Papers Directory, Third Quarter 2022 Update

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Contents

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 quarterly update is at the end of the third quarter (September) of 2022.

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(s) on the Energy Central Website. This is so that the title also appears in this document's table of contents, and can be quickly accessed as described below. Each section contains papers from the subject's title, 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 (TOC). Then the entries in that TOC 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 this PDF, you can click on the document title in the TOC, and you will be taken to the heading for the linked category, paper or series.

One other comment: note that, under each category (like section 2, "Climate Change Impacts & Mitigation" immediately below), the documents are listed in chronological order. Thus I posted the paper or series in section 2.1 most recently, the document/ series in section 2.2 before that, and so on. The last paper in section 2 ("Unintended Consequences") 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 a" (or Rev b or whatever).

2. Climate Change Impacts & Mitigation

2.1. Extreme Climate

In my writing on climate change, I frequently point out that the complexity of the Earth's climate greatly reduces our ability to understand the future effects that we will see from secondary, tertiary and higher-order effects of climate change. There are several things that we can do to clarify this cloudy future:

1. Continue to develop ever more powerful computer-simulations of our climate
2. Continue to support scientists' work to better understand future climate-related effects, and integrate this knowledge into the above simulations

This post covers both of these subjects, including: a better understanding we have of a secondary effect of climate change that I have written about previously, awards that the U.S. Department of Energy recently made to perform the work described in (2) above, and parts of the recently passed Inflation Reduction Act that incentivizes the Petroleum Industry to reduce its methane emissions. The last section reviews California's $54 billion in new spending on clean energy and drought resilience.

https://energycentral.com/c/cp/extreme-climate

2.2. They Just Keep on Coming

This summer it seems that every time I read a scientific or news publication or watch a program on television with a similar subject-matter, I am confronted by major effects of climate change. Going forward, these will increase in frequency and severity stressing our ability to adapt to them. They are also very complex and thus difficult to predict in advance. Most of these are secondary, tertiary or higher-order effects.

These include the following, which we have known about for some time:

- The sea-level is rising primarily due to a secondary effect and a tertiary effect of climate change. The secondary effect is the thermal expansion of sea water as it warms. The tertiary effect is the melting of glaciers and ice sheets (primarily the Antarctic and Greenland Ice Sheets) as they warm, providing run-off into the oceans thus further increasing the level of the oceans.

- Both heat and CO_2 enter the oceans and the latter acidifies them, causing major damage to coral, shellfish and possibly other aquatic life.

- The melting of the Greenland Ice Sheet has freshened the water in the North Atlantic, which has disrupted 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.

The latter has led to the slow-down or stalling of the Jet Stream in summer, leading to long-term heat waves throughout much of the World. Section 2 of this post will explore recent heat waves, and section 3 will describe other higher-order effects of climate change.

https://energycentral.com/c/ec/they-just-keep-coming

2.3. Oceanic Solutions – Coastal Sea-Level Mitigation

Sometimes you need to be ready to give something away to save it. The coasts of Earth's oceans are like that. Many of these, which are not preserved by governments, are prime development-land. But the only way we might preserve them is by moving these developments away from the coasts, give these back to Mother Nature, and let her grow forests and salt-water marshes on them. At the very least this will greatly slow their erosion, and, if we otherwise slow down climate change, they may even be able to reclaim some land that was previously under water.

I wrote the following about six months ago in the post described below.

Wet NET: Most of my readers know that NET stands for Negative Emissions Technology. The title NET are carbon dioxide negative emissions technologies that involve the oceans.

At the time I wrote the above post, unbeknownst to me, I missed a major chapter. This post will supply this. The subject is mangrove forests.

https://energycentral.com/c/rm/oceanic-solutions-%E2%80%93-coastal-sea-level-mitigation

2.4. New Networks Compendium

I started writing the “New NETWORKS” series almost two years ago. Thus, it didn’t surprise me recently when, that there were major developments in negative emissions technology (NET). The first was a subject I wrote about over a year ago:

XPRIZE officially launched the $100 Million XPRIZE Carbon Removal competition. In honor of the launch, XPRIZE founder Peter H. Diamandis sat down with Elon Musk, who is funding the competition through the Musk Foundation.

