Power To Gas The Case For Hydrogen White Paper

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Power To Gas The Case For Hydrogen White Paper ***2023-01-05***

BARKER DANIELA

Crime Must Pay the Penalty #12 MM Books
Do you find fun in pun? Perhaps you are looking for a few puns on the run? Follow the characters of Comedic Destruction in Daze and Knights as they take you on a mind-stimulating, language-enhancing journey. Puntastic and fantastic, this book will massage your intellect, and provide your laugh muscles some 'much-kneaded' exercise via wordplay vignettes!The book is divided into several chapters. The first chapter, “Their Eyes Were Watching Job,” is a collection of stories in an occupational setting or regarding a business transaction. “I Think Yet I Cram” features tales of students and teachers and, more generally, intellectual high jinks. The third chapter, “Empty Cow or Rheas: I Love My Shakes Pear,” is, as you'd imagine, a collection of tales involving food; although it should be noted that these wordplays have little or no nutritional value. The final chapter, “I've Been Around: Whirled without End,” features stories of characters in motion.Daze and Knights contains fun puns for everyone, enhanced by talented illustrator, Megan Nolton. This wild and witty work promises a few dozen laughs along the journey, as you'll discover, from cover to cover.
Principles, Applications and Case Studies Academic Press
Demand for renewable energy systems is accelerating and will account for a significant share of future power systems aimed to enhance and decarbonize the world's energy system. Unlike conventional power plants, electricity output from renewable sources cannot be adjusted easily to match consumer power

demand because renewable resources are intermittent short-term seasonal power sources. Accordingly, a rapid increase in surplus power is expected in the future. The Canadian Province of Ontario, in line with global efforts, has targeted 80 % reduction of greenhouse gas emission levels by 2050 compared to 1990 levels. One key step to accomplish this goal is to harness more renewable energies for power generation. Instead of losing the surplus power or exporting it for low returns, storage and utilization in other sectors urgently need to be explored. Power-to-Gas technology offers a possible solution for optimal use of energy surplus. It is efficient at the huge - national- consumption scale and global acceptance of Power-to-Gas as energy storage and transportation technology is growing noticeably. In short, Power-to-Gas is a potential means to manage intermittent and weather-dependent renewable energies like wind, solar, or hydro in a storable chemical energy form. The main concept behind Power-to-Gas technology is to make use of surplus electricity to decompose water molecules into their primary components: hydrogen and oxygen. Power-to-Gas is not only a storage technology; its role can be extended to other energy streams including transportation, industrial use, injection into the natural gas grid as pure hydrogen, and renewable natural gas. The current study investigated four specific Power-to-Gas pathways: Power-to-Gas to mobility fuel, Power-to-Gas to industry, Power-to-Gas to natural gas pipeline for use as hydrogen-enriched natural gas, and Power-to-Gas to Renewable Natural Gas (i.e., Methanation). This study quantifies the hydrogen volumes at three production capacity factors (67%, 80%, and 96%) upon utilizing Ontario's surplus electricity baseload. Five allocation scenarios (A-E) of the hydrogen produced to the four Power-to-Gas pathways are investigated and their economic and environmental aspects considered. Allocation scenario A in which hydrogen assigned to each pathway is constrained by a specific demand, is based on Ontario's energy plans for pollution management in line with international efforts to reduce global warming impacts. Scenarios B-E are about utilization of the produced hydrogen entirely for one of mobility fuel, industrial feedstock, injection into the natural gas grid, or renewable natural gas synthesis, respectively. The study also examines the economic feasibility and carbon offset of the PtG pathways in each scenario. The research sets the assumption that hydrogen is produced at three capacity production factors: 67% (16 h/day), 80% (19 h/day), and 96% (23 h/day). The amount of surplus baseload electricity for 2017 of each capacity factor is converted to hydrogen via water electrolysis. Accordingly, the total hydrogen produced is approximately 170 kilo-tonnes (kt), 193 kt, and 227 kt, respectively. Results indicate that the Power-to-Gas to mobility fuel pathway in scenarios A and B has the potential to be implemented. Utilization of hydrogen produced via Power-to-Gas technology for refueling light-duty vehicles is a profitable business case with an average positive net present value of $4.5 billions, five years payback time, and 20% internal rate of return. Moreover, this PtG pathway promises a potential 2,215,916 tonnes of CO2 reduction from road travel. In the scenario to utilize Ontario's surplus electricity to produce hydrogen via the PtG technology for industrial demand, results indicate that supply could achieve 82%, 93%, and 110% of the industrial demand for hydrogen at the three capacity factors, respectively.

