

List of Papers Posted to Energy Central by Subject

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July 2020

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1. Introduction

This document contains links to all of the major / educational papers I have written and posted to Energy Central. I originally posted this document at the end of 2018. This will be the sixth update of this, at the end of the second quarter (June) of 2020.

Note that I formatted each paper's (or series') title as a heading for a subsection below that contains the paper/series description and link to the paper on the Energy Central Website. This is so that it also appears in this document's table of contents, and can be quickly accessed as described below. Each section contains papers from the title subject, and this title is also linked to the table of contents.

The source document for this list is in Microsoft Word format. This supports automatic heading titles and at any time Word can automatically create or update the table of contents. Then the entries in that table are automatically linked to the actual section and subsection headings. I convert this list to a PDF (Adobe Acrobat Portable Document Format) to distribute, and this capability persists. Thus from the PDF, you can click on the document title in the table of contents, and you will be taken to the heading for the linked paper's or series' description.

One other comment: note that, under each category (like section 2, "Climate and Energy" immediately below), the documents are listed in chronological order. Thus I posted the document or series in section 2.1 a week or two ago, the document/series in section 2.2 a week or two before that, and so on. The last series in section 2 ("PICS1") is the oldest, and was posted in October 2018. I also might update important papers, in which case they move to the front of the line, and become "...Rev B" (or Rev C or whatever).

2. Climate and Energy

2.1. Options for Mitigating Climate Change

Going forward how we deal with climate change will depend on both economics and civic responsibility. This paper will explore how we will evolve from using fossil fuels for three applications: electric generation, mobility and industrial chemicals, and describe how these two forces might play a part.

<https://energycentral.com/c/ec/options-mitigating-climate-change>

2.2. Geologic Greenhouse Gas Sequestration Projects

Earlier I posted Verification of Geologic Greenhouse Gas Sequestration. This described current techniques for greenhouse gas geologic sequestration, and requirements and techniques for verifying the effectiveness of this process.

Whereas the above paper deals seriously with the above-described methods behind the projects, it really doesn't describe other processes (like site selection), the business justification for CCS or any actual projects. This post deals with the above described information that was missing from the first paper.

<https://energycentral.com/c/ec/geologic-greenhouse-gas-sequestration-projects>

2.3. Financial Greenhouse Gas Reduction Incentives

Financial greenhouse gas (GHG) reduction incentives are added costs for products that require the emission of GHG to produce and/or use. These costs are proportional to the amount of GHG emitted in the production and/or use of each unit of the product, and these costs (basically fees) slowly increase over time. The incentive part comes from lower net costs for products that emit less GHG, which make the consumer more likely to purchase the lower-cost product.

There are basically two systems for implementing the fees associated with the title incentives: Cap and Trade, as used by California and a group of Northeastern States, and a greenhouse gas tax (a.k.a. Carbon Fee and Dividend System), as being considered in the U.S. Congress.

This paper will look at the differences between these two incentive systems, the carbon fee and dividend bills being considered by Congress, and some added information on the two Cap and Trade Systems.

<https://energycentral.com/c/cp/financial-greenhouse-gas-reduction-incentives>

2.4. Carbon Offsets – Rev b

Offsets are financial instruments that are used by the California Cap and Trade Program and other similar programs. In this paper we will review the types of offsets, offset protocols and offset verification.

<https://energycentral.com/c/cp/carbon-offsets>

2.5. Verification of Geologic Greenhouse Gas Sequestration

Many types of negative (greenhouse gas) emissions technology and greenhouse gas reduction use carbon capture and storage (CCS) a.k.a. carbon capture and sequestration, which begs the question how effective is sequestration? This paper examines current techniques for greenhouse gas geologic sequestration, and requirements and techniques for verifying the effectiveness of this process.

<https://www.energycentral.com/c/cp/verification-geologic-greenhouse-gas-sequestration>

2.6. Oceanic Solutions

This paper is about two subjects. The first is the latest update on the sea level rise and other oceanic issues. The second is a "no-regrets" to do list involving the oceans that will help the fight to mitigate climate change.

<https://www.energycentral.com/c/ec/oceanic-solutions>

2.7. Economics and Climate Change Refugees

How will our economy will deal with repeated disasters that destroy infrastructure, where these disasters are mainly forced by climate change and are steadily getting worse. I believe these will eventually require one of two types of response. One is to increase the resilience of these areas (if such is economically viable) to withstand these forces for a reasonable amount of time, and the other is to retreat from the areas ravaged by these forces.

The primary "forces" I will focus on in this paper are coastal storms (hurricanes and other strong and persistent storms), inland flooding, and wildfires.

Below we will look at the economics, and a government program designed to be the ultimate solution (should all else fail), but instead has turned into the worst disaster of all.

2.8. Positive Feedback Accelerates Sea Level Rise

The surface air temperature of the arctic is rising twice as fast as the global air temperature. This is the result of many positive feedback forces, and causes previous simulations of how fast the Greenland ice sheet is melting to be out of date almost as soon as they are published, and not in a good way. Furthermore, Mother Nature seems to have many surprises for climatologists and many of these involve positive feedback.

This paper will look at the positive feedback loops that we have seen recently.

<https://www.energycentral.com/c/ec/positive-feedback-accelerates-sea-level-rise>

2.9. Trees

This post will explain the right way to do reforestation (replanting woodlands in areas that were previously cleared) and afforestation (planting woodlands in areas where there were no recent forests).

<https://www.energycentral.com/c/ec/trees>

2.10. The Path to Net-Zero, Rev B

This is a major update of a two-part series that I originally posted about in the summer of 2018. Part 1 of this series has an overview of GHG emissions, explores carbon dioxide emissions in depth and the steps we might take to reduce them.

Part 2 of this series is about reducing methane emissions and financial incentives that will drive down GHG reductions, including Cap and Trade and Carbon Fee and Dividend Systems.

