and 75.6%, respectively. Toronto and Montreal achieved the highest smart governance, while Vancouver scored the most in smart infrastructure. The economies throughout the different cities need significant improvements, while the smart society domain is also open for further improvement. The energy domain needs substantial improvements for these cities to be characterized as smart cities.

**Keywords:** Smart cities, energy sustainability, energy systems, clean fuels, energy storage.



## IEEES12- P303

## Utilization of the Osmotic Power Potential of Desalination Brine

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The world's reliance on desalinated water is ever-increasing due to increased water demand and the rapid depletion of natural water resources. Many water-stressed countries, especially those located in the GCC region, heavily use thermal desalination processes to produce freshwater. Typically, for every 1 $m^3$ freshwater produced, 2 $m^3$ brine is generated and discharged into the Arabian Gulf Sea. As a consequence, the seawater salinity continuously increases, which significantly impacts marine life and requires even more energy for desalting the seawater of higher salinity. Effective management solutions have long been sought by researchers to dissipate the impact of desalination brine. This study aims to investigate the osmotic power potential of desalination brine in order to reduce brine salinity, as well as to generate additional electrical power. A multi-stage thermal desalination process integrated with the Pressure Retarded Osmosis system is designed and analyzed in detail using the Engineering Equation Solver (EES) software. A comprehensive parametric study is conducted over the system to investigate the effect of varying process parameters on the production rate and efficiencies. The study demonstrates that the osmotic power potential of desalination brine can be effectively utilized to reduce its salinity and to generate additional clean power.

**Keywords:** Osmotic power, pressure retarded osmosis, desalination, brine management, GCC.

## IEEES12- P305

## The Effect of Entering Angle on Machinability of PH 13-8 Mo

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PH 13-8 Mo steel is attractive steel for the air and space industry as well as the medical sector due to its greater strength and better corrosion immunity. High strength and good ductility steels have great importance for industry because of lightweight engineering designs and CO2 savings. On the other hand, machining of high strength and hard materials causes high energy consumption and CO2 production. Determining cutting force is an essential factor for minimizing power consumption in the metal cutting process. For cleaner production, the consumption should be eliminated. In this study, the effect of entering angle on machinability of PH 13-8 Mo was investigated for the solution heat-treated (A0), solution heat-treated, and then aged at 400℃ (A4), 525℃ (A525) and 600℃ (A6) samples. All samples were machined at different cutting speeds and different feed rates at a 1 mm constant cutting depth. The results show, increasing entering angle decreases cutting forces, rising cutting speed reduces cutting forces and improving feed rate boosts cutting forces. The lowest cutting force was measured at 150 m/min cutting speed, at 0.04 mm/dev feed rate, and 95° entering angle for the A0 sample, and the cutting force is 56% higher at 75° entering angle.

**Keywords:** PH 13-8 Mo, machining, cutting forces.



## IEEES12- P310

## Renewable Penetration to Turkey's Electric Power Grid

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Turkey's demand for energy and industrial development, in parallel to urbanization and growing population, are constantly increasing along with electricity demand. In order to meet this demand, there are limited hydrocarbon resources, nonetheless, Turkey has a huge potential for renewable resources that can meet this demand instead of imported coal and natural gas in electricity generation. The use of renewable energy sources, including wind and solar power has increased rapidly in recent years in Turkey and record growth in renewable power generation has been recorded in a short time where solar power installed capacity reached 5062 MW and wind power reached to 7005 MW by the end of 2018. This trend has the potential to continue and the country's cleaner renewable energy sources can be the main source of electricity generation. This study examines the penetration of renewable energy sources to the grid by analyzing the current grid situation. The results show that the estimated installed capacity for electricity generation capacity of Turkey is about 111.710 MW and 127.754 MW, respectively for the years 2024 and 2029.

**Keywords:** Electrical energy, renewable, hydroelectric, wind energy, solar energy.

## IEEES12- P312

## Parametric Study of a Parabolic Trough Collector Based Solar Thermal System for Improving Asphalt Paving Sustainability

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This paper presents a proposed design of a Parabolic Trough Collector based solar thermal system, for improving the asphalt pavement installations. The purpose is to heat the bitumen used to coat the aggregates intended for the construction of road pavements. The asphalt mixture needs about 10% of bitumen mixed with 85% of aggregates, which must be dried beforehand at 165 °C to remove moisture. Each ton of asphalt needs 10 liters of fuel to reach the mixing temperature Tɵ. As the thermal process was very fossil with a large amounts of $CO_2$ emissions, the proposed solar heat system will replace the conventional process by using the Parabolic Trough Collector technology, which increase the temperature of the heat transfer fluid at the collector outlet to THTF = 230 °C, in order to reach the desired bitumen temperature gradient (From T = 70 °C to Tɵ = 165 °C). A parametric study has been established, with the measurements taken from Casablanca meteorological data. The system has been designed under TRNSYS 17 software, and the simulation results show the effectiveness of the heat production part, which contributes to minimize the cost and decreases $CO_2$ emissions.

**Keywords:** Solar energy, PTC collector, Asphalt industry, TRNSYS 17, $CO_2$ emissions, sustainability.



## IEEES12- P313

## Integrated Sustainability Assessment of a Multigeneration System

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In this study, a solar-geothermal hybrid multigeneration system integrated with the Cu-Cl cycle for hydrogen production and absorption chiller for cooling is analyzed based on the integrated sustainability assessment. A specific model containing energy, exergy, environmental, economic, technological, social and educational aspects developed for the proposed system. LCA results of concentrating solar power and geothermal power generating systems from the literature are used as input parameters to carry out the analysis. The proposed system is quantitatively evaluated giving a score between 0 and 1 to each category. The economic (0.93), exergy (0.90), and educational (0.90) aspect scores are found confirming the system is being highly profitable, sustainable, and innovative. Also, the system's overall integrated sustainability assessment score is found to be 0.74, which is higher than the sustainability index of the PV system ranged from 0.54 to 0.63, as presented in the literature.

**Keywords:** Exergy, energy, environment, sustainability, integrated sustainability index.

## IEEES12- P316

## Transient Behaviour of a Solar-Aided Shell-and-Tube Type Latent Heat TES Unit

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The solar-powered heating or cooling units, such as heat pumps or absorption chillers, provide considerable performance enhancement in COP and a remarkable reduction in the operational costs of the systems. However, due to the intermittent nature of solar energy throughout the day, the thermal energy storage (TES) systems should be integrated into the solar aided heating/cooling units to maintain a continuous heat supply. This work aims to develop a numerical model to simulate the transient heat transfer behavior of a shell-and-tube type latent heat TES unit integrated with a flat plate solar collector. The discrete system components, i.e., the collector and the storage unit, are first validated against the numerical works from the literature, and then they are combined to evaluate the transient response of the storage unit under variable weather conditions. The finite volume approach is used to discretize the energy equation, and the model is developed in the MATLAB language. The analyses are conducted for the meteorological conditions of Izmir, Turkey. Parametric transient analyses are conducted to determine the influences of the length of the heat exchanger and the melting temperature of the phase change material on the spatial and temporal temperature variations and also the significant system performance indicators such as collector efficiency and charging efficiency. Results revealed that the collector efficiency increases as increasing the tank length or reducing the melting temperature of the phase change material (PCM).

**Keywords:** Phase change material, thermal energy storage, solar collector.



## IEEES12- P323

## Thermodynamic analysis of a polygeneration system designed for Controlled Environment Poultry Farming

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With the continuous increase in human population, the need to ensure food security also increases. On the other hand, the methods used to produce food are enormously contributing towards GHG emissions and associated climate change. Furthermore, the dependence on the national grids make these food production systems vulnerable to the risks in inputs' supply chain. For this reason, there is a need to develop such self-sufficient energy systems which ensures food security without damaging the environment. In this regard, a biomass and solar energy-based polygeneration system is designed to fulfill the electricity, water, cooling and heating needs of a controlled environment poultry farm. The system is composed of solar PTCs, a biomass combustor, a steam turbine, an NH3-H2O absorption cooling system, heat exchangers and pumps. Moreover, for continuous and flexible operation of the system, a thermal energy storage (TES) unit is integrated to the system. Detailed thermodynamic analysis of the system is conducted using mass, energy, entropy and exergy balances applied on each component used in the system. In addition, effects of various environmental variables e.g. solar irradiation and ambient temperature on some of the outputs of the system are investigated. The analysis demonstrate that the proposed system performs stably and can fulfill most of the requirements of a decentralized controlled environment poultry farm in an efficient, environmentally benign and uninterrupted way.

**Keywords:** Controlled Environment Poultry Farming, food security, energy-water-food (EWF) nexus, polygeneration, biomass.

## IEEES12- P324

## A Techno-econo Environmental Assessment of the Deployment of Hydrogen Electric Fuel Cell Vehicles

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Looking at the ground transportation, heavy duty vehicles contribute a significant emission and PM which directly affect the human health and environmental concerns. Among all the heavy duty vehicles, busses are the main contributors as they operate for more than 16 hours a day on average and transfer a lot of passengers in the middle of the cities where they air quality always matters. There are several options to reduce the emission from buses such as improving the efficiency of internal combustion engines, using DPF, improving the fuel quality, and etc. Among the options, alternative fuels such as bio-fuel, hydrogen, CNG, LNG and electricity, hydrogen busses are said to be one of the best options as the fuel is carbon free and the reaction inside the fuel cell is environmentally benign. Although, hydrogen is a clean fuel, its production requires extensive energy depending on the methods. Thus, a realistic comparison is when we take the emission of all the stages into consideration. Life cycle assessment is a potential tool that can address all the emission in various phase from fuel production to fuel distribution and vehicle assembly. This research work presents a LCA of hydrogen fuel cell and diesel buses based on real-world driving cycle. In this study, hydrogen buses are assessed against diesel buses both in terms of life cycle emission and life cycle cost. A real driving cycle from a bus route in Vancouver, Canada is selected and vehicle is modeled to calculate the fuel. The results of this study show that hydrogen buses can be economically comparable to diesel buses if they are mass-produced and hydrogen is produced from renewable sources. And using hydrogen buses can be an effective way to reduce emissions in Canada.

**Keywords:** hydrogen fuel cell bus, LCA, degradation, emission, life cycle cost.



## IEEES12- P327

## Sustainable Dairy Farm Waste Management – A Polygeneration and Hydrogen Energy-Based Approach

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As the global human population is on rise, so is the need to ensure its food security. Moreover, this food security must be met without compromising the environment. In this regard, current practices in the dairy farms are producing huge quantities of GHG emissions, waste and wastewater, and are dependent on external supplies of electricity and water which make them vulnerable to the supply chain disruptions. Our current study explores the possibility of adopting an integrated approach towards fulfilling the needs of dairy farms, recycling/usage of the waste and wastewater, and avoiding the vulnerabilities because of the dependence on national grids. In addition, a hydrogen-based solution has been proposed to the social concern towards reuse of wastewater for drinking needs. For this purpose, a manure and methane based polygeneration system is designed which has a combustion chamber, Rankine cycles, air-humidification and dehumidification processes, NH3-H2O based Absorption Cooling System, an Electrolyzer, and a fuel cell. The system produces electricity, fresh water, cold air and hydrogen. The system is analyzed using thermodynamic laws including mass, energy, entropy and exergy balances applied on each subsystem. A parametric study is also conducted to observe the effects of various variations in the inputs to the system. The analysis demonstrates that the system can perform stably in a sustainable manner, is effectively managing the dairy farm waste and proposes a solution to the social concerns regarding wastewater reuse for drinking purpose.

**Keywords**: Dairy farm, waste management, food security, wastewater reuse, energy-water-food (EWF) nexus, polygeneration, biomass.