The above contest has now reached a major milestone which is covered in section 2. A summary of a report on Negative Emissions Technologies and Reliable Sequestration from the National Academies of Sciences, Engineering and Medicine is contained in Section 3.

https://energycentral.com/c/ec/new-networks-compendium

2.5. Reasonable Transition Part 2, International Liquidity

We (the U.S. The E.U. and many others) need natural gas currently, as we have not completed the transition to low, and very-low greenhouse gas generation. However modern cogeneration plants can participate in the transition, per Part 1 of this series (see section 22, Utility Generation, Non-Renewable).

Also, there is a better and much more immediate need to improve international liquidity for this commodity. Some countries are really bad actors, and some of those same countries rely on natural gas exports to keep their economy afloat.

Some of these same countries have become methane ultra-emitters.

https://energycentral.com/c/og/reasonable-transition-part-2-international-liquidity

2.6. Damn Satellite Part 3: Super-emitters and Ultra-emitters

The Permian super-emitters have now been located with better precision at the completion of a multi-year aerial survey, and additional surveys have been performed via multiple satellites.

The other news is that the Environmental Protection Agency (EPA) has started a process to define new methane emission rules for oil and gas producers.

Also, an international consortium has identified a new class of methane Ultra-emitters.

Part 3 reports on all of the above new information.

https://energycentral.com/c/cp/damn-satellite-part-3-super-emitters-and-ultra-emitters

2.7. Wet NET

“Have a Plan B, and maybe even a Plan C. Because unexpected changes are most difficult to handle when we don't have a backup.”

— Germany Kent, American Print and Broadcast Journalist

Having looked at the subject of climate change quite a bit, there are many ways we can fix this problem, IF we work on it diligently. However humans have a habit of doing really

dumb things, like not fixing a big problem we created, one that has already screwed up our climate big time, and is likely to create even worse problems in the future.

And thus my argument for all of the Plan Bs and Plan Cs we can find.

Most of my readers know that NET stands for Negative Emissions Technology. The title NET are carbon dioxide negative emissions technologies that involve the oceans.

https://energycentral.com/c/rm/wet-net

2.8. Fire & Storms Part 5: Steam and Smoke

Mother Nature must be really upset with us. As the effects of climate change multiply, she keeps delivering surprises, and not of the nice kind. The one piece of positive news for me is that it provides increased content for my posts.

Increased atmospheric humidity increases rainfall from all storms. It also has bad health effects in the world's hottest areas. Smoke from wildfires are also hazardous to our health without good air filtration. Now a new negative effect of smoke above the tropopause is looming. This post is about these subjects.

https://energycentral.com/c/ec/fire-storms-part-5-steam-and-smoke

2.9. Good News & Bad News for Climate Change

The recent news is a mixture of good and bad news on the climate frontlines. Sections 2 and 3 paint respectively, the good news resulting from the Pandemic lock downs, and the bad news coming out of those. Section 4 is a brief recap of COP26 (26th meeting of the Conference of the Parties) with a link to the full text of the Glasgow Climate Pact. Section 5 is a description of a program that was announced at COP26 by the Asian Development Bank that will hasten the replacement coal electric generation with renewables in Asia.

https://energycentral.com/c/cp/good-news-bad-news-climate-change

2.10. NETMeth – Not

Hopefully this will be a short post. I am mainly writing it to address a proposal that I do not think is a good idea. This is mainly because I read about it in a periodical that I greatly respect, and I really do not wish to hear others saying that it sounds like a great proposal.