Nevertheless, hydrogen production through PtG is still costly compared to other available cheaper alternatives, namely hydrogen produced via steam methane reforming. Power-to-Gas for industry projects should, however, be part of government incentives to encourage clean energy utilization. In addition, although using hydrogen-enriched natural gas or renewable natural gas instead of the conventional natural gas could offset huge amounts of carbon, their capital and operational costs are extremely high, resulting in negative net present values and very long payback time.

Substitute Natural Gas from Waste United Nations

California Power-to-Gas and Power-to-Hydrogen Near-Term Business Case Evaluation

The Most Comprehensive Plan Ever Proposed to Reverse Global Warming Edward Elgar Publishing

Ran for seven years and 46 thrilling issues, showing the hard-fisted underworld and the brave lawmen who worked tirelessand bravely to stop them. This comic was not afraid to scare the reader a little, to make him wince, to make him wonder if maybe this was the time the bad guywould win.The comic reprints from are reproduced from actual classic comics, and sometimes reflect the imperfection of books that are decades old. Many people enjoy these authentic characteristics

Optimization Methods for Gas and Power Markets Springer

Design, Deployment and Operation of a Hydrogen Supply Chain introduces current energy system and the challenges that may hinder the large-scale adoption of hydrogen as an energy carrier. It covers the different aspects of a methodological framework for designing a HSC, including production, storage, transportation and infrastructure. Each technology’s advantages and drawbacks are evaluated, including their technology readiness level (TRL). The multiple applications of hydrogen for energy are presented, including use in fuel cells, combustion engines, as an alternative to natural gas and power to gas. Through analysis and forecasting, the authors explore deployment scenarios, considering the dynamic aspect of HSCs. In addition, the book proposes methods and tools that can be selected for a multi-criteria optimal design, including performance drivers and economic, environmental and societal metrics. Due to its systems-based approach, this book is ideal for engineering professionals, researchers and graduate students in the field of energy systems, energy supply and management, process systems and even policymakers. Explores the key drivers of hydrogen supply chain design and performance evaluation, including production and storage facilities, transportation, information, sourcing, pricing and sustainability Presents multi-criteria tools for the optimization of hydrogen supply chains and their integration in the overall energy system Examines the available technology, their strengths and weaknesses, and their technology readiness levels (TRL), to draw future perspectives of hydrogen markets and propose deployment scenarios Includes international case studies of hydrogen supply chains at various scales

Renewable Energy Sources and Climate Change Mitigation Academic Press

This Intergovernmental Panel on Climate Change Special Report (IPCC-SRREN) assesses the potential role of renewable energy in the mitigation of climate change. It covers the six most important

renewable energy sources - bioenergy, solar, geothermal, hydropower, ocean and wind energy - as well as their integration into present and future energy systems. It considers the environmental and social consequences associated with the deployment of these technologies and presents strategies to overcome technical as well as non-technical obstacles to their application and diffusion. SRREN brings a broad spectrum of technology-specific experts together with scientists studying energy systems as a whole. Prepared following strict IPCC procedures, it presents an impartial assessment of the current state of knowledge: it is policy relevant but not policy prescriptive. SRREN is an invaluable assessment of the potential role of renewable energy for the mitigation of climate change for policymakers, the private sector and academic researchers.

Emerging Technologies and Biological Systems for Biogas Upgrading Createspace Independent Pub