<https://www.energycentral.com/c/ec/path-net-zero-%E2%80%93-part-1-rev-b>

<https://www.energycentral.com/c/ec/path-net-zero-%E2%80%93-part-2-rev-b>

2.11. Fires and Storms, Rev B

This is a minor update of a three part series that I originally posted in late 2018. Part 1 of this series is about the wildfire risk resulting from environmental changes brought about by climate change.

Part 2 of this series is about the more severe hurricanes resulting from environmental changes brought about by climate change.

Part 3 of this series is about sea level rise brought about by climate change.

<https://www.energycentral.com/c/ec/fires-and-storms-%E2%80%93-part-1-rev-b>

<https://www.energycentral.com/c/ec/fire-and-storms-%E2%80%93-part-2-rev-b>

<https://www.energycentral.com/c/ec/fire-and-storms-part-3-rev-b-sea-level-rise>

2.12. Climate and Energy Series, Rev B

This is a major update, of the "Climate and Energy" three-part series that I originally posted starting in June of 2018. Part 1 of this series is on Climate Science and what the future might hold for us.

Part 2 of this series is about climate change's impacts on utilities.

Part 3 of this series is on negative greenhouse gas emissions technology (as used to mitigate climate change).

<https://www.energycentral.com/c/ec/climate-and-energy-part-1-future-rev-b>

<https://www.energycentral.com/c/ec/climate-and-energy-part-2-impacts-infrastructure-rev-b>

<https://www.energycentral.com/c/ec/climate-and-energy-part-3-mitigating-climate-change-rev-b>

2.13. Climate Change: Two Challenges and Five Solutions

This two-part series is mainly focused on the solutions, that is, what we can start doing now (or at least soon) to deal with climate change. Part 1 covers one of the "Five Solutions", moving all electricity production to low-carbon procedures. Also it mainly focuses on methods that I have not covered before.

Part 2 covers the other four solutions:

- Mobility should be moved to almost carbon free production and fuel.
- Continue development of negative emissions technologies.
- Start moving industry to low-carbon production.
- Mitigating the impact of climate change.

<https://www.energycentral.com/c/ec/climate-change-two-challenges-and-five-solutions-%E2%80%93-part-1>

<https://www.energycentral.com/c/ec/climate-change-two-challenges-and-five-solutions-%E2%80%93-part-2>

2.14. Meaningful Change Series

Part 1 of this series contains:

- Some recent information about where climate change is going, especially sea level rise.
- How successful California has been in meeting its climate-related goals.
- Suggestions about how we might combine trade and climate change in a way that strongly encourages all nations to move in a direction that avoids future disruptions from both.
- Some ideas to protect and share intellectual property.

Part 2 deals with how California uses several of its climate-related programs to benefit its low-income customers and disadvantaged communities, including a new program that it is hoped will run for the next ten years.

<https://www.energycentral.com/c/cp/meaningful-change-%E2%80%93-part-1>

<https://www.energycentral.com/c/cp/meaningful-change-%E2%80%93-part-2>

2.15. Climate Change - When Time Runs Out

This paper lays out the case of why we are probably out of time to simply stop emitting greenhouse gases (not that this is easy), and probably need to start removing greenhouse gases (GHG) from the atmosphere, mainly carbon dioxide (CO₂), in addition to stopping the emission of GHG by 2050.

<https://www.energycentral.com/c/ec/climate-change-when-time-runs-out>

2.16. Emerging Negative Effects of Climate Change

Climate change is caused by greenhouse gases (GHG), primarily carbon dioxide (CO₂) and methane, increasing in the atmosphere. This results in atmospheric warming. There are also many secondary, tertiary and higher order effects, including the following:

- The sea-level rise
- Both heat and CO₂ enter the oceans and the latter acidifies them.
- Disruption of the Meridional Overturning Circulation (MOC, the Gulf Stream and other major ocean currents).
- Increasing atmospheric temperatures and the MOC disruption have caused major changes to weather patterns around the world.

This paper is about an emerging understanding of the last bullet, and the impacts (so far), especially in North America.

<https://www.energycentral.com/c/ec/emerging-negative-effects-climate-change>

2.17. Accelerated Warming?

As I write this climatologists are going through the early stages of bringing the next generation of climate models to life, and a strange thing is happening with many of them. The simulated earth is heating up faster in the future than the climatologists previously thought it would.

This post will explore what is known about this change along with possible causes.

<https://www.energycentral.com/c/ec/accelerated-warming>

2.18. Four Decades of Accelerating Change

I've posted papers on many subjects, but the one subject I have missed is how the foundations on which electric utilities operate has changed during this period, and how this change is accelerating.

This paper is on the changes in these foundations in the last 40 years.

<https://www.energycentral.com/c/cp/four-decades-accelerating-change>

2.19. Methane Growth

This post is on a recent paper on atmospheric methane, why we should be concerned about recent increases, and techniques for better understanding where methane emissions are coming from.

<https://www.energycentral.com/c/ec/methane-growth>

2.20. In Hot Water

This 2-part series explores the greenhouse effect and the warming of our oceans.

<https://www.energycentral.com/c/ec/hot-water-part-1>

<https://www.energycentral.com/c/ec/hot-water-part-2>

2.21. Fire – Costs and Repercussions

This short post contains links to earlier posts detailing the emerging California wildfire problem, the scope of this problem and PUC actions that might help to remedy these disasters.

<https://www.energycentral.com/c/ec/fire-%E2%80%93-costs-and-repercussions>

2.22. IPCC Special Report

The Intergovernmental Panel on Climate Change recently (6 October 2018) released a report that forecasts impacts of global warming of 1.5 °C above pre-industrial levels. This report also compares these impacts if the global mean surface temperature (GMST) rises to 2°C (3.6°F) above pre-industrial levels. Finally it spins several scenarios for actually achieving the former goal by the end of this century. This paper presents the above information from this report, but also presents my discussion suggesting that the above goals are not realistic.