The proposal was in an article in the Nov 5 issue of Science, and it was to use negative emissions technology to capture methane. The good news is that this article pointed out several problems with this proposal.

https://energycentral.com/c/ec/netmeth-%E2%80%93-not

2.11. New NETWORKS, Part 5: Oxi-Fuel Combustion

NETWORK is my term for "Negative Emissions Technologies." These are the most valuable of all renewables. They not only do not add greenhouse gas (GHG) to the atmosphere, but they have the potential of removing GHG from the atmosphere while in some cases providing other benefits.

The NETWORK described by this post is (sort of) BECCS, but the “CC” really superfluous because no carbon capture is required. The output of the process is pure CO2, water vapor and heat that can be used to produce electricity or provide process heat.

https://energycentral.com/c/cp/new-networks-part-5-oxi-fuel-combustion

2.12. Damn Satellite, Part 2 – Damn Airplane & CH4

“In California, with science under attack... the climate threat still keeps growing,” Brown told delegates at Moscone Convention Center, near the city’s financial district in 2018. “With science still under attack, we’re going to launch our own satellite, our own damn satellite, to figure out where the pollution is.”

Now California and other like-minded organizations have put together a consortium to launch our “damn satellite,” and this includes funding. The program is called Carbon Mapper.

However these satellites will only identify large sources at large-scales, so I decided to drill down to scales where significant sources of one problematic greenhouse gas (GHG), methane (CH4) can be identified.

https://energycentral.com/c/ec/damn-satellite-part-2-%E2%80%93-damn-airplane-ch4

2.13. Fires and Storms Part 4, 2021 California & Alaska

The 2021 Wildfire Season did not appear to be as severe as the prior two seasons, but the way it ended was severe in a different way – with a historically-strong atmospheric river rainstorm. At that point it wildfires were already starting to wind-down.

This post will review the 2021 season in reverse chronological order, starting with the major rain event that finished it off, and ending with the report of season itself. Then we will visit a state a bit further north that has been experiencing some major climate change driven wildfires of their own.

https://energycentral.com/c/ec/fires-and-storms-part-4-2021-california-alaska

2.14. New NETWORKS, Part 4 – Peridotite & Soil

Mantle Rocks are minerals that normally only exist in Earth’s Mantle, a layer that is normally starts 4 miles below the surface, and extends to almost 2,000 miles below the surface. Thus it makes up 67% of the mass of Earth. The main image for this post shows the Earth’s layers.

Rocks in this layer normally stay in this layer, but in a few locations they rise to the surface. That is the case with peridotite.

Mantle peridotite reacts with H_2O and CO_2 near the Earth’s surface. Note the CO_2.

Thus even though there are huge deposits of peridotite above ground, it would need to be mined and pulverized to completely store CO_2 in it. Not very efficient. But there is another way that might very efficient, and is capable of storing huge amounts of CO_2.

If Mantle Rocks might be thought of as an exotic material, soil is definitely not. It’s everywhere: in our yards, forests, deserts, plains mountains, everywhere. We will talk

about a particular type of soil, that which is used for agriculture (it too is pretty common). This soil probably has the capability to store more CO_2 than peridotite, if we modify our farming practices to do so.

These two methods of Negative Emissions Technology (NET) will be reviewed in this post.

https://energycentral.com/c/ec/new-networks-part-4-%E2%80%93-peridotite-soil

2.15. Polar Vortex – Why Texas Froze

The most frightening thing about Climate Change, is that we do not fully understand it. We do know that:

- The world will, on average, become warmer
- Sea-levels will rise
- The world oceans will become more acidic
- Ocean currents will change
- And the climate will change in unpredictable ways

The last bullet is one of the unknown variables that will keep throwing novel challenges at us, and I've written on it before (and will again).

This paper is about a fall-to-winter effect, and it caused the ERCOT power grid to laterally freeze in February of this year. This effect is known as the Polar Vortex. This paper is about this effect of climate change, how and why it nuked the Texas grid, and why it should have been anticipated (hint: it happened before).

https://energycentral.com/c/gr/polar-votex-%E2%80%93-why-texas-froze

2.16. Good People and Bad People

Yes there are good people, and bad people; heroes and villains. However, some people are not real good at identifying or differentiating these. This is specifically true when we look at decisions industrial and political leaders made several decades ago. All we can expect from these leaders then or now is that they made / make reasonable decisions based on the best information available at the time of that decision.