## IEEES12- P331

# Energy and Exergy Analysis of a Solar Driven Trigeneration System for Ammonia Synthesis, Electricity Generation and Fresh Water Production

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This research work designs and analyzes a new integrated solar-driven system for ammonia synthesis, freshwater and power production. The developed trigeneration system consists a solar thermal subsystem with a heliostat field, thermal energy storage system where the molten salt is used as a heat transfer fluid and storage medium, a solar energy-driven Rankine cycle, a multi-stage flash distillation unit for freshwater production, a proton exchange membrane electrolyser array to provide hydrogen for ammonia synthesis and an ammonia synthesis unit. The proposed integrated system uses solar energy to charge the molten salt which flows through a heat exchanger and generates steam for the topping cycle. The exhaust stream of the steam turbine provides heat for the multi-stage flash distillation (MSF) process. A 20 stage MSF unit is used and seawater is utilized as the feedwater in this study. A portion of the produced freshwater is sent to PEM electroylzer array for hydrogen production which is used for ammonia production via Haber ammonia via Haber-Bosch process. The thermodynamic analysis of the integrated system is analysed by using Engineering Equation Solver and Aspen plus software. The performance assessments based on energy and exergy efficiencies are carried out for all the system components. Electricity generation, freshwater production and ammonia synthesis capacities are also determined. The overall exergy efficiency of the system is determined as 11.0% where the ammonia synthesis, power production and freshwater production capacities 0.85 kg/s, 17.6 MW, and 143.97 kg/s respectively. The results show that the solar receiver is responsible for the highest exergy destruction plus exergy losses as 70.8 MW.

**Keywords**: Desalination, heat storage, ammonia synthesis, power production, efficiency.



## IEEES12- P334

# Exergy Loss Calculation in a Power Generation System for a Research Hospital

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The main objective of this study is to calculate total exergy losses in a power generation system designed for a research hospital in Rize, Turkey. For this purpose a multigenera-tion system is designed and all equipments are taken into consideration for the analysis. Considering all the parameters, exergy loses of each component of the system are calculated. The results from this study show that the maximum and minimum value of exergy loss in the gas turbine powered system are found to be 3214 kW in the distiller and to be 11 kW in electrolysis. In this regard, it can be said that there is a need to enhance the exergetic performance of the processes in the system.

**Keywords**: Exergy, gas turbine, hospital.

## IEEES12- P335

## Renewable energy based polygeneration system with hydrogen storage for remote decentralized coastal community

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Climate change has already adversely impacted human health, natural ecosystems, and the Economy. It is widely accepted that energy production is the main source of greenhouse gas and CO2 emissions. Approximately one third of the total energy consumption is expended by the building sector, in particular, the operational phase of buildings accounts for 73% of the building's total energy and 64% of CO2 emissions. Sixty percent of energy consumed during the operational phase of buildings is used by Heating, ventilation, and air conditioning (HVAC) systems. The desalination requirement for fresh water production in coastal area takes this retirement of energy to even the higher level. Keeping this in view, this study proposed and analyze renewable energy based poly-generation system for electricity, freshwater, heating ventilation and cooling (HVAC), hot and cold water requirement of a coastal community with hot and humid environment. Solar and wind energy based renewable energy based hybrid system is designed. Phase change material (PCM) ad hydrogen storage is used during the un-availability of current energy sources. Reverse osmosis (RO) based system is used for desalination where absorption cooling is used for cooling requirement of HVAC system. . A remote and decentralized community of 10,000 population is targeted for this purpose with fresh water requirement of 5000m3 daily. Concentrated photovoltaics and wind energy based system is designed to fulfill 7MW of electrical, 10MW of cooling and 1MW of energy requirement for RO based desalination system. The estimated requirement of fresh water is 5000m3, with electricity. The system is designed for summer season with peak load of energy and parametric study is performed for different environmental condition throughout the year. The system have successfully achieved the targeted requirement of water, electricity, HVAC and hot and cold water. Energy equation solver (EES) software is used for design and parametric study.

**Keywords**: Polygeneration, renewable energy systems, multigeneration, renewable energy, coastal area, sustainable environment.



## IEEES12- P336

## Design Quality for Green Building Delivery

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A green certified building is the construction industry's answer towards reducing the impact on the environment. The design phase converts the client needs into design drawings and conformance specifications and is done at a greater intricacy for green buildings because of the superior performance requirements exhibited. The transcendent objectives for green buildings are more complex and require greater rigor in the design phase to produce an effective design solution. The study collates responses from designers involved on green buildings on the key challenges faced compared to conventional buildings as well opportunities for improvement on the design delivery process. Certain aspects are highlighted such as project delivery systems adopted, certain design elements more culpable to redesign iterations and implications of Building Information Modelling (BIM) on the green building design process and the importance of constructability feedback. The study serves to showcase researchers and practitioners the key areas that require further improvement to have a more effective design process.

**Keywords:** Green building, project delivery, quality.

## IEEES12- P338

## Data-Driven Materials Discovery

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Data-driven approaches have accelerated materials discovery along with the upsurge of machine learning (ML) applications, big data and the adoption of computer science tools in materials science. I will give an overview of the latest advances in this field with focus on advances we made in the last few years applied to energy materials. I will show how combination of high throughput density functional theory (DFT) calculation with machine learning are used to perform a systematic analysis of the structure-to-property relation exploring hybrid ABC3 chalcogenide (I-V-VI3), halide (I-II-VII3) perovskites. Focusing on the relationship between the BC6 octahedral deformations and the thermodynamic stability of the compounds, various Machine learning algorithms are trained then tested. I will also highlight how our approach offers an interesting guideline on how to engineer mix-phase perovskites enabling to reduce the huge space of experimental trial and error of mixed anion and cation perovskites.

**Keywords:** Materials science, Density functional Theory, Machine Learning.



## IEEES12- P341

## Urban sprawl and its impact on the environment: case of the Greater El Jadida, (Morocco)

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This study conducted on the great El Jadida (between 8° and 10° West longitude and 33°.5′ and 32°.5′ North latitude) located on the Atlantic coast of Morocco, treats on the one hand the dynamics of urban sprawl and on the other hand, changes in surface temperature between 1985 and 2019. It is based on the diachronic analysis of a time series of satellite images (Landsat), supplemented by field checks. The aim of this work is to evaluate the spatio-temporal mutations of the surface temperature that this region is experiencing as a result of urban expansion and its impact on the environment. The data used are five satellite images including Landsat TM for the two scenes of 1985 and 1995, Landsat ETM for the scene of 2005 and Landsat OLI for the two scenes of 2016 and 2019. This methodology allowed the spatio-temporal comparison of the different tele-analytical maps of surface temperatures and urban and peri-urban extension between 1985 and 2019. Thus, over this period, the built-up areas of the great El Jadida, experienced an increase of 5121 ha, an increase rate of 247% in 35 years. During the same period the surface temperature underwent changes in the distribution of the different temperature intervals, marked essentially by an increase in the areas where the surface temperature is between 25 and 30°C and a decrease in those where the temperature is above 30°C. The juxtaposition of the two maps, that of the evolution of urban sprawl and that of changes in surface temperature, allows us to suggest the impact of urban sprawl on the spatial distribution of surface temperature.

**Keywords:** Environment, the great El Jadida, Landsat images, urban sprawl, surface temperature.

## IEEES12- P342

## Thermodynamic Analysis of an Automobile's Air Conditioning System Assisted by Exhaust Gas and Solar Energy

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Most of new automobile engines used all over the world, converts nearly 30% of developed power into useful work. The rest is found as losses and major losses found in the cooling and exhaust system. A novel automobile's air conditioning (AAC) system assisted by engine exhaust and solar energy is proposed in the present research study. The system is modeled in Cycle-Tempo modelling software and R22 and ammonia rich $NH_3$-$H_2O$ binary mixture are used as a working fluid for the existing and proposed automobile's AC system, respectively. Result shows that the proposed system can produce about 1.64 kW of electric power which will help in reducing the total power requirement of AC system after maintaining constant cooling effect of about 10.5 kW. As a result, the COP of an Automobile's AC system is increased from 2.453 to 2.793. The net combined energy and exergy efficiencies of the proposed system are about 4.30% and 15%, respectively. The energy and exergy efficiencies of the system are increased with increase in pressure. About 25 bar is the optimum value of operating pressure as per given boundary conditions of the present study. Exergy analysis of the system discloses the different locations of exergy destruction in the system. By this novel system, the fuel saving of the automobile can be done by about 2.17 kg/day and $CO_2$ emission can be avoided by about 6.78 kg/day. Economic analysis is also carried out for techno-commercial feasibility.

**Keywords:** Air conditioning system, COP, Energy, Exergy, Environment, Economic, Engine exhaust, Solar energy.



## IEEES12- P343

## Using Bat Algorithms for Techno-Economic Analysis of a Grid-Connected PV System and Comparison with PSO and WOA Methods

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In this study, we propose an updated methodology based on an improved algorithm for the optimizing and sizing of a grid-connected PV system. We aim to minimize total net present cost using a novel optimization algorithm, the improved bat algorithm (IBAT), based on teaching and learning processes. To manage this optimization, several methods such as particle swarm optimization (PSO), the whale optimization algorithm (WOA), and cuckoo search (CS) are widely used. However, new approaches are needed to increase the efficiency. Optimized grid-connected PV systems can reduce production expenses, even in countries with large supplies of fossil fuel. The net present cost (NPC) and the cost of energy (COE) of the grid-connected PV system are $19595 and 0.134 $/kWh more efficient, respectively. To validate the proposed method and to ascertain the speed and accuracy of the IBAT, NPC and COE were measured and compared with the results of other common optimization algorithms, namely PSO, WOA, and CS. A policy for energy efficiency was then illustrated. The loss of power supply probability (LPSP) was evaluated to confirm operating stability. Since the IBAT is easy to build and requires fewer control parameters, it was deemed more feasible. The modeled system was tested on a grid-connected PV system installed at the Centre for Solar Energy Research and Studies (CSERS) in Tripoli, Libya. Annual data of irradiance, load profile, and temperature of the PV system were obtained and used for comparing the IBAT performance results and others. Obtained results proved that the proposed IBAT provides better optimal configuration than the commonly used algorithms. The LPSP value of the IBAT is 0.0965 compared with WOA, PSO, and CS values of 0.415, 0.625, and 0.845, respectively.

**Keywords:** Techno-economic analysis, PV Power System, IBAT Algorithm, PSO, WOA, CS.

## IEEES12- P346

## Building transferable Reactive Force Field potentials: towards an enhanced understanding of metal dusting corrosion initiation

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Metal dusting is a severe type of corrosion at high temperature resulting from the carburization of metal surfaces into dust particles (coke) during uncontrolled steam methane reforming process. Although it has been known for decades, dusting corrosion still represents a challenge for oil and gas industry, especially that our understanding of the various competing atomistic scale mechanisms is still limited. Reactive force-field (ReaxFF) have been used in molecular dynamics simulations for the last two decades to obtain a fundamental understanding of the mechanisms behind the dissociation of hydrocarbon on iron surfaces or the diffusion of the dissociated atoms to the bulk. Yet, various versions of these potentials struggle to capture simultaneously surface dissociation barriers and bulk diffusion pathways due to a lack of transferability. In this work, we will present how we could incorporate all needed information in the ReaxFF potential enabling us to treat at the same time low and high coordination atomistic environments. Applying this new method on molecular dynamics simulation box containing a syngas consisting of carbon monoxide, molecular hydrogen, water and Argon reacting with an iron surface a qualitative alignment with lab scale and field observation could be achieved. Our results show that at a certain CO concentration the atomic arrangement of the iron surface is sufficiently altered to cause reconstruction of the surface, triggering the formation of carbide, oxides and hydrates. The radial distribution function analysis and charge density maps show a variety of carbon bond formation at different stages/layers highlighting the complexity of these mechanisms.