<https://www.energycentral.com/c/cp/ipcc-special-report>

2.23. Unintended Consequences

This is a story of a journey leading to the title of this paper, and going through climate change, leading to wildfires, leading to power shutoffs (to avoid the wildfires), leading to major outages, leading to PICS (prior paper, below).

<https://www.energycentral.com/c/cp/unintended-consequences-0>

2.24. PICS

This paper will explore how the "Power of Informed Collective Self-Interest" will shape the future evolution of our energy infrastructure. It includes sections on how to flatten the duck curve and various incentives currently offered by California utilities.

<https://www.energycentral.com/c/cp/pics>

3. Industries and Facility-Types

3.1. Financial Systems and Climate Vulnerabilities

In past posts we've frequently visited the economics behind renewables, but this is a different journey.

This paper will look at the largest industries, and those that are unique in their sensitivity to the forces that are likely to be brought about by predicted changes to our environment and economy resulting from climate change.

<https://energycentral.com/c/pip/financial-systems-and-climate-vulnerabilities>

3.2. Public Safety Power Shutoffs

This paper is about conditions where the energized electric grid is likely to increase the risk of a disaster like wildfires. Under these conditions, some utilities use public safety power shutoffs to greatly reduce this risk. This paper also describes reasonable steps residents of areas where these shutoffs are likely can take to prepare for them.

<https://www.energycentral.com/c/ec/public-safety-power-shutoffs>

3.3. Good Chemistry

This paper will cover the chemical industry, how it uses energy, and the potential for more economic and sustainable energy use in the future.

<https://www.energycentral.com/c/pip/good-chemistry>

3.4. Oil & Gas, Present & Future

Today the primary sources of energy for mobility and electric utilities come from the oil and gas industry. Thus I would be remiss if I didn't write about these. This paper is on the current use of energy, future changes, and possible evolution in the oil and gas industry.

<https://www.energycentral.com/c/og/oil-gas-present-future>

3.5. 20,000 Terabytes under the Sea

Microsoft is building prototype data centers under the seas.

<https://www.energycentral.com/c/cp/20000-terabytes-under-sea>

3.6. Concrete Greenhouse

This paper is about the cement and concrete industries, their energy use, greenhouse gas (GHG) emissions, and how they might reduce the emissions in the future.

<https://www.energycentral.com/c/cp/concrete-greenhouse>

3.7. I Like Smoke and Lightning, Heavy Metal Thunder

This paper is about the metals industrial subsector, how these industries use energy and how they are evolving. The subject of this paper contains a segment on the largest industrial producer of these emissions, the Iron and Steel Industry Group.

<https://www.energycentral.com/c/cp/i-smoke-and-lightning-heavy-metal-thunder>

3.8. Candidates for Advanced Energy Systems

This paper describes a process for identifying industries and facility types that are good candidate for microgrids and other advanced energy systems. It then describes several of these candidates.

<https://www.energycentral.com/c/cp/candidates-advanced-energy-systems>

3.9. Clouds and Lightning - Data Centers and Energy

From a utility perspective many commercial and industrial loads are extremely important, but few, if any loads, have the financial impact of data centers. This paper examines data centers and how they measure and use electricity.

<https://www.energycentral.com/c/pip/clouds-and-lightning-data-centers-and-energy>

3.10. Disruption in U.S. Product Distribution Sectors

A major disruption is occurring in a number of very large related sectors in the U.S. economy. The combined size of these sectors in terms of receipts was approximately \$13 Trillion in 2012. These industries include: Wholesale Trade, Retail Trade, Transportation and Warehousing. The disruptions are primarily seen in large warehouse-like facilities that are primary assets for each of the above sectors.

<https://www.energycentral.com/c/pip/disruption-us-product-distribution-sectors>

4. Mobility

4.1. Elon's Amazing Adventures, Vol 1

This part will cover the fun games that Elon and Alameda County have played, the fun visit that Elon's astronaut friends are currently making to the International Space Station, Elon's main large Battery Energy Storage Systems (BESS) and finally a review of Elon's prior work to develop his own batteries.

The planned second part of this (report on "battery day") was delayed for five months, so it will be posted independently.

<https://energycentral.com/c/cp/elon%E2%80%99s-amazing-adventures-vol-1>

4.2. Low Carbon Fuel Standard & Low Emissions Provisions

In California one of the programs that allow firms implementing CCS to monetize this practice is California's Low Carbon Fuel Standard (LCFS), and one method of gaining returns from CCS using LCFS is a recent method that deploys zero emission vehicle infrastructure.

This post reviews California's Low Carbon Fuel Standard (LCFS), the Zero Emissions Fuel Infrastructure (part of LCFS) and California's Advanced Clean Cars Program.

<https://energycentral.com/c/cp/low-carbon-fuel-standard-low-emissions-provisions>

4.3. Tesla, Inc.

This paper contains some Tesla numbers on its first quarter, Model Y early deliveries, various Gigafactories, and most important, some specifics on how far Tesla is ahead of other EV manufacturers. And one non-EV subject: Tesla glass solar roofs.

<https://energycentral.com/c/ec/tesla-inc>

4.4. Big Electric Trucks, Little e-Trucks & Charging Buses

In this post we will cover a couple of trucks and a SUV from Tesla; SUVs and trucks from GM and Ford, Tesla's big rig competitors, and some trade-offs in charging electric buses.

<https://energycentral.com/c/ec/big-electric-trucks-little-e-trucks-charging-buses>

4.5. Battery Electric Vehicle Reliability & Maintenance

In this paper we will explore electric vehicle reliability and maintenance requirements, and primarily focus on Teslas. Also Tesla has announced their fourth quarter deliveries. These are included along with the other quarterly deliveries from 2019 for comparison.