Geothermal Power Plants: Principles, Applications and Case Studies is the latest book from Ron DiPippo, Professor Emeritus, University of Massachusetts Dartmouth. It is a single resource on all aspects of the utilization of geothermal energy for electric power generation. Written in one voice by a respected authority in the field with twenty-five years of experience in geothermal research, teaching, and consulting, it is intended for those involved in any aspect of the geothermal industry. Grounded in fundamental scientific and engineering principles, its practical emphasis is enhanced by the use of actual case studies from historic and present-day plants. The thermodynamic basis for the design of geothermal power plants is at the heart of the book. The Second Law is used extensively to assess the performance and guide the design of various types of geothermal energy conversion systems. The case studies included in the third part of the book are chosen from plants around the world, and increase the reader's understanding of the elements involved in gaining access to, and making use of, this important renewable energy resource. The book is illustrated with over 240 photographs and drawings, many in full color. Nine chapters include practice problems, with answers, for the reader to test his/her understanding of the material. A comprehensive and definitive worldwide compilation of every geothermal power plant that has ever operated, unit by unit, is given in detailed tables as an appendix. In another appendix, DiPippo offers a concise digest of applicable thermodynamics. * Unique and thoroughly up to date * Comprehensive and international in scope * Author of international repute

Technical Assessment and Industrial Applications of Biochemical and Thermochemical Processes Club Lighthouse Publishing

With the development of renewable electricity and the expected important surpluses of production, how can the use of hydrogen improve the green energy portfolio? Power-to-Gas covers the production of hydrogen through electrolysis and its storage or conversion in another form (gas, chemicals or fuels). It emphasises the need for new technologies with global energy consumption, markets, and logistics concepts. Pilot projects around the world are discussed as well as how policy and economics influence the real use of these energy harvesting and conversion technologies.

Design, Deployment and Operation Lulu.com

Could everything we know about fossil fuels be wrong? For

decades, environmentalists have told us that using fossil fuels is a self-destructive addiction that will destroy our planet. Yet at the same time, by every measure of human well-being, from life expectancy to clean water to climate safety, life has been getting better and better. How can this be? The explanation, energy expert Alex Epstein argues in The Moral Case for Fossil Fuels, is that we usually hear only one side of the story. We're taught to think only of the negatives of fossil fuels, their risks and side effects, but not their positives—their unique ability to provide cheap, reliable energy for a world of seven billion people. And the moral significance of cheap, reliable energy, Epstein argues, is woefully underrated. Energy is our ability to improve every single aspect of life, whether economic or environmental. If we look at the big picture of fossil fuels compared with the alternatives, the overall impact of using fossil fuels is to make the world a far better place. We are morally obligated to use more fossil fuels for the sake of our economy and our environment. Drawing on original insights and cutting-edge research, Epstein argues that most of what we hear about fossil fuels is a myth. For instance . . . Myth: Fossil fuels are dirty. Truth: The environmental benefits of using fossil fuels far outweigh the risks. Fossil fuels don't take a naturally clean environment and make it dirty; they take a naturally dirty environment and make it clean. They don't take a naturally safe climate and make it dangerous; they take a naturally dangerous climate and make it ever safer. Myth: Fossil fuels are unsustainable, so we should strive to use "renewable" solar and wind. Truth: The sun and wind are intermittent, unreliable fuels that always need backup from a reliable source of energy—usually fossil fuels. There are huge amounts of fossil fuels left, and we have plenty of time to find something cheaper. Myth: Fossil fuels are hurting the developing world. Truth: Fossil fuels are the key to improving the quality of life for billions of people in the developing world. If we withhold them, access to clean water plummets, critical medical machines like incubators become impossible to operate, and life expectancy drops significantly. Calls to "get off fossil fuels" are calls to degrade the lives of innocent people who merely want the same opportunities we enjoy in the West. Taking everything into account, including the facts about climate change, Epstein argues that "fossil fuels are easy to misunderstand and demonize, but they are absolutely good to use. And they absolutely need to be championed. . . . Mankind's use of fossil fuels is supremely virtuous—because human life is the standard of value and because using fossil fuels transforms our environment to make it wonderful for human life."

Special Report of the Intergovernmental Panel on Climate Change Frontiers Media SA

Killian knows all about vampires and aliens. They're not real. But when a handsome swimmer climbs into her storm-tossed boat an hour from her summer destination, the worlds of fantasy and reality suddenly collide… Cuttylea Island has no mall, no social scene, and no action. But it does have a mysterious stone tower, ageless islanders, and a secret as astonishing as a mermaid's tale… Before the summer is through, Killian will find the truth of her family's past…and the role she is destined to play in a centuries-old curse.