Since this is "Energy Central", we will specifically look at decisions made by leaders in the energy sector and political decisions that effected this sector in the past.

We will also focus on one issue that has heavily influenced our way forward and will continue to do so, both in this sector and most other sectors for at least the next century: climate change.

https://energycentral.com/c/ec/good-people-and-bad-people

2.17. Emerging Technologies to Mitigate Greenhouse Gases

I have said many times that predicting the future is risky, and so I try to avoid it. However, when it comes to mitigating climate change, there are some emerging plans that might rewrite the future road map for this quest and plug future holes.

Recently I posted California's roadmap for decarbonizing our electric grid. This post will examine the other primary sources of greenhouse gas (GHG) in California, how my state intends to greatly reduce those, offset any residual GHG and an emerging innovation that may help with both efforts.

https://energycentral.com/c/ec/emerging-technologies-mitigate-greenhouse-gases

2.18. Damn Satellite

It was just three years ago. Jerry Brown was in his second Governorship, and was in a running battle with the then president (I forget his name).

California Gov. Jerry Brown started the week by signing a pair of actions to get his state to use nothing but electric power drawn from green sources like wind and solar by 2045. He ended the week Friday with a surprise: The state would launch its "own damn satellite" to track down greenhouse gas emitters who fuel global warming.

"In California, with science under attack, in fact we're under attack by a lot of people, including Donald Trump. But the climate threat still keeps growing," Brown told delegates at Moscone Convention Center, near the city's financial district. "With science still under attack, we're going to launch our own satellite, our own damn satellite, to figure out where the pollution is."

Now California and other like-minded organizations have put together a consortium to launch our "damn satellite," and this includes funding. The program is called Carbon Mapper.

This post will provide a summary of this program.

https://energycentral.com/c/ec/damn-satellite

2.19. Reversing Climate Change – Future Foundation

As we slowly emerge from the pandemic, one of the positive things we have demonstrated is how far humanity will go to preserve human life. We could have allowed the virus to run its course, and several tens of millions human deaths and a decade or two later we would have reached herd immunity. Instead we used our bio-tech tools and developed a series of vaccines in record time. In the U.S. there have still been almost 600,000 deaths, but some areas are approaching herd immunity. And thus we have started turning to other priorities. As a nation there are plenty of jobs that need doing. To mention a few: economic recovery, infrastructure rebuilding, full-employment, racial and sexual fairness and housing issues.

However there is one issue that will require several decades to implement solutions and several centuries to live through the trauma that is already baked-in: climate change.

Thus this post is about how we should proceed with dealing with all of our priorities: That is, start with each of the above listed "jobs" (and others), but understand that mitigating climate change must form the foundation of all solutions. We must seek the intersection between each program that is intended to deal with the listed need and the mitigation of climate change.

https://energycentral.com/c/ec/reversing-climate-change-%E2%80%93-future-foundation

2.20. XPRIZE Carbon Removal

First I must say I have no interest in competing in the title contest. I'm perfectly happy in my present occupation. However, I do feel like this is a very worthy endeavor.

XPRIZE officially launched the $100 Million XPRIZE Carbon Removal competition. In honor of the launch, XPRIZE founder Peter H. Diamandis sat down with Elon Musk, who is funding the competition through the Musk Foundation.

I would ask my readers, and fellow Energy Central contributors to forward this post to anyone that they believe might be interested in this competition.