<https://energycentral.com/c/ec/battery-electric-vehicle-reliability-maintenance>

4.6. Floating Anodes and Cathodes

In this post we review nautical electric vehicles. When I started writing this paper, I assumed that there would be some volume of fuel-cell nautical EVs, and also some battery-electric nautical EVs. I started with the latter, and found a large volume of these (hereafter BNEVs) already in service. When I got to fuel cell versions, I basically came up empty. Thus below will cover BNEVs, followed by a short section where we review possible reasons why I was wrong about hydrogen/fuel-cell ships.

<https://www.energycentral.com/c/ec/floating-anodes-and-cathodes>

4.7. Electric Vehicle Charging Networks

If you are considering purchasing an Electric Vehicle (EV), this PDF provides descriptions of the two groups of charging networks you probably need to know about.

<https://www.energycentral.com/c/cp/electric-vehicle-charging-networks>

4.8. Toyota, Tesla & Schumer

The EV things in the title are explored in this paper.

<https://www.energycentral.com/c/ec/toyota-tesla-schumer>

4.9. Trucks and Teslas

This post will mainly focus on heavy electric vehicles, and includes subsection of battery-electric delivery trucks/vans, a brief subsection on battery-electric buses, and a last section on Teslas.

<https://www.energycentral.com/c/ec/trucks-and-teslas>

4.10. Flying Cathodes and Anodes Everywhere

As I started researching this paper I quickly determined that there is a surprising range of flying EVs that transport humans (as opposed to unmanned aerial vehicles (UAVs)) that are starting to enter various markets, and that is what this paper is about.

<https://www.energycentral.com/c/ec/flying-cathodes-and-anodes-everywhere>

4.11. Tesla

This paper starts out with a silly tidbits, but is really about a minor subject and a major subject. The former is one of the most important individuals in the history of the U.S. Electric Utility Industry, and the major subject is Tesla, Inc.

<https://www.energycentral.com/c/cp/tesla>

4.12. EV Update 2019

The first section of this paper is on major issues with California, et al, meeting their climate change goals due to resistance from the current federal administration. The rest is on the latest electric vehicle (EV) plans from major manufacturers that will probably offer these EVs in the U.S. in the next two to three years.

<https://www.energycentral.com/c/cp/ev-update-2019>

4.13. California Rail Electrification

The California High Speed Rail System (HSR) is an important part of our state's efforts to reduce our greenhouse gas emissions. Currently, there is a huge amount of travel between the San Francisco Bay Area and the Los Angeles Area, and this is mostly by Auto or Airlines. Although there are efforts to reduce the greenhouse gas from both of these transports, a viable electrified rail system between these two areas will contribute mightily to this effort.

This project currently seems to be devolving into a political and legal contest, so this paper is an update of this project. The good news is that the current change in direction appears to be likely to bring more benefits to more of California's citizens sooner than the original plan.

<https://www.energycentral.com/c/ec/california-rail-electrification>

4.14. More Trucks and Cars

This is a paper on recent developments regarding light and heavy electric vehicles.

<https://www.energycentral.com/c/cp/more-trucks-and-cars>

4.15. Bucket-Trucks and Buses

This paper is on the current technology available for making electric utility trucks, and some predictions about how these might evolve. This paper also covers California's efforts to evolve their bus fleets to 100% electric power.

<https://www.energycentral.com/c/cp/bucket-trucks-and-buses>

4.16. EV Update

Much is happening in electric mobility, so it is a good time to report on the latest news in these markets, which follows in the rest of this paper. Much of this paper focuses on electric buses, which are starting to emerge, big-time.

<https://www.energycentral.com/c/cp/ev-update>

4.17. The Evolution of Battery Electric Vehicles and their Supply Equipment

As electric vehicles continue to displace vehicles based on internal combustion engines, there are many questions about how rapidly this will occur. Also, what will the effects of this technological change be? This paper explores these issues and others related to electric vehicles and electric vehicle supply equipment (EVSE).

<https://www.energycentral.com/c/pip/evolution-battery-electric-vehicles-and-their-supply-equipment>

4.18. Solutions for EVSE-Related Overloads

Electric vehicles (EVs) are expected to comprise 30% of all cars globally by 2030. As the EV population surges, so must the population of EVSE (chargers). There is a need for charging stations at locations like workplaces, hotels, car rental centers, parking garages, etc. Simultaneous charging of several EVs can easily overload the facility electrical infrastructure. As more facilities start providing EV chargers at their locations, this will eventually overload the grid and threaten grid stability. This paper explores the use of planning and control software as facilitating solutions for these overloads.

<https://www.energycentral.com/c/pip/solutions-evse-related-overloads>

4.19. Imminent Unexpected Electric Loads

Unexpected loads, especially very large loads, can wreak havoc on facility and utility distribution systems. Several very large classes of facilities will start to encounter these loads in the next few years as electric vehicles start to form an increasing percentage of the overall vehicle fleet. The classes of facilities include those with a large number of employees, those with a large number of customers, those with both and those with large fleets of automobiles. The following link is to the second edition of this paper posted on Feb 8, 2018.

<https://www.energycentral.com/c/pip/imminent-unexpected-electric-loads-second-edition>

5. Renewables and Microgrids

5.1. Wind Market & Technology

After a brief information update on offshore wind, and market review this paper focuses on major onshore projects in the U.S. and turbines from major manufacturers that address the U.S. onshore market.

<https://energycentral.com/c/cp/wind-market-technology>

5.2. Long-Term Storage

This paper describes long-term storage technologies, some economic considerations, and recent developments.

<https://energycentral.com/c/cp/long-term-storage>

5.3. Renewably Into the Future

This paper is about the steps that California, other U.S. States and selected other countries have planned to achieve or approach carbon neutrality by 2045.