Emerging Technologies and Applications Springer Science & Business Media

In light of recent alarming environmental trends combined with

increasing commercial viability of fuel cells, the time is propitious for a book focusing on the systematic aspects of cell plant technology. This multidisciplinary text covers the main types of fuel cells, R&D issues, plant design and construction, and economic factors to provide industrial and academic researchers working in electrical systems design, electrochemistry, and engineering with a unique and comprehensive resource.

Hybrid Energy Systems for Offshore Applications Aei Press

Symonds & O'Toole on Delaware Limited Liability Companies byrenowned experts Robert L Symonds, Jr. and Matthew J. O'Toole combinespractice-based Delaware LLC insights, completely current coverage, andup-to-date forms presented in logical order, allowing you to confidentlyrepresent your clients from start to finish. Everything you need to know aboutDelaware Limited Liability Companies is included in this one easy-to-usereference, complete with Bonus Delaware LLC Forms CD-ROM.Since the 1988 IRS ruling permitting the advantages of pass-through taxreporting, the number of Delaware Limited Liability Companies formedannually has increased at an explosive rate. Symonds & O'Toole onDelaware Limited Liability Companies provides practical evaluation ofthe Delaware Limited Liability Company, expertly analyzing the mostcurrent Delaware LLC law, as well as the underlying principles andreasoning, allowing you to master the specific issues facing Delaware LLCpractitioners today, and to find workable approaches to potentiallyproblematic Delaware LLC situations.Symonds & O'Toole on Delaware Limited Liability Companies isthe first resource to include complete coverage of all 2006 statutory changesregarding:Filings of Delaware LLC Documents with the Secretary of StateDelaware Limited Liability Company managementFundamental Transactions, including Delaware LLC mergers, conversionand consolidation of other entities into the Delaware LLC (andDelaware LLC into other entities)Everything you need to know about a Delaware Limited Liability Company isfound in this one easy-to-use reference:Expert "how to" guidance on drafting Delaware Limited LiabilityCompany agreementsExtensive Tables covering changes to the Delaware limited Liability CompanyAct and Delaware LLC case lawDelaware LLC Forms for practitioners drafted by experiencedpractitionersReliable In-Depth, Expert Coverage of all 2006 Delaware LLC statutoryamendmentsAbout Authors Robert L. Symonds Jr. and Matthew J. O'Toole:Robert L. Symonds Jr. and Matthew J. O'Toole are shareholders and directors inthe Delaware office of Stevens & LeeP.C. Both have broad experience with the structuring and use ofDelaware business entities. Mr. Symonds is one of the original drafters of theDelaware Limited Liability Company Act, and is a member of the Delaware StateBar Association's committee charged with reviewing and proposing amendments tothe Delaware Statutory Trust Act. Mr. O'Toole is a member of the Council ofthe Corporation Law Section of the Delaware State Bar Association. Mr. Symondsand Mr. O'Toole both serve on the Delaware State Bar Association's committeethat reviews and proposes amendments to Delaware's Limited Liability Companyand Partnership Statutes, and Mr. Symonds is immediate past Chair of thatcommittee.

The Case of Natural Gas RJ Crayton

As power and gas markets are becoming more and more mature and globally competitive, the importance of reaching maximum

potential economic efficiency is fundamental in all the sectors of the value chain, from investments selection to asset optimization, trading and sales. Optimization techniques can be used in many different fields of the energy industry, in order to reduce production and financial costs, increase sales revenues and mitigate all kinds of risks potentially affecting the economic margin. For this reason the industry has now focused its attention on the general concept of optimization and to the different techniques (mainly mathematical techniques) to reach it. Optimization Methods for Gas and Power Markets presents both theoretical elements and practical examples for solving energy optimization issues in gas and power markets. Starting with the theoretical framework and the basic business and economics of power and gas optimization, it quickly moves on to review the mathematical optimization problems inherent to the industry, and their solutions – all supported with examples from the energy sector. Coverage ranges from very long-term (and capital intensive) optimization problems such as investment valuation/diversification to asset (gas and power) optimization/hedging problems, and pure trading decisions. This book first presents the readers with various examples of optimization problems arising in power and gas markets, then deals with general optimization problems and describes the mathematical tools useful for their solution. The remainder of the book is dedicated to presenting a number of key business cases which apply the proposed techniques to concrete market problems. Topics include static asset optimization, real option evaluation, dynamic optimization of structured products like swing, virtual storage or virtual power plant contracts and optimal trading in intra-day power markets. As the book progresses, so too does the level of mathematical complexity, providing readers with an appreciation of the growing sophistication of even common problems in current market practice. Optimization Methods for Gas and Power Markets provides a valuable quantitative guide to the technicalities of optimization methodologies in gas and power markets; it is essential reading for practitioners in the energy industry and financial sector who work in trading, quantitative analysis and energy risk modeling.