**Keywords:** Metal dusting corrosion, molecular dynamics, CO, reactive force field.



## IEEES12- P347

## Entropy production and Human life cycle assessment for Indians with considering protein, fat, and carbohydrate

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In present work, the thermodynamic life cycles of humans has been determined on the bases diurnal entropy generation with considering energy intake per day for people living in India. This study has been carried out on the food and energy intake data provided by the National Sample Survey Office (NSSO) and National institution of nutrition, Hyderabad. The protein, fat and carbohydrate intake of 18 Major Indian states are considered for the study. With the help of the second law of thermodynamics, entropy production is determined from protein, fat and carbohydrate in whole life duration. In this work, life spans of humans are calculated from entropy production living in different Indian states and, it is seen that people living in Tamilnadu has the maximum life span of 79 years, and Haryana has the least life span of 66 years. Remaining states vary in the range of 66-79 years. This life span of humans is validated by the NITI Aayog study on Life expectancy in India and shows a little variation in the range of 3-8 years.

**Keywords:** Energy, Entropy, Human body, Thermodynamics Life span, food habits, NITI Aayog.

## IEEES12- P352

# Entropy Generation and Exergy Analysis under transient condition for Large Diameter Natural Circulation Loops

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Natural circulation systems are the most reliable heat transportation systems applied widely in nuclear and solar thermal systems. Particularly in generation IV nuclear reactors, it is used as a decay heat removal system during accidental scenario and as a secondary power generating unit during normal operation. However, a stable power generation is of concern as instability in natural circulation loops (NCL) leads to unstable power. In case of single phase NCL, horizontal heater and horizontal cooler (HHHC) configuration delivers the highest flow rate compared to other arrangements with a penalty of least stability. The entropy generated in NCL is mainly due to the fluid friction, heat transfer across the cooler and heater. In the present experimental work with water as loop fluid, transient analysis (with instantaneous entropy generation) is done with and without orifice plates. Different operating procedures like startup from rest, power raising from a stable steady state and power step down from an unstable state are explored. The observation was that the system could switch from either an unstable to stable state, stable to unstable state, or remain in the stable/unstable state. This phenomenon is further quantified using the entropy generated in the system along with the exergy analysis. Further, the system stability is improved by using orifice plates and, entropy generation rate is observed to decrease with reduction in orifice diameter. This drop is attributed to the significant reduction in mass flow rate than increase in temperature difference across the legs. Also noted that the NCL with lower orifice diameter and high heater input lead to better exergy efficiency.

**Keywords:** Natural circulation systems, instantaneous entropy generation, instability, orifice plates, horizontal heater horizontal cooler, exergy analysis.



## IEEES12- P356

# An Effective Hardware–In-The-Loop Testing Technology for an Electro-Mechanical System: Application on Drill String System

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The increasing demand for prototyping and testing of high-power plants in realistic and safe environments has led to the development of new types of real-time investiga-tions without hurting the real system or building a small-scale prototype for testing. The hardware in-the-loop (HIL) testing technology allows virtual or actual components of a complex system to be implemented and tested together in a real-time environment. The advantage of using this technology is that it allows one to perform different tests that are so difficult or harmful to implement on a real prototype or would require one to operate the system under extreme conditions. HIL technology is very useful for different applications, including power systems, automotive, power electronics, and aerospace. The paper presents an effective HIL platform for drill string system that can be used to implement different types of active feedback controllers for torsinal vibration elimination. A discontinuous lumped-parameter torsional model of vertical drill string based on four components (rotary table, drill pipes, drill collars and drill bit) is considered. A power plant of the drill string system including (Induction motor, gearbox, and variable frequency drive) are designed and implemented in the real-time simulator OPAL-RT 5600, whereas the controllers are implemented in the dSPACE 1103 control board. The results obtained through simulation and HIL testing demonstrate are provided. The proposed HIL infra-structure, can serve as a basis for further experimental studies on drill string system as well as other electromechanical systems.

**Keywords:** Drill string system, OPAL RT ; torsi onal vibration; induction motor ; hardware in the loop.

## IEEES12- P359

## Study on challenges and opportunities of Dish type Solar Stirling engine utilization at UAE conditions

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Solar thermal power plants are gaining popularity in the Middle East region. They have the potential of revolutionizing the oil-independent power supply sector in the coming years Diversification of energy mix is critical in meeting the ambitious renewable energy targets and net zero emissions by 2050 for UAE. Although the Concentrated Solar Power (CSP) has widespread application, Solar thermal energy extraction using a point-focusing dish collector and power generation with the use of Stirling engine is studied numerically. A theoretical model of a solar dish Stirling system is modelled with MATLAB®, applying year-round weather conditions of UAE to analyze the overall system performance and study the opportunities and challenges of the technology in the region. The maximum overall efficiency is noted to be 27% for the maximum DNI and having an average total annual power output estimated to be 11.8 MW. Also, the peak power of more than 3KWe was attained for an average of 5.7 hrs a day. The offset $CO_2$ emissions account to 620 $kgCO_2$/kWh for a 10kWe dish Stirling engine. Cleanliness factor of the mirrors considerable reduced the net power output by up to 15%. Challenges in terms of ensuring the tracking efficiency, cleanliness of the mirrors, structural stabilities and limited energy storage possibility are discussed.

**Keywords:** Dish/Stirling engine, Solar thermal energy, Numerical Analysis, $CO_2$ emissions.



## IEEES12- P360

## Synthesis and characterization of carbonized nano-micro materials from agricultural and industrial wastes

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This research explored the potential of corn cobs (CC) and rubber tyres (RT) as the pyrolysis feedstock with a focus on the yield of biochar. These wastes were placed individually into the pyrolysis fixed-bed reactor and pyrolysis was performed at 500°C in the nitrogen ($N_2$) environment. Carbonized CC (CCC) and carbonized RT (CRT) were collected after this process with the yield of 47.43% and 50.05% by weight of biomass respectively. Various properties of these carbonized materials were characterized and compared with the commercially available activated charcoal (ACC). The laser granulometry, scanning electron microscopy with energy dispersive spectroscopy (SEM & EDS), thermal gravimetric analysis (TGA), X-ray diffraction (XRD), and Fourier transform infrared (FTIR) spectroscopy were performed to assess the particle size, morphology, elemental composition, thermal stability, crystallinity and functional groups corresponding to each sample. The $D_{50}$ of all the biochars was in the range of 3.42 µm to 4.78 µm with key minerals of $CaCO_3$ and Graphite, similar to ACC. The biochars showed the erratic surface texture from irregular micro-sheets to round nano-particles. All of the characteristics of biochars were comparable to the ACC; thus they can be used as the replacement material of carbon to modify various properties and reduce the cost of composite materials.

**Keywords:** Biochar, pyrolysis, carbonized materials, activated charcoal, agricultural and industrial wastes.

## IEEES12- P361

## The Effect of Air Layer Thickness on Insulation Thickness Applied to Buildings with Sandwich Walls

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In this study, the effect of different air layer thickness between two brick walls called the Sandwich wall on insulation thickness to be applied was investigated. The recommended heat transfer coefficients for each climate zone were taken from the Turkish Insulation Standart (TS 825). It has been taken into consideration that the wall surfaces between the two walls are unpainted and painted with aluminum-containing. Conduction, convection, and radiation heat transfers are used to calculate the thermal resistances of the air layer of different thicknesses. The temperature values of January, which is the coldest month and given for each climate zone in outdoor temperatures are used. Indoor temperature is accepted as 19 °C given in TS 825. Rock wool is used as an insulation material. Firstly, the minimum insulation thicknesses for rock wool insulation material with unpainted wall surfaces and painted with aluminum-containing are calculated for each climate zone recommended. Secondly, minimum insulation thicknesses for rock wool insulation material between two walls without using the air layer were determined. Finally, differences in insulation thickness and cost-saving due to insulation material were investigated.

**Keywords:** Sandwich wall, heat insulation, air layer, cost saving.



## IEEES12- P363

## Comfort as the dead state of buildings: a preliminary discussion

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Exergy is typically defined as the maximum work that can be extracted from a system when reaching equilibrium with its “reference environment” - a large region unaffected by the interactions - and derives from Gibbs’ original concept of “available energy of a body and medium”. The reference environment definition plays a key role in exergy analysis but is still controversial, especially in the case of buildings; the most popular choice is the local outdoor air, because readily available and largely unaffected by the presence of the building, but its fluctuating conditions pose various challenges. The controversy around the reference environment arguably remains one of the main blockers for the practical application of building exergy methods. However, going back to the origins, Gibbs defined available energy not only for a “body and medium”, but also for the case of a “body alone”, a system formed by subsystems in non-equilibrium conditions. Later, exergy too was defined for this second case, as the subsystem contribution to the body available energy. In the case of the “body alone”, the reference is the “dead state” (or “thermostatic state” of the body), in place of the reference environment. The main idea of this article is that building exergy analysis can be based not only, as currently, on the exergy definition originated by Gibbs’ case of the “body and medium”, but alternatively on the exergy definition originated by the case of the “body alone”, for which a large environment is not needed. The outdoor reference environment can thus be substituted by an indoor “dead state”, making the analysis simpler and “warm” and “cool” exergies more relevant to practical heating and cooling applications. The study discusses typical fluctuations of indoor conditions and the impact on exergy values, and proposes a fixed dead state as the exergy reference.

**Keywords:** Exergy, reference environment, dynamic analysis.

## IEEES12- P366

## Exergetic analysis of trigeneration system using Heliostat and PTC solar technique as energy source

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This paper presents a study to evaluate the exergetic analysis of trigeneration system powered by two different types of solar techniques i.e. Heliostate and Parabolic Trough Collector (PTC). Energetic and exergetic study for both the techniques are analysed. A parametric analysis is performed to determine the affect of parameters like ambient temperature, pressure ratio, DNI, Turbine Inlet temperature (TIT) and the turbine efficiency on trigeneration system. Energy and exergy analysis for both the solar techniques powered combined cycle is carried out to assess the cycle performance and shows the components with primary exergy destruction. Exergy destruction is quantified and shown using an exergy flow diagram, and the energy flow diagram. Exergetic efficiencies of the major components are determined to analyse their individual performances.

**Keywords:** PTC, Heliostate, Trigeneration, Exergy destruction.



## IEEES12- P368

## Techno-Economic Analysis of a 500MWe Supercritical Coal-based Thermal Power Plant with Solar Assisted MEA-based CO2 Capture

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Coal-based thermal power plants are the largest emitter of $CO_2$ in the atmosphere. Emissions of $CO_2$ in the atmosphere increase its concentration level and leads to global warming. The integration of the post-combustion $CO_2$ capture system with coal-fired power plants has the techno-economical potential to mitigate $CO_2$ but a large energy penalty resulting in a decrease of plant efficiencies. The present study deals with the 4-E (Energy, Exergy, Environment, and Economic) analysis of a coal-fired Supercritical thermal power plant with solar assisted Monoethanolamine (MEA) based post-combustion $CO_2$ capture. The thermodynamic analysis of the plant configurations is accomplished with the help of a computer simulation program 'Cycle-Tempo'. It is found that the maximum energy and exergy losses take place in cooling water and combustor, respectively. The addition of solar energy for MEA regeneration helps in increasing the plant energy and exergy efficiencies by about 2.2% and 5% points, respectively, and contributing 26% of the total energy demand for the $CO_2$ capture unit. The Levelized Cost of Electricity (LCoE) and the payback period of the proposed plant are 4.96 INR/kWh and 4.18 years, respectively. Moreover, $CO_2$ avoided of the novel plant configuration is increased by 12.5%. The study also shows that the total area required for installing the solar trough is about 326 acres.