<https://energycentral.com/c/cp/renewably-future>

5.4. 2020 Large PV and PV + Storage Update

Recently I wondered how long it had been since I posted a paper on photovoltaic (PV) generation. I looked and it had been well over a year, and thus this post. Also, since PV

is often paired with storage in recent projects, I included this duo. This paper is limited to projects in the U.S. that are at least 100 MW and that are either recently completed, under construction or planned to be complete by 2022.

<https://energycentral.com/c/cp/2020-large-pv-and-pv-storage-update>

5.5. A Wet & Windy Post

This post will focus on updates for U.S. East Coast off-shore wind projects, and any advancements in products from turbine vendors that supply these to the aforementioned projects.

<https://energycentral.com/c/cp/wet-windy-post>

5.6. The Five Dimensions of Microgrids

A few weeks ago I posted a two part series on PG&E's likely reorganization details. One of these details is how they intend to mitigate the Public Safety Power Shutoffs (PSPS) used to reduce the chances of sparking additional wildfires. Although there were multiple actions to do this, the primary strategy for remote parts of their service territory was a series of 20 microgrids. These will allow long stretches of transmission line to be de-energized while keeping the remote consumers powered.

<https://energycentral.com/c/cp/five-dimensions-microgrids>

5.7. The Reemergence of Microgrids – Part 1, Rev b

This is an update of Part 1 of this 2-part series originally published in 2017. This is in preparation for another post on microgrids (above) where I reference this Part. I have no plans to update Part 2.

Part 1 focuses on microgrid history, configurations and technology. Part 2 focuses on how microgrids might be integrated in the electric utility culture.

<https://energycentral.com/c/cp/reemergence-microgrids-%E2%80%93-part-1-rev-b>

5.8. Hydrogen's Role

About a year ago I posted a two part series: "Hydrogen Futures". Recently I encountered a good article on hydrogen in Scientific American (February hardcopy issue) that made me revisit these to compare notes. I saw some updates were needed in this earlier series. The updates have now been made.

This paper will be a clarification for the additional roles for hydrogen from the above referenced article.

<https://energycentral.com/c/ec/hydrogen%E2%80%99s-role>

5.9. Hydrogen Futures – Rev b

This is a two-part series. This part 1 will explore current and future methods of hydrogen production and part 2 will deal with possible future roles of hydrogen-based mobility and hydrogen energy storage systems.

<https://www.energycentral.com/c/cp/hydrogen-futures>

<https://www.energycentral.com/c/cp/hydrogen-futures-part-2>

5.10. The Other Major Renewables

This paper is about two types of renewable energy: geothermal generation and hydroelectric generation. The former supports one major western U.S. grid with substantial dispatchable capacity, and has significant potential for expansion. Hydro supports many U.S. grids, but is still somewhat regional, and has limited potential for expansion. Neither emits significant greenhouse gases. Although both are dispatchable (and thus can mitigate intermittent renewable sources like PV and Wind), hydroelectric is highly constrained, and geothermal is only slightly constrained.

<https://energycentral.com/c/cp/other-major-renewables>

5.11. Renewables Accelerating

This paper is primarily on U.S. photovoltaic (PV) and PV plus battery energy storage systems (BESS). Section 2 is on recent news on wind, PV and PV+BESS economics, and specifically how their levelized cost of energy compares with other types of generation. Section 3 is on recent major PV+BESS and PV-only projects. It also includes some amazingly low power purchase agreement energy-pricing.

<https://energycentral.com/c/cp/renewables-accelerating>

5.12. 2020 Wind Energy Update

This paper contains several subjects. It starts with some “grand challenges” that wind power will face in the future. Following that we will briefly review technology improvements that have been made to small wind turbines. Finally we will review major projects throughout the world.

<https://energycentral.com/c/cp/2020-wind-energy-update>

5.13. Renewable Collaboration – Rev c

A little less than a year ago, I posted a two-part series on startup support organizations (Audacious Ambitions) Part 1 covered California-government and private groups (a.k.a. venture capitalists or “VCs”) that help fund green-tech startups. Part 2 covered global networks of clean energy incubators and accelerators that support these startups.

This paper will continue this theme, but with a focus on the relationship between California and China.

<https://energycentral.com/c/ec/renewable-collaboration>

5.14. California Offshore Wind

In a recent post I indicated that there were no active projects on the U.S. West Coast. Although that is still basically true, there is quite a bit of early-stage activity on the California coast. This post reviews that activity, and possible barriers to future development.

<https://www.energycentral.com/c/cp/california-offshore-wind>

5.15. Recent Developments in Storage, Wind and PV

There have been many more large PV wind and storage projects in the U.S. recently, and we will review those. Also there have been a recent news that impacts the cost of battery energy storage systems (BESS), and we will start this paper with this subject.

<https://www.energycentral.com/c/cp/recent-developments-storage-wind-and-pv>

5.16. Off-Shore Wind Update

This two-part series will focus on the positive political moves in many states, off-shore projects, the latest turbine designs from major manufacturers and planned supporting infrastructure.

Note that I updated part 2 to a few weeks after originally posted to add some more recent awards. The link below is to the updated version

<https://www.energycentral.com/c/cp/shore-wind-update-%E2%80%93-part-1>

<https://www.energycentral.com/c/cp/shore-wind-update-%E2%80%93-part-2-rev-b>

5.17. Wind Power Update

This paper explores the recent growth of the U.S. onshore wind-power fleet that is under development, the latest turbines currently being deployed, a few sample projects, and the next generation of on-shore turbines.

<https://www.energycentral.com/c/cp/wind-power-update>

5.18. Combustible Storage

The fact that fires in BESS (or battery electric vehicles) generally make the news speaks to how rare they are. A fire in a coal-fired or gas-fired generation facility, not so much. Regarding vehicles fueled by gasoline or diesel fuel, a fire resulting from a major crash is an expected outcome.