Also, I have written frequently on this subject, and will reference my most recent and important posts in this brief paper.

https://energycentral.com/c/ec/xprize-carbon-removal

2.21. Recent Climate Change Effects

It hasn't been that long since I posted More than 2°C of Committed Warming. However, recently I saw more direct evidence that humanity is failing to mitigate climate change, and this post will present this.

https://energycentral.com/c/ec/recent-climate-change-effects

2.22. More than 2°C of Committed Warming

According to the report just published by Nanjing University, Lawrence Livermore National Laboratory (LLNL) and Texas A&M University, there is already enough greenhouse gas in the atmosphere to have driven radiative forcing to (today's) level, and that is sufficient to ultimately warm our planet's average surface temperature to a "most likely value of +2.3 degrees C (4.1 degrees F) above pre-industrial levels.

https://energycentral.com/c/ec/more-2%C2%B0c-committed-warming

2.23. New NETWORKS, Part 3: Two Solutions

California has two challenges. One is the yearly batch of wildfires that keep getting worse every year. In 2020 the acreage burned was more than double any previous year, and other metrics were similarly dire.

The other challenge is that we have the most ambitious goals for mitigating climate change in the U.S.

One might think that the challenge from wildfires would be detrimental to our climate change goals, and indeed in most ways it is, but there is at least one synergy between these as described in the following paper.

https://energycentral.com/c/cp/new-networks-part-3-two-solutions

2.24. New NETWORKS, Part 2: Mineralization for GHG Capture

This paper covers several potential methods using mineral incorporation (a.k.a. mineralization) to store and/or permanently sequester carbon dioxide (CO2), the main greenhouse gas (GHG). Section 2 is about a simple process that will combine two hazardous industrial wastes, alkaline mineral waste and carbon dioxide (CO2). This

process creates a stable mineral that can be safely buried or perhaps used in long-lived structures. Others that are described in section 3 are similar methods already in use.

https://energycentral.com/c/ec/new-networks-part-2-mineralization-ghg-capture

2.25. New NETWORKS, Part 1: BECCS

This post covers sources of biomass that have the potential contribute to carbon dioxide sequestration while fulfilling other human needs.

https://energycentral.com/c/ec/new-networks-part-1-beccs

2.26. Fires and Storms – Part 1, Rev c

This is a major rewrite of this paper. I updated this paper a little over a year ago, however the conditions leading to wildfires in the Western U.S. have changed radically this year, and a major rewrite is needed. Although some of the prior version will be reused, we will start by describing how conditions have changed.

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

2.27. A journey of a thousand miles…

This paper is about low carbon fuels, emergency generation, green / blue hydrogen and development vs. deployment.

https://energycentral.com/c/ec/journey-thousand-miles%E2%80%A6

2.28. Tough Love – Part 1

This is a two-post paper in Part 1 we will focus on top three greenhouse gas emitters: transportation, electricity production, and industry. In the second post (about a week after the first) we will look at possible roles of government and negative emissions technology. Part 2 is in section 4.10.

We already have the technologies and most of the products we will need to substantially roll back our greenhouse gas (GHG) emissions, although we should continue the research and development to improve these. The competitive forces and for-profit firms in our markets are capable of funding most of this R&D. Many of the low-GHG products are more competitive in a free economy than the older high-GHG products. The U.S. and state governments will have roles, but possibly not what you would expect.

https://energycentral.com/c/ec/tough-love-%E2%80%93-part-1

2.29. 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

2.30. Geologic Greenhouse Gas Sequestration Projects

Earlier I posted Verification of Geologic Greenhouse Gas Sequestration (see section 4.14). 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

2.31. 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

2.32. 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.

https://energycentral.com/c/ec/economics-and-climate-change-refugees

2.33. 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). This post also explores negative emissions technology using woody biomass.

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

2.34. 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

2.35. 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

2.36. Climate and Energy Series, Parts 2 & 3, 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 1 is listed under Climate Science. Parts 2 and 3 are listed under Climate Change Impacts & Mitigation.

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-2-impacts-infrastructure-rev-b

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

2.37. 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

2.38. 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

2.39. 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 PICSI (prior paper, below).

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

3. Climate Science

3.1. Stuck

I've known for some time that, in the U.S., in summer, weather patterns can stall in one place for some time, because I read an article in Scientific American about it in 2019, and consequently wrote the paper on the climate change effect that caused this.