Essays on Modeling Energy Future of India Springer

This thesis explores three topics that are central to a low-carbon development path for India, namely, the Indian natural gas market, grid integration of renewable energy, and energy efficiency programs. In the first part of the thesis, the effect of price liberalization on the natural gas market is analyzed by developing a mixed complementarity model. Gas prices in the liberalized market are found to be significantly higher than the government regulated prices under the status quo. However, the liberalized market is found to overcome the prevailing gas shortages in the country and improve total welfare. Irrespective of the gas pricing policy, imported liquefied natural gas is found to be a significant part of the supply mix in the future. Inadequate investments in gas pipelines can lead to network congestion and price spikes. Gas pipeline infrastructure would, therefore, be the key to developing an efficient gas market. Finally, the present formula for sharing profits of domestic gas producers with the government is found to incentivize inefficient investments in gas exploration and production. The second part of the thesis tests

the feasibility of integrating large scale renewable energy projects into the electricity grid using the state of Delhi as a case study. Wind resources from the state of Tamilnadu were found to have a very high seasonal and diurnal correlation with electricity demand in Delhi. Solar energy from the state of Rajasthan is found to have a complementary seasonal profile to that of wind power from Tamilnadu. Simulation of the optimal grid dispatch shows that integration of wind and solar power is feasible at modest incremental costs. However, regional coordination for planning transmission investments is a must. The third part of the thesis analyzes the effect on utility finances and consumer tariffs of implementing utility-funded demand-side energy efficiency (EE) programs using the state of Delhi as a case study. The impacts are examined by developing scenarios for (a) incentive mechanisms for mitigating the financial risk of utilities, (b) the share of utility funding in total program costs, (c) the sale of conserved electricity into the spot market and (d) the level of power shortages utilities are facing. Although the average consumer tariff would increase only modestly, consumers participating in EE programs would benefit from a reduction in their electricity consumption. While utility incentive mechanisms can mitigate the utilities' risk of losing long-run returns, they cannot address the risk of a consistently negative cash flow. In case of power shortages, the cash flow risk is significantly amplified. It is found to be very sensitive to marginal tariffs of consumers facing power shortages.

Geothermal Power Plants Academic Press

While the IAIA defines EIA as "the process of identifying, predicting, evaluating and mitigating the bio-physical, social, and other relevant effects of development proposals prior to major decisions being taken and commitments made," the US EPA defines Life cycle Analysis as a way to "evaluate the environmental effects associated with any given industrial activity from the initial gathering of raw materials from the earth until the point at which all residuals are returned to the earth" or "cradle-to-grave." Of the several oil and gas impacts, drilling and production disrupts the global natural carbon cycle equilibrium by artificially releasing naturally sequestered geological carbon back into the biosphere. The global gross carbon dioxide emissions, from coal usage were 14.5 gigatonnes in 2016. Coal-fired electric power generation emits around a tonne of carbon dioxide for each megawatt-hour generated. This is double the amount emitted by a natural gas-fired electric plant. Despite hydroelectricity renewable nature, it has adverse impacts such as communities relocation, transboundary conflicts, free-flowing rivers fragmentation, habitat changes, freshwater biodiversity alteration, water flow dynamics, fish migration route blockade, sediment retention and nutrients upstream, turbidity, suspended material which undermines biological productivity downstream, decreasing wetlands fertility and impacting their carrying capacities. For wind power, noise and visual impacts are the main impacts associated with their turbine operations. With regards to bioenergy, a fossil energy balance of 1.0 means that it requires as much energy to produce a litre of that biofuel as it contains; in other words, the biofuel provides no net energy gain or loss. A fossil fuel energy balance of 2.0 means that a litre of biofuel contains twice the amount of energy as that, required in its production. Petrol and diesel have fossil energy balances of about