**Keywords:** Energy, Exergy, CO2 capture, MEA, Solar energy.

## IEEES12- P369

# Comparative 3-E (Energy, Exergy, and Environmental) Analysis of Partial Oxy-Coal and Air-Coal Combustion based 500 MWe Supercritical Thermal Power Plants with $CO_2$ Capture

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The present study deals with the comparative performance analysis of a 500MWe Partial Oxy-Coal Combustion (POCC) based Supercritical (SupC) power plant with membrane based $CO_2$ Capture Unit (CCU) at a fixed furnace temperature by varying the amount of oxygen rich air (varying from 0% to 100%) supplied in the combustor. Also, the results are compared with a similar kind of Air Coal Combustion (ACC) based power plant. The detailed thermodynamic study is carried out based on 3-E (Energy, Exergy and Environment) analysis and different plant configurations are modelled by using a computer based software 'Cycle-Tempo' at different operating conditions. The results show that the net plant energy and exergy efficiencies of ACC power plant are about 35.07 % and 30.88 %, respectively which is higher than the POCC plant by about 8 % and 7.04 %-points, respectively at 70% oxygen rich air supply. The reason is inferred by the huge auxiliary power consumption in the Air Separation Unit (ASU) of POCC based plant contributing about 2.113 times higher than the ACC based power plant. However, the $CO_2$ emission in case of POCC based plant is about 0.861 kg/kWh which is about 3.198 times lower than the ACC based power plant due to lower volume of flue gas emission with higher concentration of $CO_2$ present in it. Further, the result shows that the performance of CCU for the POCC based plant is about 45.54% and contributing 2.07 times higher performance than the ACC based plant. Higher concentration of $CO_2$ in the flue gas reduces the auxiliary power consumption of POCC based plant per kg of $CO_2$ captured.

**Keywords:** Air-Coal Combustion, $CO_2$ Capture, Partial Oxy-Coal Combustion, Supercritical Power Plant.



## IEEES12- P370

# Investigation of Using Hemp as a Thermal Insulation Material in the Building Envelope in Terms of Thermal Comfort

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In this study, the use of hemp as an insulation material in building envelopes such as external walls, ceilings, and floors has been investigated in terms of thermal comfort. For thermal comfort; the temperature difference between the inner surface of the external wall and the indoor environment and the difference between the ceiling surface temperature and the floor surface temperature is very important. In this study, thermal comfort analysis has been made for the building. The temperature difference between the inner surface of the external wall and the indoor temperature should be below 3 °C for an acceptable thermal comfort environment. The temperature difference between the ceiling and floor should be below 8 °C. For the values below these temperature differences, occupants can comfortably lead their lives in their buildings. In the study, thermal comfort analysis has been investigated according to the heat transfer coefficient which calculated depending on optimum insulation thickness and recommended values in TS 825. While the optimum insulation thickness was found, natural gas was used as an energy source for the heating period, and electricity was used for the cooling period.

**Keywords:** Hemp, insulation material, thermal comfort, surface temperature, building envelope.

## IEEES12- P372

## Impact of Fossil Fuel Subsidies on Renewable Energy Sector

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The incessant growth of carbon emissions from fossil fuel based power plants need to be controlled in order to limit the global temperature rise. Energy subsidies are one of the reasons for the over consumption of fossil fuel all over the world. Instead of providing benefits, they are damaging the environment. In comparison, subsidies for renewable energy (RE) are very low which is one of the factors for the laggard growth. Additionally, subsidies data for the renewables is not available, unlike fossil fuel. In this work, we discussed that by providing subsidy the cost of environmentally damaging fuel is decreased hence excess usage. Subsidies for renewable may provide long term benefits, are also discussed and some policy recommendations are put forward to accelerate the growth of RE across the world.

**Keywords:** Fossil Fuels, Subsidies, Barriers, Renewable Energy, Incentives.



## IEEES12- P374

## Simulation of Heavy Duty Electric Vehicle Powertrain with Wheeled and Half Tracked Alternatives

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Electric vehicles offer clean and efficient op tions in tr ansportation an d he avy duty applications. Electrification o f heavy vehicles w hich can be used i n t ransportation, construction and military applications, can reduce fuel consumption and exhaust emissions more than small sized vehicle. In this study, drive cycle analysis of heavy duty electric vehicle is performed using Matlab/Simulink for both wheeled and half tracked powertrain alternatives. Battery power requirements and SOC (State of Charge) history is determined according to the drive cycle of HHDDT (Heavy Heavy-Duty Diesel Truck) Transient Mode for constant vehicle weight and battery capacity. On the other hand, gradebility of vehicles is calculated as slope potential during the drive cycle. According to the results, it is clearly shown that, higher vehicle range is achieved by wheeled alternative but half track vehicle offers higher climbing potential.

**Keywords:** Electric vehicle, heavy duty, half tracked, wheeled.

## IEEES12- P377

# Prospects of $CO_2$ Utilization after Carbon Capture Process

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It has been estimated that keeping the global temperature rise below 1.5 °C as per Paris agreement would be difficult to achieve; unless the efforts are significantly scaled up. For this purpose, both renewable energy resources and carbon capture should be employed to restrict the global warming effects. The carbon capture utilization and storage (CCUS) involves three stage: (i) carbon capture (ii) transportation and (iii) $CO_2$ utilization or storage. The $CO_2$ transportation is well established and would not significantly affect the overall CCUS project cost. Therefore, in-depth analysis is required to enhance the efficiency of carbon capture and $CO_2$ utilization processes in order to make CCUS projects financially viable. In this study, available and proposed $CO_2$ technologies are reviewed and analyzed. It is found that the enhanced oil recovery (EOR) and enhanced coal bed methane (ECBM) recovery are more feasible and can be further improved. While other utilization processes are still in the development phase but have room for improvements that can make them feasible in the future.

**Keywords:** Carbon Capture, $CO_2$ Utilization, CCUS, Feasibility.



## IEEES12- P378

# Energy and Water Conservation Index Application for Optimizing the Conservation of Energy and Water at Facility

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The sustainability of a system with challenge of economy and environment needs to be managed through integrating energy and water. Indexing energy and water with quantity and quality is proposed to show the conservation performance. A method consisting of water conservation index and energy conservation index is mentioned to show its ability for optimizing of energy and water in a facility. Analysis of the exergy destruction which is the main factor of exergy efficiency, mentions that reducing the exergy destruction in water processing effectively reduces the exergy supplied for the system. Minimization of water processed also determines exergy supplied. Namely, reducing water availability to as close as unity significantly reduces the cost of energy for water. The index optimization to as close as unity implies reducing water processed and exergy supplied.

**Keywords:** Exergy, Energy and Water Nexus, Energy and Water Conservation Index.

# POSTER PRESENTATIONS

## IEEES12- P006

## Blade Design for Horizontal Axis Wind Turbine

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Wind energy is one of the most important sources of renewable energy and an excellent alternative for the transition to sustainable energy that the word experiences. One of the determining elements in the energy performance and efficiency of a horizontal axis wind turbine is the propeller, whose correct aerodynamic design is essential in an efficient wind turbine. In this work, the calculation and simulation of the parameters that model the performance of the right propeller for a low power wind turbine working at an average annual speed of 4-6 m/s are made, using MATLAB® software to show the aerodynamic behavior of the blades and their main characteristics. The control system of the propeller seeks to maximize the power obtained in accordance with the objective of capturing energy with a low environmental cost.

**Keywords:** Wind energy, 3D CAD, mathematical modeling, renewable energy.



## IEEES12- P020

## Green Plantation to Mitigate Particulate Matter (PM)- A Case Study for Clean Air in Qatar Public Schools

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Air pollution is a mixture of various natural and anthropogenic pollutants including particulate matter (PM), which imposes a major threat to human health. It has been revealed that the rapid rate of urbanization globally had resulted in the creation of serious health problems especially on the respiratory system of humans if exposed to outdoor air pollution. Identifying the causes, sources, and developing effective solutions to enhance air quality by reducing the emitted gaseous and airborne particles from its sources are taking a long time to fully implement and realize their impacts. As a result, rapid, cost-effective, and multi-functional mitigations and options are investigated. The green plantation is one of the best and rapid options that can be implemented in many areas such as roadside and residential areas in many countries, and it shows positive impacts on reducing the population's exposure to air pollution. Vegetation works as a barrier between sources of pollution and population, which act through removing particles, re-suspension of particles, or emitting particles. Furthermore, trees indirectly reduce the air temperature through shading and introduce beautification of streets full of concrete structures. Certain types of species of vegetation have a better ability to enhance the air quality than the rest of the species. Therefore, while choosing the species, careful testing and validation should be conducted to ensure achieving the objective of vegetation permanently and effectively. This study presents the environmental value of urban trees in Qatar and their effect to enhance the air quality within the school environments where children sent a significant amount of their time in a given period. Three local urban tree species; namely Acacia (Wattles), Ziziphus (Sidra), and Phoenix dactylifera (palm date) trees were selected. Measurement of air quality is conducted before and after planting the selected species in the locations specified for this study.

**Keywords:** Air quality, particulate matter, air pollution, vegetation, health impact, green species.

## IEEES12- P022

## Fuel Life Cycle Assessment of Non-Passenger Diesel Vehicles in Qatar

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Qatar has ranked first in the world index of countries that have achieved record economic growth in 20 years from 1997, which was accompanied by the exponential growth in population and registered vehicle count. Hence, the impact of these vehicles on the air quality shall be investigated. In this work, we report on the first study on diesel fuel life cycle assessment in Qatar for all registered vehicles in Qatar as of November 2017with the aim of quantifying diesel emissions from non-passenger vehicles that have an adverse environmental impact. The emissions of $CO_2$, $NO_x$, CO, $SO_2$, VOC, black carbon (BC), organic carbon, fine particulates PM2.5, and coarse particulates PM10were evaluated during the well to pump (WTP) and pump to wheel (PTW) phases. In order to accomplish this task, the Greenhouse gases, Regulated Emissions, and Energy use in Transportation (GREET) model were used as a source of normalized data to evaluate diesel fuel emissions for all non-passenger vehicle categories due to the absence of such emission factors locally. The results show that CO, VOC, PM10, PM2.5, and BC emissions have dominated the pump to wheel (PTW) stage. Moreover, $SO_2$ emissions were dominant during the well to pump (WTP) stage of the life cycle assessment process, while it was found that $NO_x$ and organic carbon emissions were virtually the same during both stages. Total greenhouse gas emissions have amounted to 5367 kt of $CO_2$ equivalent ($CO_2$-eq) in 2017 as compared with that in 2014 (5277 kt), the only reported value in Qatar for transportation emissions. These results are of critical importance to enlighten planners and policymakers to propose strict interventions addressing traffic air pollution. To this end, several recommendations and mitigation strategies have been proposed for the public to consider, such as using the rail, carpooling, and owning green vehicles.

**Keywords:** Life cycle assessment, GREET, sustainability, diesel vehicles, air quality Qatar.



## IEEES12- P027

## Assessment of TPHs and PAHs in the Marine Sediment Relating to Oil and Gas Extraction Activity on the Western Coastline of Qatar

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Total Petroleum Hydrocarbons (TPHs) and Polycyclic Aromatic Hydrocarbons (PAHs) are priority pollutants which are known to be associated with petroleum products. They are released into the marine environment via accidental spillage, exploration, and transportation. The present study aims to assess the impact of petroleum and gas extraction activities on the pollution of coastal marine sediment of the western coastline of Qatar. Sixty-six surface sediment samples were collected along the western coastal area. The concentration of organic hydrocarbons (TPHs and PAHs) were determined using GC-FID and GC-MS, respectively. Sediment characteristics, including pH, temperature, TOC, and particle size, were also measured. The results indicated low concentrations of TPH (<0.001-0.246 µg/g dry weight sediment) and PAHs (<0.001-0.044 µg/g dry weight sediment). The concentrations for both organic pollutants were lower compared to the previous studies done within Qatar and in the Arabian Gulf and also indicated below the available permissible limit set by the Ministry of Municipality and Environment of Qatar, and other Sediment Quality Guidelines (SQGs) used worldwide (NOAA).