The safety systems in BESS are very different from these same systems in fossil-fueled generation facilities as will be seen in this paper.

<https://www.energycentral.com/c/cp/combustible-storage>

5.19. Future Energy Economics

This paper describes the basic underlying technologies and associated economics that support wind, photovoltaic (PV) and battery energy storage. We also look at how these technologies are disrupting legacy generation, and how currently evolving technology might take a few pages out of their play-book.

<https://www.energycentral.com/c/cp/future-energy-economics>

5.20. Repowering

This paper is about how repowering older PV and Wind projects are rapidly becoming some of the largest segments in the renewable marketplace.

<https://www.energycentral.com/c/cp/repowering>

5.21. NUTS

This paper is about woody biomass, why, when and how we should use this for energy production. Oh yes, and it is also about everything nuts.

<https://www.energycentral.com/c/cp/nuts>

5.22. Hydrogen Futures

This is a two-part series. This part 1 will explore current and future methods of hydrogen production and part 2 will deal with possible future roles of hydrogen-based mobility and hydrogen energy storage systems.

<https://www.energycentral.com/c/cp/hydrogen-futures>

<https://www.energycentral.com/c/cp/hydrogen-futures-part-2>

5.23. Photovoltaic plus Storage

This is a two-part series. Part 1 is on new technologies for utility-scale PV, utility-scale storage, PV plus storage systems, and the evolution of their missions. Part 2 describes recent major U.S. PV and storage projects and some new twists on residential PV plus storage.

<https://www.energycentral.com/c/cp/photovoltaic-plus-storage-%E2%80%93-part-1-technology>

<https://www.energycentral.com/c/cp/photovoltaic-plus-storage-%E2%80%93-part-2-projects>

5.24. Audacious Ambitions

The first paper in this two part series explores contributions that the California Government makes in funding clean energy startups, and also the roles of clean energy funds in California. The second paper covers a couple of unique California-based organizations and look at their world-wide activities.

<https://www.energycentral.com/c/cp/audacious-ambitions-%E2%80%93-part-1-california>

<https://www.energycentral.com/c/cp/audacious-ambitions-%E2%80%93-part-2-world>

5.25. Advances in Battery Energy Storage

Several recent advancements in flow batteries have been made that lend hope to an expansion in their role of augmenting renewables. This paper explores these advancements.

<https://www.energycentral.com/c/cp/advances-battery-energy-storage>

5.26. Future Grid - Sun, Wind and BESS

When it comes to producing power, the best way to determine this is via a power purchase agreement (PPA). Briefly, this is a contract whereby the owner/developer of a generation project finances the project, pays any expenses, and delivers power to the user at a fixed cost (more or less) per kWh over a period ranging from 5 years to 25

years. We will look at these, and also look at projects that incorporate photovoltaic (PV) plus battery energy storage systems (BESS) and wind turbines plus BESS.

<https://www.energycentral.com/c/cp/future-grid-sun-wind-and-bess>

5.27. Large Battery Energy Storage Systems

This paper focused on large to very large battery energy storage systems (BESS) that are starting to transform our electric utility operations world-wide, and also creating increased energy economy and resilience among facilities. Then it looks at leading vendors that are deploying these systems and some major projects.

<https://www.energycentral.com/c/cp/large-battery-energy-storage-systems>

5.28. Wind and Water

Recently there has been much interest in building offshore wind farms. The U.S. finally commissioned our first offshore project, but the Europeans are well ahead of us. Read this paper for more details.

<https://www.energycentral.com/c/iu/wind-and-water>

5.29. Large Wind, Small Wind and Future Wind

Sources of renewable energy, mainly solar and wind, are moving together to quickly displace a large percentage of fossil energy. At a distance, one might think these two renewables are very similar: Both have no fuel-cost but are intermittent. However up-close these are very different resources.

<https://www.energycentral.com/c/pip/large-wind-small-wind-and-future-wind>

5.30. Photovoltaic Technologies – Past, Present and Future

Photovoltaic technologies' (PVs') decreasing cost and increasing reliability have made this the most attractive generation option for many utilities and facilities. PVs are the most scalable generation option, being cost-effective on many scales. This two-paper series explores the history, technologies, pricing and future of PVs.

<https://www.energycentral.com/c/pip/photovoltaic-technologies-%E2%80%93-past-present-and-future>

<https://www.energycentral.com/c/pip/photovoltaic-technologies-%E2%80%93-past-present-and-future-part-2>

5.31. The Reemergence of Microgrids – Part 2

This is a two part series. Part 1 was updated in April 2020 (see above). Part 2 focuses on how microgrids might be integrated in the electric utility culture.

<https://www.energycentral.com/c/pip/reemergence-microgrids-part-2>

5.32. Energy Storage Survey

This paper covers technologies used to store energy, with the focus on large battery energy storage systems.

<https://www.energycentral.com/c/iu/energy-storage-survey>

5.33. Alternatives for Alternative Energy

This paper is about alternative methods of electric generation that the reader might consider when wind, solar, geothermal and hydro all have shortcomings that make them unsuitable. Wind and solar are intermittent. If the application requires the ability to dispatch the generation, storage would need to be added to wind and solar to provide this capability. Wind and solar also require large amounts of minimally used land (or roof-surfaces in the case of solar). Geothermal and hydro have very unique site requirements, and thus we will assume that very few sites are suitable.

<https://www.energycentral.com/c/pip/alternatives-alternative-energy>

6. Utility Technologies

6.1. Grid Modernization – Preparing for the Future

Clearly the future is renewable power, and the grid needs to deal with renewable variability today. This short post will deal with this challenge, and a few others that grid managers are currently responding to. This response involves modernizing grid components and systems to push beyond traditional boundaries.