0.8-0.9, because some energy is utilized in refining crude oil into usable fuel and transporting it to markets. Since biofuels have greater fossil energy balances than these numbers, they make positive contributions in this regard to widely differing degrees. The estimated fossil fuel balances for biodiesel range from about 1 to 4 for rapeseed and soybean feedstocks. There are higher estimated balances for palm oil (around 9) due to oilseeds crushing before oil extraction. The estimated balances for crop-based ethanol, range from less than 2 for maize to around 2-8 for sugar cane, while the favourable fossil energy balance of sugar-cane-based ethanol, depends both on feedstock productivity and the fact that it is processed using biomass residues from the sugar cane known as bagasse, as energy input. The fossil fuel balance estimated ranges, for cellulosic feedstock, is even wider, indicating the wide variations regarding this technology and the diversity of potential feedstocks and production systems. While most estimates of life-cycle emissions for solar photovoltaic systems are between 0.07 and 0.18 pounds of carbon dioxide equivalent per kilowatt-hour, that for concentrating solar power range from 0.08 to 0.2 pounds of carbon dioxide equivalent per kilowatt-hour. However, both cases, are far less than the lifecycle emission rates for natural gas (0.6-2 lbs of CO2E/kWh) and coal (1.4-3.6 lbs of CO2E/kWh). Nuclear power plants have lifecycle emissions of between 4 and 110 gCO2eq/kWh, which is less than 90% of that of coal (820 gCO2eq/kWh) and 80 percent less than gas (490 gCO2eq/kWh), and therefore nuclear energy is similar to renewable sources like solar, wind, and geothermal energy as far as low lifecycle emissions are concerned (IPCC, 2011; 2014). The 13 chapters of this book include EIA, LCA, oil and gas, the case for natural gas, coal, hydropower, nuclear power, bioenergy, wind, solar, hydrogen, electric vehicles and energy decarbonization.

Natural Gas Independently Published

Gasification of Waste Materials: Technologies for Generating Energy, Gas and Chemicals from MSW, Biomass, Non-recycled Plastics, Sludges and Wet Solid Wastes explores the most recent gasification technologies developing worldwide to convert waste solids to energy and synthesis gas and chemical products. The authors examine the thermodynamic aspects, accepted reaction mechanisms and kinetic constraints of using municipal solid waste (MSW), biomass, non-recycled plastics (NRP), sludges and wet solid wastes as feedstock. They identify the distinctions between pyrolysis, gasification, plasma, hydrothermal gasification, and supercritical systems. A comprehensive summary of laboratory and demonstration activities is presented, as well as field scale systems that have been in operation using solid waste streams as input, highlighting their areas of disconnect and alignment. The book also provides a summary of information on emissions from the stack, comparing them with other thermal conversion systems using similar feedstock. It then goes on to assess the areas that must be improved to ensure gasification systems become as successful as combustion systems operating on waste streams, ranging from feedstock processing to gasifier output gas clean-up, downstream system requirements and corrosion. The economics and future projections for waste gasification systems are also discussed. For its consolidation of the current technical knowledge, this text is recommended for engineering researchers, graduate students,

industry professionals, municipal engineers and decision makers when planning, designing and deploying waste to energy projects, especially those using MSW as feedstock. Provides field demonstrations of large scale systems, their results and the challenges that need to be overcome when developing commercial applications and possible solutions Presents the most recent technologies in lab and demonstration scale Examines the critical development needs and real life challenges for the deployment of waste to energy technologies Provides information on the economics and sustainability of these technologies, as well as their future perspectives

Stopping Climate Change: the Case for Hydrogen and Coal
Elsevier

A hydrogen economy, in which this one gas provides the source of all energy needs, is often touted as the long-term solution to the environmental and security problems associated with fossil fuels. However, before hydrogen can be used as fuel on a global scale we must establish cost effective means of producing, storing, and distributing the gas, develop cost efficient technologies for converting hydrogen to electricity (e.g. fuel cells), and creating the infrastructure to support all this. Sorensen is the only text available that provides up to date coverage of all these issues at a level appropriate for the technical reader. The book not only describes the "how" and "where" aspects of hydrogen fuels cells usage, but also the obstacles and benefits of its use, as well as the social implications (both economically and environmental). Written by a world-renowned researcher in energy systems, this thoroughly illustrated and cross-referenced book is an excellent reference for researchers, professionals and students in the field of renewable energy. Updated sections on PEM fuel cells, Molten carbonate cells, Solid Oxide cells and Biofuel cells Updated material to reflect the growing commercial acceptance of stationary and portable fuel cell systems, while also recognizing the ongoing research in automotive fuel cell systems A new example of a regional system based on renewable energy sources reflects the growing international attention to uses of renewable energy as part of the energy grid Examples of life cycle analysis of environmental and social impacts