I occasionally use and reference writings by Dr. James Hansen. If you know anything about climate science, you know who Dr. Hansen is. Once or twice a month his team sends me a brief paper. The words and images below are about this same effect and others, and are from his most recent paper (7/13/2021). There are also words on the same effect and others from other sources.

https://energycentral.com/c/ec/stuck

3.2. Coastal Storms

This post reviews increases in hurricane and tropical storm (a.k.a. tropical cyclones) landfalls in and near the U.S. A recent article in Science contains an analysis of data for these storms' behavior from the last 36 years. This analysis determined that the behavior of these storms has changed in a way that made them more likely to increase damage in many coastal areas, including the U.S., and these changes are likely to continue into the future.

Occupied coastal areas more frequently impacted by these storms, as a minimum, will need to harden their electric distribution systems and other infrastructure. Worst case: occupants and infrastructure may need to retreat from the coasts.

https://energycentral.com/c/ec/coastal-storms

3.3. Climate and Energy Part 1: The Future, Rev c

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, and includes a second (minor) update in January 2021. Part 1 is listed under Climate Science. Parts 2 and 3 are listed under Climate Change Impacts & Mitigation.

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://energycentral.com/c/ec/climate-and-energy-part-1-future-rev-c

3.4. Accelerating Sea Level Rise

This post is about improved techniques for measuring the average sea-level, the accelerating rise these are showing, and the probable main driver of the speed-up.

https://energycentral.com/c/ec/accelerating-sea-level-rise

3.5. 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

3.6. 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

3.7. 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

3.8. 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

3.9. 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

3.10. 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

4. Climate Change Politics & Regulations

4.1. Climate and Trade

I have written at least two earlier posts on the title subject. These posts had some reasonable ideas, but what I didn't have was the skill (nor credibility) to have anyone to take them seriously.

Recently I came across a really good article in Science, by a large group of highly credible professionals. Excerpts from this article will form a large part of this post. Note that the primary source is written by EU and North American authors and relies upon early EU experience with climate / trade adjustment mechanisms. The EU seems to currently be taking the lead in this area.

https://energycentral.com/c/ec/climate-and-trade

4.2. DC Moves

I frequently post papers on moves that California is making to mitigate climate change. However if California is the only government doing this, mankind will lose this war. I am happy to report on some new efforts that the U.S. Federal Government is making to reduce the amount of greenhouse gas (GHG) our economy is emitting. This paper will report of these.

The "Inflation Reduction Act of 2022" was passed by both houses of the U.S. Congress recently. It is only waiting for a final signature by President Biden this week as I finalize this post. A large percentage of the spending mandated by the bill is focused on incentivizing individuals and corporations to "do the right thing" relative to the climate.

I'm sure that many of my readers have heard in the news that the Federal Supreme Court struck down some elements of the Clean Power Plan, the Obama Era regulations intended to moderate the amount of GHG power plants are emitting. When I researched this ruling, I found that the elements that were struck down were very specific to the

methodology used and will just require a different path. Possible paths will be reviewed in this post, including one facilitated by the “Inflation Reduction Act of 2022.”

https://energycentral.com/c/cp/dc-moves

4.3. California Adjusts

The past is mostly known, but the future is generally unpredictable. The latter is true even under the best of circumstances, but our path recently has become increasingly unstable. This is primarily due to alterations in our environment caused by human-actions.