**Keywords:** Total petroleum hydrocarbons, polycyclic aromatic hydrocarbons, marine sediment, oil, and gas extraction.

## IEEES12- P034

## Novel Phosphide Electrocatalyst for Enhanced Oxygen Evolution

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Recently, there is an increasing demand for clean and sustainable energy source, electrochemical water splitting has emerged as an alternative source for traditional fossil fuels. Herein, we studied the synthesis of Lanthanum ruthenium phosphide, LaRuOxPy, and investigated its performance as electrocatalyst for oxygen evolution reaction over a wide range of pHs. The synthesis procedure involves two consecutive steps. The first step includes the formation of hydroxide, LaRu(OH)n by coprecipitation of Ru3+, and La3+ from their aqueous solution. Then the second step involves the phosphatization of as-synthesized hydroxide using sodium hypophosphite. The phosphide catalyst demonstrated a good electrocatalytic performance towards oxygen evolution reaction, OER at different pHs. For instance, in 1.0 M KOH solution, the phosphide produced a current of 10 mA cm-2 at an overpotential 310 mV.

**Keywords:** Phosphide, oxygen evolution reaction, ruthenium, Ph universal electrocatalyst.



## IEEES12- P097

## Natural Gas Portfolio Optimization for Thermopower and Petrochemical Feeds

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Natural gas (NG) is a clean fuel, highly efficient (highest enthalpy per mass), and the lowest carbon intensive among fossil fuels. For these reasons, its increasing importance for society related to climate change and industry for energy security and costs pushes the $CH_4$ based fuel into the demanded transition to an environment-friendly energy market. The development of infrastructure to produce and process natural gas for exports or utilization in thermopower and petrochemicals will become essential to its value chain. In such a context, the installation of thermopower plants and processing units (associated with transmission pipelines) are considered in the proposed portfolio optimization. The problem considers the NG projections in Brazil, with a potential of a 65% increase in its production between 2020 and 2029, to determine business models capable of fulfilling expectations of entrepreneurs and stakeholders in this industry. In the example, the main exploration regions found in the Brazilian National Energy Plan are defined as production clusters to aggregate the exploration fields properly. The definition of the production clusters follows the already installed transmission pipelines connecting the locations of the thermopower plants and processing units to be installed. The net present value (NPV) of the investments are compared to determine the optimal scenarios to be adopted for the set of the GN production nationwide. The methodology is generic enough to the applied in other countries such as Qatar where recent discoveries of new reserves will enlarge its giant production in 65% as like Brazil, although with an absolute value much higher, which will allow the country increase its long-distance exports from its current 25% of liquid natural gas (LGN) worldwide as well as intensify its use in thermopower and petrochemical feeds.

**Keywords:** Natural gas, portfolio optimization, net present value.

## IEEES12- P098

# $CO_2$ Emission through Road Gradient and Real-Time Traffic Monitoring for Vehicle Routing Problems

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The upsurge in atmospheric $CO_2$ levels has come to humankind's attention during the last couple of decades, mainly because the global temperature has risen, ice sheets have melted, and natural disasters have been happening more frequently and with more intensity. Hereby, the focus of this study is to develop a robust routing model that minimizes $CO_2$ transportation emissions that could be used worldwide. The empirical study proves that the advantages of our proposed method for $CO_2$ reduction in the region with a growing economy, especially in Latin America and the Caribbean, where GDP growth disassociates from fossil fuel consumption and the topography can seriously affect the air pollution generated by vehicles, is an efficient solution as a short-term mitigation strategy. Therefore, the main contribution of this study is to penalize very steep or slow roads from the fleets rout map. The application of this method is vastly relevant in areas where elevation above sea level of towns is very high. Therefore, the way streets are made plays a huge role in the carbon footprint of vehicle fleets. The problem considered in this paper is to produce routes for a fleet of delivery vehicles that minimizes fuel emissions, considering the load of the vehicle, the time traveled, the distance traveled, and the road gradient of a road network using the API of Google Maps. The study investigates a dynamic Capacitated Vehicle Routing Problem as an NP-hard problem and generates a linear model that efficiently can capture $CO_2$ emissions. Numerical results using Ant Colony Optimization validate the proposed strategy. Key findings highlight -2.62% of $CO_2$ emissions changes within a short computational time.

**Keywords:** $CO_2$ emission, vehicle routing problems, road gradient, real-time traffic monitoring, ant colony.



## IEEES12- P101

# Underwater Solar Irradiance and Performance analysis of various Silicon Solar Cells with Change in Water Conditions: A Comparative Study

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Solar Photovoltaics (PV) is one of the emerging technology in underwater power systems, especially to power water monitoring and sensing devices in marine environments. Harnessing the underwater Solar energy is a huge advantage because of the abundant amount of Solar energy and space covered by water on the Earth's surface. The utilization of underwater Solar PV systems resolves several issues like cooling, cleaning, and land constraints facing in terrestrial conditions nowadays. Although there are many challenges and constraints because of the decrease in Solar radiation underwater, the PV systems have enough potential to work even in underwater conditions and also to interface as hybrid systems with other marine-based power systems. By considering all such pros and cons, there is a need to study and understand the utility of Solar PV in underwater conditions. In this study, an experimental setup has been designed to characterize the underwater Solar radiation and, accordingly, the performance of various silicon-based solar cells such as the Monocrystalline, Polycrystalline, and Amorphous Solar cells using different water conditions with a controlled indoor atmosphere. The transfer of Solar radiation underwater has been studied with an increase in water depths and also changing water conditions like in the presence of salinity, bacteria, algae, and other water impurities. Subsequently, the underwater performance of Solar cells was also studied with the change in the aforementioned underwater conditions. The obtained results manifest that there is a suitable amount of Solar energy that can be harvested underwater with Solar PV cells to generate power for many commercials, defense, navy, and marine-based applications.

**Keywords:** Underwater solar energy, photovoltaic (PV) technology, solar radiation, silicon solar cells (Monocrystalline, Polycrystalline, and Amorphous), water quality.12- P

## IEEES12- P102

## Vegan Burger Recipe Optimization for Meat Quality Nutrition in the Food Industry

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The move to an environment-friendly lifestyle is modifying the food industry and supply chain as well as agriculture of crops, livestock, etc. From this context, for a diet-behavioral change, one can replace meat (like fish, chicken, goat, cattle) by a vegan diet in its variants of pure vegan and the well-known ovo-lacto-vegan. Considering the impacts of this scenario in the food industry, we select to study the vegan burger recipe optimization that meets meat quality nutrition. The vegan burger to be considered is made by a blend of beans for proteins, leaves (for cellulose and fiber) and other types of vegetables as roots (carrots, beets, etc.) for carbohydrates, where we need to maintain the protein, lipids, carbohydrates, fiber, etc., contents to match meat burger nutrition, at a comparable cost and with a desired taste. In the vegan burger recipe optimization problem, a nonlinear programming (NLP) solution determines the amounts of each vegetable inside the main groups (beans, leaves, and roots) to match the ingredient contents found in the diverse meat burgers. A linear (LP) approximation using factors for qualities is also calculated to be compared to the NLP approach, where cuts of linear amounts of qualities are replaced by the NLP formulas. A comparison between both LP and NLP vegan burger recipe approaches are considered for their applicability in the optimization of the processing plants when integrated to a complete supply chain of harvesting farms and distribution centers. A broad discussion on the impacts of veganism by replacing meat with vegetables in the daily diet is given.

**Keywords:** Vegan burger, recipe optimization, food supply chain, nutrition.



## IEEES12- P115

## 3-D Computational Study on a Spray Cooled Solar Photovoltaic Panel

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A photovoltaic (PV) panel converts a small part of solar energy to electrical energy, and the rest is reflected and transmitted to the panel causing a rise in panel temperature. The heat generated due to the rise in temperature decreases the electrical efficiency of the PV panel. Therefore, it is necessary to implement cooling on a PV panel. The advantage of using spray cooling on a PV panel is its additional benefit of self-cleaning effect on the surface of the panel, which is an added benefit to the reduction in panel temperature. In this paper, a 3-D computational fluid dynamics (CFD) study is done on a water spray cooled PV panel to find the influence of the mass flow rate of water ejected from the nozzles on the PV panel temperature profile. Here spray cooling is done on both the top and bottom surface of the PV panel. The gain in electrical efficiency due to a reduction in temperature can be found out using a mathematical model. The CFD model is generated for steady-state heat transfer analysis, which deals with the heat transfer through the PV module and provides insight into the intensity of heat extraction from the module with spray cooling technique. First, the validation of the numerical model is done by comparing the PV panel temperature profile obtained from the computational results to the available experimental results. The mass flow rate of water ejecting from the nozzles is varied, and the resulting change in temperature profile on the panel is studied. The change in temperature affects the electrical efficiency of the PV panel resulting in a change in electrical output.

**Keywords:** Photovoltaic, computational fluid dynamics, spray cooling.

## IEEES12- P124

## Electro-Thermochemical Water-Splitting Cycle for Hydrogen Production

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The thermochemical water-splitting cycles have been paid more attention in recent years because they directly convert thermal energy into stored chemical energy as $H_2$. However, most thermochemical cycles require extremely high temperatures as well as a temperature switch between reduction and oxidation steps, which are the main obstacles for their development. Herein, we introduced an electrochemical reaction into the thermochemical cycle and established a novel two-step water-splitting cycle based on redox pair. The two-step water-splitting process involves a cyclic operation of electrochemical reduction and water-splitting steps. The feasibility of the water-splitting cycle for hydrogen production was thermodynamically and experimentally investigated. A mechanism of hydrogen production based on the $LiFeO_2$/Fe redox pair was developed. Compared with the traditional high-temperature thermochemical cycles, the electrochemical reduction and water-splitting steps of the process can be isothermally operated in the same cell at a relatively low temperature of 500°C. The main advantages of the cycle are not only easily available heat sources without involvement of the associated engineering and materials issues but also without any temperature swings. This is a promising method to achieve water splitting for hydrogen production in the future.

**Keywords:** Water splitting, hydrogen production, electro-chemical, energy.



## IEEES12- P129

## Development of Virtual Sensors for Prediction of Flue Gas Composition of a Cement Plant Through Ensemble Learning Technique

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The cement industry is one of the largest sources of $CO_2$ emission to the environment. To minimize the impact of the $CO_2$ emission on the environment, $CO_2$ capturing has been the focus of research. Sour compression technique (SCU) is one of the most commonly used techniques for $CO_2$ capture. For a stable and efficient operation of SCU, a robust sensing and control system is vital. The data-based model, also termed as data-based virtual sensors have been getting attention in the process industry for enhancement/ replacement of the conventional hardware sensors, i.e., flow meter, pressure gauge, composition analyzer, etc. In this study, a data-based virtual sensor is designed to relate process conditions, i.e., temperature, pressure and flow rate, etc. to the carbon-capturing capability of SCU. An Aspen Plus based model of the SCU comprising the $CO_2$ capturing, desulfurization, and denitrification processes were developed. To capture the behavior of real-time cement plant operation, the process model was converted to dynamic mode through the interfacing of MATLAB-Excel-Aspen. Four hundred fifty (450) datasets were generated that consisted of process conditions and their corresponding values of the $CO_2$, $SO_2$, NO, and CO in the process outlet streams. The data was used to develop virtual sensors through ensemble learning, i.e., bagging. Prediction performance of the virtual sensors for CO2, $SO_2$, NO, and CO was 96%, 95%, 97%, and 96%, respectively. The results demonstrated that the proposed framework could be effectively used for monitoring the composition of $CO_2$, $SO_2$, NO, and CO in the exhaust stream of a cement production plant.