Ten Thousand A-year Academic Press

Increased production of energy from renewable sources leads to a need for both new and enhanced capacities for energy transmission and intermediate storage. The book first compares different available storage options and then introduces the power-to-gas concept in a comprehensive overview of the technology. The state of the art, advancements, and future requirements for both water electrolysis and methanation are described. The integration of renewable hydrogen and methane into the gas grid is discussed in terms of the necessary technological measures to be taken. Because the power-to-gas system is very flexible, providing numerous specific applications for different targets within the energy sector, possible business models are presented on the basis of various process chains taking into account different plant scales and operating scenarios. The influence of the scale and the type of the integration of the technology into the existing energy network is highlighted with an emphasis on economic consequences. Finally, legal aspects of the operation and integration of the power-to-gas system are discussed.

The Role of Oil and Gas Companies in the Energy Transition California Power-to-Gas and Power-to-Hydrogen Near-Term Business Case EvaluationFlexible operation of electrolysis systems represents an opportunity to reduce the cost of hydrogen for a variety of end-uses while also supporting grid operations and thereby enabling greater renewable penetration. California is an ideal location to realize that value on account of growing renewable capacity and markets for hydrogen as a fuel cell electric vehicle (FCEV) fuel, refineries, and other end-uses. Shifting the production of hydrogen to avoid high cost electricity and participation in utility and system operator markets along with installing renewable generation to avoid utility charges and increase revenue from the Low Carbon Fuel Standard (LCFS) program can result in around $2.5/kg (21%) reduction in the production and delivery cost of hydrogen from electrolysis. This reduction can be achieved without impacting the consumers of hydrogen. Additionally, future strategies for reducing hydrogen cost were explored and include lower cost of capital, participation in the Renewable Fuel Standard program, capital cost reduction, and increased LCFS value. Each must be achieved independently and could each contribute to further reductions. Using the assumptions in this study found a 29% reduction in cost if all future strategies are realized. Flexible hydrogen production can simultaneously improve the performance and decarbonize multiple energy sectors. The lessons learned from this study should be used to understand near-term cost drivers and to support longer-term research activities to further improve cost effectiveness of grid integrated electrolysis systems.Allocation of Hydrogen Produced Via Power-to-gas Technology to Various Power-to-gas PathwaysDemand for renewable energy systems is accelerating and will account for a significant share of future power systems aimed to enhance and decarbonize the world's energy system. Unlike conventional power plants, electricity output from renewable sources cannot be adjusted easily to match consumer power demand because renewable resources are intermittent short-term seasonal power sources. Accordingly, a rapid increase in surplus power is expected in the future. The Canadian Province of Ontario, in line with global efforts, has targeted 80 % reduction of greenhouse gas emission levels by 2050 compared to 1990 levels. One key step to accomplish this goal is to harness more renewable energies for power generation. Instead of losing the surplus power or exporting it for low returns, storage and utilization in other sectors urgently need to be explored. Power-to-Gas technology offers a possible solution for optimal use of energy surplus. It is efficient at the huge -national- consumption scale and global acceptance of Power-to-Gas as energy storage and transportation technology is growing noticeably. In short, Power-to-Gas is a potential means to manage intermittent and weather-dependent renewable energies like wind, solar, or hydro in a storable chemical energy form. The main concept behind Power-to-Gas technology is to make use of surplus electricity to decompose water molecules into their primary components: hydrogen and oxygen. Power-to-Gas is not only a storage technology; its role can be extended to other energy streams including transportation, industrial use, injection into the natural gas grid as pure hydrogen, and renewable natural gas. The current study investigated four specific Power-to-Gas pathways: Power-to-Gas to mobility fuel, Power-to-Gas to