<https://energycentral.com/c/gr/grid-modernization-%E2%80%93-preparing-future>

6.2. Cyber-Security Basics – Rev b

This paper defines how cyber-security threats came into existence and the basic techniques to avoid intrusion and disruption from these threats.

<https://energycentral.com/c/iu/cyber-security-basics-rev-b>

6.3. Nukes – Part 3

This is my third part in this series: The original “Nukes” was posted in October of 2018. In that paper we reviewed the various generations of reactors, and reviewed the economics of the large reactors currently being constructed (Generation III) versus the economics for other generation technologies.

Nukes – Part 2 (Little Nukes) was posted in January, 2019. This specifically focused on small modular reactors (SMRs), and on the most promising for these designs for U.S. which is being produced by NuScale.

<https://energycentral.com/c/cp/nukes-%E2%80%93-part-3>

Recently in a periodic review of SMR technology, I discovered that at least one new player has decided to join the party. This post will review the new player and any additional potential SMR designs.

<https://energycentral.com/c/cp/nukes-%E2%80%93-part-3>

6.4. Initial Resilience

This three-part series looks at how various utility components impact resilience. In order to this we will look at each type of component, one at a time, along any factors that significantly impact resilience, economics or climate change.

The first paper covers "supporting structures" for overhead circuits, a.k.a. poles and towers, and current-carrying components. The latter includes conductors (cables and wires) but also devices that are slightly smarter (fuses) as well as those that actually include communicating and programmable components (reclosers and switches) and several other categories.

In Part 2 of this series we look at protective automation, which involve protective relays and systems, as well as some suggestions to reduce the overall use of these, primarily effective vegetation management.

In part 3 of this series we look at how some major changes in the requirements for electric utilities will impact their operations. Most of these changes resulted from new bills passed recently in my home state (California). In this post we will drill down and define some of the requirements for utilities and how they are likely to be implemented. However, first we will briefly review some of other challenges that California IOUs (and potentially other utilities). Must deal with in moving to a more resilient grid.

<https://www.energycentral.com/c/ec/initial-resilience-%E2%80%93-part-1>

<https://www.energycentral.com/c/pip/initial-resilience-%E2%80%93-part-2>

<https://www.energycentral.com/c/pip/initial-resilience-%E2%80%93-part-3>

6.5. Watts and Water

Electricity and water are invariably linked. Given enough inexpensive power, there will be no shortage of water.

This post is about three technologies. One is the current state-of-the art technology for desalination, one is a potentially more efficient technology for desalination, and a third is a technology for extracting water from the atmosphere.

<https://www.energycentral.com/c/ec/watts-and-water>

6.6. Zero-Emissions Combined Cycle and Beyond

This paper has a proposal that will keep combined cycle power plants running by converting them to (nearly) zero greenhouse gas (GHG) emission operation. Ultimately these can be converted to negative emissions technology to offset other GHG sources.

<https://www.energycentral.com/c/cp/zero-emissions-combined-cycle-and-beyond>

6.7. Flying Nuke on Saturnian Moon Titan

This paper is about an interesting project that NASA just selected for launch in 2026. This brief post describes this mission, and references an earlier post that describes the nuclear power generators used by NASA and potentially suitable for specialized use on Terra Firma.

<https://www.energycentral.com/c/ec/flying-nuke-saturnian-moon-titan>

6.8. One company aims to reinvent the nuclear reactor

This link is to an article that was in my latest issue of Science. This is on the NuScale Power Reactor. I posted a paper on this reactor (prior subsection), but the Science article covers different subject matter.

<https://www.sciencemag.org/news/2019/02/smaller-safer-cheaper-one-company-aims-reinvent-nuclear-reactor-and-save-warming-planet>

6.9. Nukes, Part 2: Little Nukes

NuScale's Small Modular Reactor Design now appears to be viable, and thus this paper on their technology and economics.

<https://www.energycentral.com/c/cp/nukes-part-2-little-nukes>

6.10. Squirrel up to No Good

This series is on outage management, and how it has evolved over the years to quickly restore power. The first paper is on history, hardware and system-level solutions, and a second paper in this series is on metrics and software.

<https://www.energycentral.com/c/pip/squirrel-no-good-%E2%80%93-part-1>

<https://www.energycentral.com/c/pip/squirrel-no-good-%E2%80%93-part-2>

6.11. Wide-Area Grid Security

What if all transmission and distribution lines (substations, etc.) were able to be observed a high percentage of the time? Then most of the time "incidents" could be observed in realtime. There might be a way to do this. Read the paper linked below.

<https://www.energycentral.com/c/rm/wide-area-grid-security>

6.12. Nukes

This paper explores past, present and potential future nuclear power technologies and the potential for nuclear power to play a major role in a future carbon-free U.S. electric utility infrastructure.

<https://www.energycentral.com/c/cp/nukes>

6.13. Advanced Metering Infrastructure (AMI)

In papers in this 4-part series we will explore the functions of the meter data management (MDM), the major advancements in commercial and industrial (C&I) meter technology, how advanced C&I metering led to AMI, how this market evolved and how it is evolving into the Internet of Things. The link below is to part 4 of this series, which contains links to the other three parts.

<https://www.energycentral.com/c/iu/ami-part-4-%E2%80%93-internet-things>

6.14. Supervisory Control and Data Acquisition (SCADA)

SCADA systems are still very important, and many potential readers that work for electric utilities and large facilities are likely to encounter them in the future, thus this six-

part series was posted. The link below is to part six of this series, which contains links to all of the other papers.

<https://www.energycentral.com/c/pip/scada-%E2%80%93-part-6-transmission-and-distribution-network-management>

6.15. Old and New Cycles

This paper is on combined cycle power plants, combustion turbine generators and steam turbine generators. The last two technologies these are frequently used in facilities. This paper also explores the history of these technologies.