**Keywords:** Sustainability, soft-sensors, process flowsheeting, greenhouse gases, process industry.

## IEEES12- P130

# Model-Based Quality, Exergy and Economic Analysis of Fluidized Bed Membrane Reactors

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Naphtha reforming units are of great interest for hydrogen and reformate production in petroleum refineries. Conventionally employed packed bed reactors for naphtha reforming have drawbacks such as a high pressure drop, diffusion limitations in catalyst, and radial and axial gradients of temperature and concentration. A fluidized bed reactor (FBR) attends to some of the draw backs of packed bed reactor. Coupled with the advantages of fluidization, the incorporation of membrane can improve the yield of products by selectively removing hydrogen from the reaction side. In this work, a sequential modular simulation (SMS) approach was adopted to simulate hydrodynamics of a fluidized-bed membrane reactor (FBMR) for catalytic reforming of naphtha in Aspen Plus. Aspen Plus was used for flowsheet development of the FBMR. The hydrodynamic parameters and membrane permeation phenomena were implemented using an interfacing of Excel with the Aspen Plus model of the FBMR. A fluidized-bed reactor without membrane, i.e., FBR, was also modeled for comparison with FBMR. FBMR outperformed the FBR in terms of increase in aromatics in reformate stream, effective separation of hydrogen during the reaction, chemical exergy efficiency, and economic viability. The proposed method can be readily adopted by process engineers for design and optimization decisions.

**Keywords:** Naphtha catalytic reforming; Aspen Plus; Excel interfacing; Two-phase theory of fluidization; Hydrogen production; Fluidized-bed membrane reactor; Increase in aromatic production; Pd–Ag membrane; Exergy Analysis; Economic Analysis.



## IEEES12- P138

# Integration of Kalina Cycle with CPVT for Multi-generation and Hydrogen Production: An Energy, Exergy and Environmental Performance Study

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Electricity is the most convenient and versatile form of energy. Unlike steam and gas cycles, Kalina cycle can utilize low grade heat to produce electricity with ammonia solution as working fluid. Concentrated photovoltaic thermal (CPVT) systems have proven to be a technology that can be used to maximize solar energy. In this research, the integration of a Kalina cycle with a CPVT system for multigeneration and hydrogen production is presented. The aim of this study is to increase the share of electricity produced by the CPVT system. The performance of the multigeneration system with and without a kalina cycle is compared. The multigeneration system is designed to produce electricity, hot water, cooling effect, hot air, and hydrogen. A proton exchange membrane is integrated with the multigeneration system for hydrogen production. The analysis of the system modeled will focus on the energy and exergy performance. The environmental benefit of this configuration in terms of carbon emission reduction and fossil fuel savings is also highlighted. The energy and exergy efficiencies of the heliostat used in concentrating solar radiation onto the CPVT are 90% and 85.53% respectively and the hydrogen production when integrated with a Kalina cycle is 58.39 L/min. The CPVT system has a 74% energy efficiency and 45.75% exergy efficiency while the hot air production chamber has a 95% and 92.12% energy and exergy efficiency. Although the overall energy efficiency of the multigeneration system reduces with the integration of kalina cycle, the increase in electricity production justifies the importance of the configuration.

**Keywords:** CPVT, energy, exergy, hydrogen production, Kalina cycle, multigeneration.

## IEEES12- P148

# Removal of Crystal Violet Dye from Water by Sand of Algerian Sahara

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Dye-based industries, particularly small and medium scale, discharge their effluents into waterways without treatment due to cost considerations. In this study, sand from the ELOUED region in Sahara of Algeria was evaluated for his ability to remove crystal violet (CV) dye from aqueous solutions. Adsorption studies were carried out at different initial dye concentrations (20, 40, 80 and 100 mg/L), contact time (5, 10, 15, 20, 30, 60, 90 and 120 min). Sorption equilibrium reached rapidly with 99.99% CV removal in 15 min. The fit of the sorption experimental data was tested on the pseudo-first, pseudo-second-order, intraarticular diffusion, and Temkin kinetics mathematical equations. Kinetic data followed the pseudo-second-order model, with a coefficient of correlation $R_2$ = 1, suggesting that the sorption process is more inclined toward the chemisorption mechanism. We found a maximum sorption capacity of 4.99 mg/g (R=99.99%) for the CV with stirring speed of 100tr/min, the concentration of 50 mg/L, the temperature of 20°C, particle size less than 0.375 mm, the ratio of 10mg/L, and natural pH = 9.87. The sand was also shown to be highly effective in removing CV from aqueous solution in a continuous-flow fixed-bed column with an efficiency of 99.99% after 15 minutes of reaction. The study shows Saharian Sand has the potential of application as an efficient sorbent for the removal of CV from aqueous solutions.

**Keywords:** Sorption, crystal violet, tannery, wastewater treatment, Sand.



## IEEES12- P149

# Removal of Crystal Violet Dye from Water by Carob Powder: Kinetic and Thermodynamic Study

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This work deals with the study of the sorption of a violet crystal dye by carob to decontaminate wastewater. the sorption tests of CV by carob showed that equilibrium was established after 30 minutes. Its capacity reaches the value of 24.2913 mg/g with a yield of 97.16%. The pH which gives better retention is pH = 6.8. The temperature, the biosorbent dose, and the initial CV concentration have an influence on the sorption capacity.

The study of the kinetics shows that the second-order model is the most suitable with $R_2$=1, $q_{calculated}$ = 24.3902 mg/g, and $q_{experimental}$ = 24.2913 mg/g. But the diffusion plays a role non-negligible. Temperature seems to have no significant influence on the sorption phenomenon, which confirms that diffusion is not a limiting step in retention. The parameters of the thermodynamic study show that the retention process is spontaneous and exothermic.

We found a maximum sorption capacity of 24.29 mg/g (R=97.16%) for the CV with stirring speed of 300tr/min, concentration of 50 mg/L, temperature of 20°C, particle size less than 0.375mm, ratio of 10mg/L, natural pH = 6.8 and during 30 minutes of reaction.

**Keywords:** Sorption, crystal violet, tannery, wastewater treatment, biomaterial, biosorbent, carob by-product.

## IEEES12- P184

## CFD Investigation of Falling Film Flow over Horizontal Tube

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The heat exchangers employed in multi-effect desalination (MED) and ammonia/lithium bromide refrigeration systems are usually of falling film types. In horizontal falling film exchangers, liquid is sprayed on the top of bundle, which forms thin film around the tube that makes these exchangers to operate at low temperature difference and spray density. The film hydrodynamics around the tube affects the heat and mass transfer mechanisms, which causes heat exchanger performance to change. In this work, a 2D computational fluid dynamics (CFD) model has been developed in Ansys fluent v18.0, to understand falling film dynamics around the tube of 25.4 mm diameter. The physical domain consists of two tubes with an impingement height of 15.9 mm and inter-tube spacing of 31.8 mm. For water entrance, 2 mm orifice is selected at the top of first tube. The spray density is varied from 0.02-0.05 kg/(m·s) to examine film thickness and residence time for first and second tube. The CFD results shows that the film thickness increases with the increasing spray density, the average film thickness rises by 56% and time for complete wetting decreases by 48.6% ,when the spray density increases from 0.02 to 0.05 kg/(m·s). In addition, the average film thickness reduces by around 13.7% for second tube as compared to that of first tube because of impingement height difference.

**Keywords:** CFD, falling film, horizontal tube, hydrodynamics.



## IEEES12- P185

## 3D Analysis of Film Thickness Distribution in a Horizontal Type Falling Film Evaporator

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The film thickness characterization in the horizontal type falling film evaporators have been the primary focus of research in the past decade. Several experimental and numerical studies have been carried out to analyze film thickness distribution around horizontal tube. Because of experimental setup limitations, thickness measurements on complete tube area are not conceivable. However, numerical studies allow researchers to characterize falling film under flexible operating conditions. Present study focuses on quantification of film thickness distribution around horizontal tube in a three dimensional domain. Two tubes of 25.4 mm diameter have been selected for the computational fluid dynamics (CFD) simulations, with an orifice of 2x1 mm2, an impingement height of 2 mm and an inter-tube spacing of 7.6 mm. The tube section of 22 mm has been opted as per critical wavelength formulation/distance between droplet sites. In order to reduce computational efforts, only quarter of the domain is considered for numerical calculations. The CFD model has been established in Ansys fluent v18.0 and has been validated quantitatively against Nusselt correlation and qualitatively with the experimental data available in the literature. The film thicknesses at different axial positions z = 0, 5.5 and 11 mm have been computed and compared and results show higher film thickness distribution at z = 0 mm (in line with droplet formation site) as compared to that of z = 11 mm (halfway between two droplet formation sites). The film thickness at θ = 90° is found to be 0.195 mm at z = 0 mm which is 21.1% higher than that of z = 11 mm.

**Keywords:** 3D, CFD, falling film, film thickness, horizontal tube, numerical model.

## IEEES12- P187

## Study on Nitrogen Doped Carbon Paper Electrodes for Vanadium Redox Flow Battery Applications

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In recent years, vanadium redox flow batteries (VRFBs) have attracted significant attention as a promising large-scale system for storing excess energy from renewable sources like wind or solar energy. In VRFB, the vanadium-containing electrolytes flow through carbon materials, which are usually porous felts or carbon paper electrodes. Carbon electrodes exhibit good stability and electrochemical conductivity in the acidic and corrosive electrochemical environment of the battery system. One disadvantage is their poor kinetic reversibility and electrochemical activity, which makes an activation step necessary. To address this issue, various approaches including heat treatment and acid oxidation have been pursued by several groups to obtain enhanced activity. Several works described heteroatom doping that should provide more active centers for the vanadium redox reactions, and hence lead to a higher electrochemical activity. However, most of these procedures are high energy/time consuming and require the use of environmentally unfriendly and expensive chemical reagents but, more importantly, they appear to be unsuitable for synthesizing large-area electrodes. Herein, we present a new method for the direct fabrication of a nitrogen-doped carbon paper electrode for VRFBs. We developed the electrodes by controlled deposition of a thin layer of conducting polymer on the surface of a carbon electrode followed by pyrolysis in an inert atmosphere. The study proves that the conducting polymer is an effective precursor for the preparation of nitrogen-doped carbon electrodes, and the adopted method for its preparation is convenient and scalable. The prepared carbon electrodes by this method have only very few $\Delta E$ values, i.e., < 200mV on both anodic and cathodic sides. The electrode structure and morphology will be investigated by X-ray photoelectron spectroscopy, scanning electron microscopy and the electrochemical performance of the N-doped carbon electrodes will be evaluated by a charge-discharge performance by deploying it in VRFB real cell configuration.

**Keywords:** Flow battery, energy system, novel carbon electrodes



## IEEES12- P200

## Research on Spatial Non-Uniformity of Power Distribution for Solar Radiation Simulation

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The worldwide rapid development of renewable energy sources, primarily solar technologies, forces scientists to develop testing devices enabling a meaningful comparison of their work. Solar radiation simulators are used for studying solar technologies in fixed, predetermined conditions. The distribution of energy on the tested surface is an important factor in the case of testing solar cells and radiation concentrators of various types. Compared to natural solar radiation, simulators are characterized by a heterogeneous distribution of energy due to the use of many sources. This article presents the results of modeling, using numerical optical-engineering software, aimed at comparing the spatial non-uniformity of the total energy distribution on a given surface using parabolic floodlights of different distribution, size, and estimation of the optimal solution. In addition to the indicators contained in the radiation simulation standards, an own factor has also been defined, based on the method of least squares. A 1x1 m illuminated surface, with a minimum of 4 and a maximum of 22 parabolic reflectors was considered. The modeling results are to be used as a guide to the optimal selection of the number, arrangement, and size of the reflectors for simulating solar radiation.