industry, Power-to-Gas to natural gas pipeline for use as hydrogen-enriched natural gas, and Power-to-Gas to Renewable Natural Gas (i.e., Methanation). This study quantifies the hydrogen volumes at three production capacity factors (67%, 80%, and 96%) upon utilizing Ontario's surplus electricity baseload. Five allocation scenarios (A-E) of the hydrogen produced to the four Power-to-Gas pathways are investigated and their economic and environmental aspects considered. Allocation scenario A in which hydrogen assigned to each pathway is constrained by a specific demand, is based on Ontario's energy plans for pollution management in line with international efforts to reduce global warming impacts. Scenarios B-E are about utilization of the produced hydrogen entirely for one of mobility fuel, industrial feedstock, injection into the natural gas grid, or renewable natural gas synthesis, respectively. The study also examines the economic feasibility and carbon offset of the PtG pathways in each scenario. The research sets the assumption that hydrogen is produced at three capacity production factors: 67% (16 h/day), 80% (19 h/day), and 96% (23 h/day). The amount of surplus baseload electricity for 2017 of each capacity factor is converted to hydrogen via water electrolysis. Accordingly, the total hydrogen produced is approximately 170 kilo-tonnes (kt), 193 kt, and 227 kt, respectively. Results indicate that the Power-to-Gas to mobility fuel pathway in scenarios A and B has the potential to be implemented. Utilization of hydrogen produced via Power-to-Gas technology for refueling light-duty vehicles is a profitable business case with an average positive net present value of $4.5 billions, five years payback time, and 20% internal rate of return. Moreover, this PtG pathway promises a potential 2,215,916 tonnes of CO2 reduction from road travel. In the scenario to utilize Ontario's surplus electricity to produce hydrogen via the PtG technology for industrial demand, results indicate that supply could achieve 82%, 93%, and 110% of the industrial demand for hydrogen at the three capacity factors, respectively. Nevertheless, hydrogen production through PtG is still costly compared to other available cheaper alternatives, namely hydrogen produced via steam methane reforming. Power-to-Gas for industry projects should, however, be part of government incentives to encourage clean energy utilization. In addition, although using hydrogen-enriched natural gas or renewable natural gas instead of the conventional natural gas could offset huge amounts of carbon, their capital and operational costs are extremely high, resulting in negative net present values and very long payback time.Substitute Natural Gas from WasteTechnical Assessment and Industrial Applications of Biochemical and Thermochemical Processes
Substitute Natural Gas from Waste: Technical Assessment and Industrial Applications of Biochemical and Thermochemical Processes provides an overview of the science and technology of anaerobic digestion and thermal gasification for the treatment of biomass and unrecyclable waste residues. The book provides both the theoretical and practical basis for the clean and high-efficiency utilization of waste and biomass to produce Bio-Substitute Natural Gas (SNG). It examines different routes to produce bio-SNG from waste feedstocks, detailing solutions to unique problems, such as scale up issues and process integration. Final sections review waste sourcing and processing. This book is an ideal and practical reference for those developing,

designing, scaling and managing bio-SNG production and utilization systems. Engineering students will find this to be a comprehensive resource on the application of fundamental concepts of bio-SNG production that are illustrated through innovative, recent case studies. Presents detailed scientific and technical information Describes up-to-date concepts, processes and plants for efficient anaerobic digestion and gasification of wastes and syngas utilization Compares gasification with anaerobic digestion for different situations Proposes alternative strategies to increase efficiency and overcome energy balance limitations Includes benchmarking data and industrial real-life examples to demonstrate the main process features and implementation pathways of bio-SNG systems from dry and wet waste, both in developed and developing countries *Gasification of Waste Materials* Academic Press

Engineering Energy Storage explains the engineering concepts of different relevant energy technologies in a coherent manner, assessing underlying numerical material to evaluate energy, power, volume, weight and cost of new and existing energy storage systems. With numerical examples and problems with solutions, this fundamental reference on engineering principles gives guidance on energy storage devices, setting up energy system plans for smart grids. Designed for those in traditional fields of science and professional engineers in applied industries with projects related to energy and engineering, this book is an ideal resource on the topic. Contains chapter based numerical examples, with applied industry problems and solutions Assesses underlying numerical material for evaluating energy, power, volume, weight and cost of new and existing energy storage systems Offers a cross-disciplinary look across electrical, mechanical and chemical engineering aspects of energy storage