<https://www.energycentral.com/c/pip/old-and-new-cycles>

7. Western Grid

7.1. PG&E – Final Agreement and Bankruptcy Resolution

This post is rather long, verses my normal 3,000-word limit. However, this describes PG&E going forward, and needs to be of one piece.

In part 2 of the post below on PG&E we reviewed the February 18 California PUC proposals for PG&E's reorganization. We will repeat these proposals, greatly shortened, with the final decision's acceptance or modification plus additional comments by the decision. The last section in this post deals with some final matters.

<https://energycentral.com/c/um/pge-%E2%80%93-final-agreement-and-bankruptcy-resolution>

7.2. PG&E – Components of an Agreement

This paper goes well over my usual 3,000 word limit, thus, I have broken it into two posts. The first post addresses the elements of the bankruptcy settlement, and supporting agreement (like the financing of this settlement and the agreement with the State of California), the current amended reorganization plan, and the evolution of the microgrids that PG&E will use to mitigate future Public Safety Power Shutoffs (PSPS).

The second post addresses the CPUC's Proposals for PG&E's reorganization. Even though the second post is longer than I prefer, it contains many details about what PG&E will probably look like going forward.

<https://energycentral.com/c/pip/pge-%E2%80%93-components-agreement-part-1>

<https://energycentral.com/c/pip/pge-%E2%80%93-components-agreement-part-2>

7.3. PG&E and Climate Changes

You might not think the title subjects of this post have much in common.

However, the two categories are closely related. February has been a really weird month with two interrelated events: A record-breaking high-wind event, and a record breaking dry spell. One would almost think that this was Mother Nature's way of reminding PG&E that they need to get their grid hardened and trees trimmed ASAP or they will have much bigger financial issues than they do now.

<https://energycentral.com/c/pip/pge-and-climate-changes>

7.4. PG&E – Near the Finish Line?

As I'm starting to write this paper (Feb 2), proposals and counter-proposals have been flying back and forth between PG&E and Governor Newsom. Late on Friday PG&E filed a new Plan of Reorganization. It appears that PG&E and the Governor are getting much closer to a resolution that will allow the former to emerge from bankruptcy (or not).

<https://energycentral.com/c/pip/pge-%E2%80%93-near-finish-line>

7.5. New / Old Major Municipal Utility

I've written several posts recently about the California wildfires in the last three years, and the attendant liability and bankruptcy of PG&E. But I almost missed a major result of the latter. This is a very complex story, but from the resolution of this bankruptcy at least one new major municipal utility will almost certainly emerge. Except they are not new, but over 100 years old.

<https://www.energycentral.com/c/pip/new-old-major-municipal-utility>

7.6. California Wildfires, Utilities and Grid Resilience

This is a two-part series on the subjects in the title. Although we have had many hundreds of wildfires this year, the most severe repercussions seem to have been avoided.

Part 1 is a review of the Public Safety Power Shutoffs (PSPS) as used by PG&E and other California IOUs. Also CAL FIRE and other fire-fighting departments and agencies are getting much better at recognizing and quickly fighting the wildfires that have the potential to become monsters and evacuating residents early in their likely path. California is rapidly pouring resources into this battle, and plans to do much more.

Part 2: Governor Newsom, realized that the state of California was dealing with a related series of hugely complex problems early this year as PG&E started talking about filing for Chapter 11 bankruptcy. The state assembled a strike force to create a report regarding the situation. This report was issued on April 12, and is summarized in this paper.

<https://www.energycentral.com/c/pip/california-wildfires-utilities-and-grid-resilience>

<https://www.energycentral.com/c/pip/california-wildfires-utilities-and-grid-resiliency-part-2>

7.7. Wildfire & 2019 Repercussions

There has been much work to improve the resiliency of areas affected by California wildfires and help some utilities that might have liability. The former includes Public Safety Power Shutoffs, and the latter includes a new fund that might mitigate utilities' wildfire liabilities.

And if you haven't heard about the PG&E Bankruptcy that primarily resulted from these wildfires, you're probably on the wrong website.

This post will update all of the above.

<https://www.energycentral.com/c/cp/wildfire-2019-repercussions>

7.8. PG&E – Reasonable Judgement

Being a large electric utility is tough. Climate change that turns your service area into a tender-box makes it tougher. However, when the utility in question is already on probation, it seems that they would be really cautious when it comes to events that might incinerate parts of their service area. Especially when they have a poor record when it comes to vegetation management.

This post reviews PG&E's current legal problems, and a few suggestions that might mitigate wildfires.

<https://energycentral.com/c/pip/pge-%E2%80%93-reasonable-judgement>

7.9. CAISO Part 6a – Expansion, Update

This paper is an update to the six-part California Independent System Operator (CAISO) series posted in the late summer through early fall of 2018 (see below). This specifically addresses the evolving the Energy Imbalance Market and Security Coordinator West functions that CAISO supports.

<https://www.energycentral.com/c/iu/caiso-part-6a-%E2%80%93-expansion-update>

7.10. California Resource Adequacy Procedures, Community Choice Aggregators and Direct Access

Substantial changes are well under way in California resource adequacy procedures that will impact how electricity is procured. This paper reviews the sources of these changes and how they are likely to play out.

<https://www.energycentral.com/c/pip/california-resource-adequacy-procedures-community-choice-aggregators-and-direct>

7.11. California Independent System Operator

This six-part series describes in detail the operation of the CAISO and its present and likely future direction as an operator of the western grid. This series includes a glossary of many specialized terms used by CAISO in their operations, as well as links to more comprehensive interactive glossaries. The link below is to part six of this series, which contains links to the other parts and the glossary.

<https://www.energycentral.com/c/pip/california-independent-system-operator-part-6-%E2%80%93-expansion>