**Keywords:** Solar simulation, solar energy, power distribution.

## IEEES12- P223

## Energy Saving in an Academic Institution through Passive Daylighting Strategy

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Passive daylighting strategies minimize artificial l ighting r esulting i n a r eduction i n energy consumption of a building as well as the operating cost. Vernacular tropical architecture, with its focus on climate responsiveness, has always been focused on passive strategies of lighting and thermal comfort. Techniques interpreted from vernacular strategies are widely used in building design in Kerala, as evidenced in the lighting interventions included in the design of the Department of Architecture, College of Engineering Trivandrum. However, owing to the unique terrain, there are design studios in the Ground-minus-one floor wherein there exists a shortage of natural daylighting. This paper focuses on the analysis and design recommendations for improving daylighting in spaces without access to typical passive lighting strategies.

A design studio room at the basement floor in an architecture department was taken for study in lighting levels. Simulation studies using Ecotect was done with the room at different times of the day. The daylight factor was found and the light level distribution within each part of the room was obtained. The daylighting levels were compared with the required light levels for the classroom. Though the design of the studio was ideal for thermal comfort, the lighting inside the classrooms was poor due to the orientation. The reduction in the daylight factor had to be supplemented to obtain good luminous comfort. As a passive daylighting strategy horizontal light pipes were proposed which provide outside daylighting to the interiors. The number and arrangement of light pipes were determined to have the optimum light intensity which can provide the required lighting level.

**Keywords:** Energy saving, passive daylighting, light pipes.



## IEEES12- P247

## Cobalt Based Catalysts for Water Oxidation or Oxygen Evolution Reaction

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The future of the world energy lies in clean and renewable energy sources. Many technologies, such as solar cells, wind turbines, etc., have been developed to harness renewable energies in different forms of fuel. Amongst them, electrolysis of water to produce hydrogen and oxygen is one of the most important developments towards achieving clean energy, which has attained significant attention due to its green and simple method for the production of fuels. In electrolysis of water, the half-reaction containing the oxygen evolution reaction (OER) is a kinetically sluggish reaction, which requires higher overpotential to produce $O_2$, when compared to the other half-reaction, i.e., hydrogen evolution reaction (HER). Many electrocatalysts are studied extensively to be used in the OER process to get an economic yield out of it. Noble metal-based catalysts are the state of the art catalyst used for OER currently. But due to their high cost and scarcity, they cannot be applied in a large-scale manner to be used in the future. The non-noble metals (transition metals and perovskites) are gaining interest by exhibiting on par or better OER performance compared to the noble metal used. Due to their low cost, ample resources and a number of metals available, they have opened up a variety of areas with a different combination of metals to be used as a catalyst for OER. Amongst these metals, cobalt has received massive appreciation for performing as an excellent OER catalyst. Multi metals, multimetal mixed oxides, multimetal phosphides, perovskites, and carbon-supported catalysts containing cobalt have shown low overpotential with high long term stability. Herein, we go through different cobalt-based electrocatalysts for OER, the general mechanism governing the OER process, the challenges that we are facing today to improve the performance of the catalyst, and future aspects to overcome such challenges.

**Keywords:** Fuel cell, oxygen evolution reaction, cobalt catalysts, water oxidation, electrolysis.

## IEEES12- P248

## Anode Catalysts for Methanol Oxidation Reaction in Direct Methanol Fuel Cell

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Direct methanol fuel cells (DMFC) have received considerable research interest as an on-demand energy conversion device with benefits of having high energy density renewable liquid fuel, efficient energy conversion, small footprint and the possibility of simultaneous production of valuable chemicals (e.g., formic acid, formaldehyde, etc.) along with energy. Methanol oxidation reaction takes place on the anode side of the fuel cell system. The synthesis of electrocatalyst with high activity and durability for methanol oxidation reaction has been one of the main focus of researchers, with considerable development and break-throughs in recent years. Herein we try to summarize and compare the performance of electrocatalysts comprising of noble and non-noble metals. The effect of manipulating catalysts by introducing nanostructured morphology, metal alloys, support materials, acidic or basic electrolyte, and synthesis methods are also examined. The paper concludes with details of challenges that are generally faced in the making of direct methanol fuel cell (DMFC) as a reliable source of energy for future prospects, and the approach to be taken to reduce the complexity in synthesizing new generations of anode electrocatalysts.

**Keywords:** Methanol oxidation catalyst, anode catalysts, CO poisoning, direct methanol fuel cell.



## IEEES12- P249

## Recent Progress in Catalyst Development for Water Gas Shift Reaction

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Water-gas shift reaction ($H_2O + CO = H_2 + CO_2$) is a ubiquitous intermediate in hydrocarbon reforming reactions. It is widely used in ammonia synthesis, hydrogen production, methanol, and petrochemical industries. Being exothermic in nature, low-temperature conditions are particularly suitable for CO and $H_2O$ conversion; however, the commonly used copper-zinc based catalysts have low catalytic activity, require long activation processes, and they are sensitive to contaminants (e.g., sulfur, chlorine, etc.). Herein, we discuss the recent development, particularly over the last decade, in the catalysts development for low-temperature water-gas shift reaction. We also plan to provide an overview of the reaction conditions, noble and transition metal-based catalysts, oxide-supports, and strategies for suppressing side reactions (e.g., hydrocarbon formation, etc.) and improving the long term stability of the catalyst.

**Keywords:** Low-temperature water-gas shift, hydrogen production, CO conversions, supported catalysts.

## IEEES12- P270

## Revisit of Modeling Techniques for Foam Flow in Porous Media

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There are generally two approaches for modeling foam in porous media, namely, the texture implicit local equilibrium (LE) foam model and texture explicit population balance (PB) mode. Both models need to solve the mass conservation equation and the momentum conservation equation.

The LE model uses an empirical algebraic formula to correlate the gas mobility reduction with certain local conditions, such as surfactant concentration, water saturation, shear-rate, and oil saturation. Contrastively, the PB model correlates the gas mobility reduction with foam texture, i.e., the number of bubbles per unit pore volume, which is calculated dynamically with exact functions of lamellae generation and destruction. The physics behind the PB foam model is clearer. Thus, the PB model is capable to capture the foam entrance effect and transient foam behavior. However, it needs to solve an additional partial differential equation (PDE) for foam texture, which makes the PB model more complex and computationally costly than the LE model. Another restriction for the application of the PB model is the difficulty of determining the number of kinetic parameters in foam generation and destruction terms. Although both models could be used at lab scale and reservoir scale in principle, only the LE model is considered practically at the reservoir scale. The most widely used LE foam model is the STARSTM foam model developed by the Computer Modeling Group (CMG).

**Keywords:** Foam, local equilibrium, population balance, numerical simulation.



## IEEES12- P282

## Influence of Boundary Conditions on the Exergetic Optimization of a Thermal Energy Storage Unit Combined with an Organic Rankine Cycle

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Within this work the promising combination of a Thermal Energy Storage (TES) with an Organic Rankine Cycle (ORC) – named ORCTES – is analyzed and optimized from an exergetic point of view. The investigated application is waste heat recovery and the TES is used to overcome the temporal mismatch between heat supply and electricity demand. A numerical model was set up in MATLAB Simulink to describe the ORCTES facility with a thermal storage capacity of approximately 1.5 MWh. Air is used as heat transfer fluid (HTF) for the horizontal flow TES consisting of a packed sand bed with a maximum charging temperature of 600 °C. Within the numerical model all relevant material properties of the TES and the HTF are implemented temperature dependently and convection, diffusion and radiation as well as heat and pressure losses are included in the simulations. The ORC is represented by characteristic curves taken from literature. Parameter variations regarding several boundary conditions including the charging temperature and the mass flow of the HTF are performed with the implemented numerical model. A recently developed detailed exergetic evaluation method for TES in systems is applied to identify the optimization potential of the TES and its interactions with the remaining system. Later on, a mathematical optimization concerning the TES dimensions etc. is carried out for two characteristic sets of boundary conditions. The results reveal that the effect of physical aspects on the exergetic performance strongly depends on the boundary conditions and might be different for the TES itself compared to the effect on the overall system. Furthermore, the optimum of some of the TES parameters is also dependent on the boundary conditions. For the two cases analyzed in detail, the exergetic efficiencies of the optimized system are about 43 % and 28 %.

**Keywords:** Exergetic evaluation, optimization, thermal energy storage, Organic Rankine Cycle.

## IEEES12- P300

# Model and Flow Sheet Improvements for Coal fired Power Plants Equipped with a $CO_2$ Capture Process Using Monoethanolamine

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The present paper follows two prior works by Liu et al. (2015) and Liu et al. (2017), conducted on the subject of $CO_2$ capture with a monoethanolamine based process. The study presented in this article is about the improvements brought to the flow sheet of supercritical coal-fired power plant aiming to reduce as much as possible the efficiency penalty created by the $CO_2$ capture process.

MEA based capture processes require a lot of energy, extracted from the steam cycle, in order to regenerate the solvent, hence the loss of efficiency. Reducing the efficiency penalty is operated through several methods. The first one is reducing the energy consumed by the reboiler in the MEA capture process itself by splitting the rich solvent and using a kettle type heat exchanger for the heat exchanges between the rich and lean MEA solvent. The second method consists of getting heat from the lean solvent back into the steam cycle by pre-heating the water after the low-pressure turbine to 327K. The pre-heating can be improved with a water-ammonia Absorption Heat Transformer. The pre-heating is first being conducted with heat coming from the vapor and liquid phases generated by the AHT, and in a second simulation, only the liquid phase is being used for the pre-heating, and the vapor is sent through a turbine to generate an additional 6.17 MW of power. The last simulation is a combination of the kettle type heat exchanger and the AHT process with the additional turbine. The impact of a reduced capture rate is also being studied in this paper, as the original 90% capture is being decreased to 50% in order to reach the same emission levels as gas-fired power plants (Gonzalez-Salazar et al., 2018). The reduction of the capture rate decreases the efficiency penalty linearly and goes from 8.62% at 90% of the capture rate (Liu et al., 2017) to 5.53% at a 50% capture rate. After modifying the models, by replacing “Heater” type blocks by real heat exchanger and optimizing the steam flow rates with User-Defined Functions in Aspen+, to make the models more precise, the reference efficiency penalty of 8.62% is decreased to 8.46%, which is then reduced to 8.03% for the capture process modification, 7.83% for the pre-heating of the water with the AHT process, 7.45% for the AHT equipped with a turbine and 6.70% when combining the kettle heat exchanger and the AHT process equipped with a turbine.

**Keywords:** Carbon dioxide, monoethanolamine, flow sheet, efficiency penalty, coal-fired power plant, modeling.



## IEEES12- P301

# Theoretical Investigations of Stirling Engine Performances for Different Working Fluids

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The present paper is performed to investigate the effect of working fluids on a double-acting Stirling engine performance. A numerical model that includes major thermal losses that decrease the Stirling output power and efficiency was developed. The influences of tree monatomic gases (helium, Neon, and Argon) and one diatomic gas (nitrogen) on optimal compression ratio and optimal regenerator form factor, as well as the optimal frequency of the Stirling engine, are studied. It was found that the optimal design of the regenerator, allowing the maximum output power, depends on the working fluid characteristics. Results showed that the compression ratio corresponding to the optimum power depends on the working fluid used. It was shown that to achieve a high output power of the Stirling engine, and it is preferable to use a monoatomic gas having the highest heat capacity and thermal conductivity and the lowest density as working fluid.

**Keywords:** Working fluids, double-acting Stirling engine, rotational speed, compression ratio, regenerator form factor.

## IEEES12- P302

## Spectral Analysis of LBM-LES Numerical Data on Lid-Driven Cavity

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The lid-driven cavity is an important fluid mechanical system work for as a benchmark for testing numerical methods and for examining fundamental aspects of incompressible flows in confined volumes which are driven by the tangential motion of the bounding wall. A numerical study is provided of lid-Driven cavity flows focusing on the evolution of the flow for high Reynolds number. Spectral analysis and a fluctuation velocity are performed on the numerical data obtained from the Lattice Boltzmann method (LBM) and large-eddy simulation (LES) of the turbulent flow. The analyzed data or signals are picked at two specific points inside the cavity, allowing investigating three drastically different flow regimes over time: laminar, transitional, and turbulent. In comparison with direct numerical simulation, the LBM-LES model not only has a reduced resolution in space but also in time. In this context, the background of LBM is presented and the construction of Navier-Stokes equations from the Boltzmann equation is discussed. The LBM-LES model for solving transition is developed and turbulence modeling is implemented. In the second part, a Fourier transform is chosen to study signals from LBM-LES model, to provide a local analysis of transient turbulent events.

**Keywords:** Lid-driven cavity, turbulence, LBM-LES model, spectral analysis.



## IEEES12- P307

## Heating Rate Effect on Tetrapak Paper Pyrolysis: Thermogravimetric Analysis

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Biomass and plastics are considered to be one of the most important renewable sources in nature. The typical composition of a tetrapak is 70% of cardboard (Kraft paper), 25% of low-density polyethylene (LDPE), and 5% of aluminum foil. In this paper, we present the heat rate effect on tetrapak pyrolysis using thermogravimetric TG analysis. Three heating rates (5°C/min; 10°C/min; 20°C/min) and three Nitrogen flow rates (20, 40, and 60 ml/min) were used. The Tetra Pak is composed of 47.46% of carbon, 7% of hydrogen, and 0,325% of nitrogen. The derivative TG curves function of time and temperature for the different heating rates and Nitrogen flow rates were illustrated and discussed.

**Keywords:** Tetrapak paper wastes, energetic valorization, pyrolysis, heating rate, thermogravimetric analysis.

## EEES12- P321

# Application of Artificial Neural Networks for Solar Multi-parameters Prediction; A Case Study of Nigeria

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In this research, the use of three artificial neural network (ANN) models for solar irradiance and solar PV parameters forecasting in Nigeria is presented. Although solar irradiance prediction exists in literature, the use of ANN for solar PV parameter prediction is limited in previous studies. Six different locations are selected in Nigeria and datasets from these locations have been used to train, and the ANN models developed. This research aims to model ANN algorithms that can forecast solar irradiance and solar PV parameters based on an hourly time-step. A deep learning regression model built on the Levenberg-Marquardt backpropagation algorithm is used to train and test the ANN model for all the locations considered. Three different ANN models were developed for each location in Keras python using all the input parameters. The evaluation metrics used in this study are; R, R-squared, RMSE, and MAE. The models developed are capable of predicting solar irradiance and solar PV parameters. The R values for the ANN models range from 0.9046 – 0.9777 for solar irradiance and 0.7768 – 0.8739 for solar PV multi-parameters prediction.

**Keywords:** Deep learning, artificial neural network, solar irradiance, solar PV.



## IEEES12- P328

# Application of Magnetite Iron oxide Nanoparticles ($Fe_3O_4$) grafted with Silica nanoparticles ($SiO_2$) for Oil Recovery from Oil/Water Emulsions

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Separation of oil from produced water specifically oil and gas produced water is the most difficult treatment process comparing to other produced water types. In this study, an innovative magnetic demulsifier ($Fe_3O_4$-$SiO_2$) was prepared by grafting the silica nanoparticle on the surface of the magnetite nanoparticles ($Fe_3O_4$-$SiO_2$) using the method of modified Stober process. The amount of oil separated and effect of the demulsifier concentration and settling time on the demulsification efficiency were evaluated. Results indicated that at same conditions $Fe_3O_4$-$SiO_2$ nanoparticles showed high demulsification efficiency comparing to the other types applied. Moreover, the ability of these nanoparticles to be recycled and reused again using an external magnetic field for separation is very high and $Fe_3O_4$-$SiO_2$ nanoparticles still showed high recyclability after 9 cycles. Our results approve that this developed demulsifier is effective and reused type which can be applied for oil recovery and produced water treatment.

**Keywords**: Oil, recovery, energy, waste.

## IEEES12- P353

## Techno-economic Assessment of a Synthetic Fuel Production Facility by Utilizing the Hydrogenation with $CO_2$ Captured from Biogas

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In this study, a techno-economic assessment of a novel design synthetic fuel production is carried out. In order to utilize the process, the biogas which is produced in an actual wastewater treatment plant (WWTP) is separated into $CO_2$ and $CH_4$ by utilizing a water washing facility in order to achieve synthetic fuel of methanol ($CH_3OH$). In the first stage of the designed system the biogas is purified by removing the 2-3 % of $H_2S$ content. Then, the rest of biogas (60 % $H_2$ and 40 % $CO_2$) is transferred to the methanol production facility (MPF). Also, the totally purified biogas ($CH_4$) is sent back to the cogeneration system in the WWTP to achieve the higher efficiency for the system. The methanol is obtained by hydrogenation of $CO_2$ in a catalytic reactor in the MPF. In the designed system, in order to feed $H_2$ to the methanol production facility, electricity is generated with photovoltaic panels (PV) and then the electrolysis is carried out with polymer electrolyte membrane electrolysis (PEM). Afterwards, the produced H2 is transferred to the MPF. As a result of this study, the biogas produced in WWTP is enriched and the $CO_2$ in the biogas is used in synthetic fuel production.

**Keywords:** Biogas purification, PEM electrolyzer, hydrogenation, methanol, synthetic fuel.



## IEEES12- P367

## Geospatial Assessment of *Jatropha curcas* Plantation in Qatar: A GIS Modelling Approach

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Qatar is one of the largest producers and exporters of fossil-based fuels including natural gas. Though, the country is striving to diversify its energy resources by incorporating renewables to mitigate associated emissions and expand its fossil reserves lifetime for the coming generations. Energy crops are believed to be amongst the prominent resource for biofuel production for being carbon neutral. However, no attempts were made to grow energy crops due to the extremely limited arable land area as well as the water scarcity in this part of the world. Meanwhile, Jatropha curcas is preferred over other energy crops due to its superior agronomical traits, where it can grow in non-arable lands and harsh climates with minimal water requirements. Besides, it proved to yield higher seeds with the supply of treated sewage effluent, which is widely available and not completely utilised in Qatar. According to the UN's Food and Agricultural Organisation, Jatropha can grow within 30°N and 35°S latitudes. Yet, there is a need to investigate suitable sites to grow Jatropha across Qatar. As such, this study utilises the Geographic Information System (ArcGIS) and Analytical Hierarchy Process (AHP) to identify the suitable sites based on multicriteria including soil type, depth and pH contents, as well as average annual humidity and temperature. The combination of these methods and criteria may provide a better insight on the potential of biofuel production from Jatropha in Qatar. The GIS-based spatial analysis identified wasteland area of 6779 $km^2$ in Qatar as highly suitable to grow Jatropha. In addition, 1564 $km^2$ are identified as moderately suitable sites. The obtained results indicate a high potential to grow Jatropha in Qatar for biofuel production with no competition on land and water resources.

**Keywords:** Qatar, *Jatropha curcas*, GIS, Geospatial modeling, Site suitability, Biofuel.

## IEEES12- P371

## Impact of Hazardous Domestic Waste on Human Health in Qatar: Policy Proposal for Integration into the Environmental Law

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With the development of economic and population growth around the globe, lifestyle changes along with rising community living standards all lead to an increase in consumption of substantial materials and waste production. Variable sources generate different household waste depending on different human activities, localities, climate, geography, income levels and cultural context. Several studies reported that 55-80% of municipal solid waste generated in developing countries are mainly from household sources. Waste can be classified into food waste, plastic, wood, papers, metals, hazardous batteries, construction material rubber,fabric, pharmaceuticals and other materials that are not classified yet. Uncontrolled disposal of different waste, lack of sanitation services and improper waste management facilities are conducive to the environmental and health problems such as causing contamination of the water, land and soil. Such environmental problems that are not properly dealt with, threat human as well as ecosystem well-being. In general, there are several aspects that should be designed and implemented for significant improvements and achievements in advanced waste management including, but not limited to community awareness and involvement, regulations and policies, and advanced technologies for sustainable waste removal. Qatar has witnessed unprecedented growth in economic development and population since 2006. This has inreased the waste generation which made Qatar among the highest producers of waste worldwide at 1.8 kg of waste produced per capita daily as it has been reported by the World Bank. This project is about investigating the characterization of household domestic waste in Qatar, their impact on human health such as workers who collect the household domestic waste as well as the workers at the waste management facilities, measuring the level of awareness related to hazardous impact of domestic waste on human health as well as proposing proper disposal methods at residential locations.

**Keywords:** Household domestic waste, Improper disposal, Environmental pollution, Human Health, Community awareness, Qatar.



## IEEES12- P373

## Powertrain Analysis of Heavy Duty Electric Vehicle with Wheeled and Tracked Alternatives

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Heavy duty electric vehicle applications are becoming more popular on transportation, construction and military applications because of the economical and environmental targets. Parameters of powertrain components according to vehicle weights and the type of the drive are the key parameters for vehicle performance in heavy vehicles. In this study, drive cycle analysis of heavy duty electric vehicle is performed using Matlab/Simulink for both wheeled and tracked drive alternatives. Battery power requirements and SOC (State of Charge) history is determined according to the drive cycle of HHDDT (Heavy Heavy-Duty Diesel Truck) Transient Mode for constant vehicle weight and battery capacity. On the other hand, gradebility of vehicles is calculated as slope potential during the drive cycle. According to the results, wheeled vehicle range is calculated higher than tracked versions, however, climbing potential of tracked vehicle found as more advantageos than wheeld type.

**Keywords:** Electric vehicle, heavy duty, tracked, wheeled.

IEEES12- P376

# Quantified Literature Database for Methane Dehydroaromatization - An Opportunity for Statistical and Artificial Intelligence to Unravel Hidden Intercorrelations

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Most of the commercial processes to convert methane to chemicals starts with one of the reforming reactions which produce 9 to 15 kg of $CO_2$ for each kg of hydrogen as part of reaction stoichiometry, and the required energy for the process. Further, other processing units are required to convert the resulting hydrogen or syngas to chemicals. One of the ways to reach sustainable and simpler methane conversion to chemicals process is a direct conversion process known as Methane Dehyroaromatization (MDA). The reaction uses a high temperature of and a heterogeneous catalyst (the commonly studied one is Mo on ZSM-5). The methane C-H bond is activated to form useful products mainly benzene, naphthalene, and hydrogen without producing any $CO_2$ from the reaction. Although this is a very promising route, MDA has major limitations hindering it from commercialization. These are the low single-pass methane conversion around 10 to 20%, the rapid catalytic deactivation due to the formation of carbon on the catalyst surface and inside its pores, and the narrow operating window. Due to the significant value of this reaction, so far, a large number of patents and articles (around 300) are reported to overcome these challenges. In this work, we established a structured framework that allowed us to combine results published from different studies in a single quantified database. Having such a database can become the cornerstone for benchmarking future studies on this process. Besides, it enables using the powerful techniques of statistical science and artificial intelligence in order to reveal unknown correlations between the different parameters and studies, identify gaps and guide future experimental work including that in our laboratory. In this work, we will present the database and methodology behinds it, the ongoing work to analyze the inter-correlations between the different variables, and some of our experimental work.

**Keywords:** Natural gas utilization, Sustainability, Chemical kinetics, Heterogenous catalyst, Data science and statistics.