California is aggressively attempting to mitigate one of the alterations: climate change. Because our state’s goals are very audacious, any obstacles that appear in our path require us to adjust. Although we have met all major climate-related goals to date, as challenges appear, wise project/program managers will develop contingency plans, which is exactly what my state is doing. This paper will lay out the obstacles we have encountered in the last few years, and a few contingency plans that we have begun to define.

https://energycentral.com/c/cp/california-adjusts

4.4. Climate Here and There: Part 2, U.S. Perspective

This paper extends the goals of Part 1’s (and California’s) SB 100 to our entire country and explains how this can really happen via a new powerful coalition. It also delves into the methods behind our first major goal for the U.S. (50% greenhouse gas reductions by 2030). The above content is from two highly-respected sources.

https://energycentral.com/c/cp/climate-here-and-there-part-2-us-perspective

4.5. External Note: RE100

Note that “PV and BESS, Early 2022” has a large subsection (2.2) on the *RE100 global corporate renewable energy initiative bringing together hundreds of large and ambitious businesses committed to 100% renewable electricity.* This includes *Selected U.S. Companys’ Reports.* This is in section 18, “Solar and Solar + Storage.”

4.6. Climate, Here and There, Pt 1, California SB 100 Progress

It is very important to most Californians (including your author) that we meet our environmental progress goals. I believe the reasons that we typically exceed our goals is that we monitor them closely, and a large majority of stakeholders are heavily involved.

This paper is a summary of a report on our progress meeting the goals of the 100 Percent Clean Energy Act of 2018. This is a landmark policy that establishes a target for renewable and zero-carbon resources to supply 100 percent of retail sales and electricity procured to serve all state agencies by 2045, and also increases the state’s Renewables Portfolio Standard (RPS) to 60 percent of retail sales by December 31, 2030.

https://energycentral.com/c/cp/climate-here-and-there-pt-1-california-sb-100-progress

4.7. A SORE Subject

We all have our pet peeves. One of mine are anything that is loud. This includes:

Autos that make too much noise, either through:

- Loud exhaust
- Loud audio equipment (generally accompanied by fully open windows)
- Other vehicles that make too much noise
- Construction that makes too much noise
- SORE that make too much noise

You are probably asking what are SORE? They are: “small off-road engines.” The California Legislature passed a bill that would ban them in the next few years, and Governor Newsome just signed this bill.

4.8. Honest Accounting

I’m sort of a stickler when it comes to how we measure the greenhouse gas (GHG) emissions from everything. In the process of writing another post, I was happy to find there are others so inclined.

The Greenhouse Gas Protocol Initiative is a multi-stakeholder partnership of businesses, non-governmental organizations (NGOs), governments, and others convened by the World Resources Institute (WRI), a U.S.-based environmental NGO, and the World Business Council for Sustainable Development (WBCSD), a Geneva-based coalition of 170 international companies. Launched in 1998, the Initiative’s mission is to develop internationally accepted greenhouse gas (GHG) accounting and reporting standards for business and to promote their broad adoption.

This brief post will present some basic information and concepts for the above initiative.

https://energycentral.com/c/cp/honest-accounting

4.9. Linking Trade and Sustainable Practices

Two days ago I posted “Damn Satellite.” California and other like-minded organizations have put together a consortium to launch our “damn satellite,” and this includes funding. The program is called Carbon Mapper.

It occurred to me as I was final proofing the above described paper, that Carbon Mapper enables a suggestion that I made in a post almost exactly two years ago. I am repeating that suggestion in this post.

https://energycentral.com/c/ec/linking-trade-and-sustainable-practices

4.10. Tough Love – Part 2

In this post we will look at possible roles of government, negative emissions technology, and a brief review of an excellent book on climate change politics (Part 1 is in section 2.28).

https://energycentral.com/c/ec/tough-love-%E2%80%93-part-2

4.11. 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

4.12. 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

4.13. 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

4.14. 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

4.15. 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

4.16. 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

5. Large Industries

5.1. I Like Smoke & Lightning, Heavy Metal Thunder, Part 3

This post is the third in the series. This series is about the metals subsector, and more specifically this post, is about the Iron and Steel Mills and Ferroalloy Manufacturing Industry Group.

One reason that I am writing this is that, in an earlier post I said: “I believe that hydrogen will have a strong role to play in our path to a greenhouse-gas (GHG) free future.”

The day after I finalized the above wording I was reading an issue of Time, and came across a pilot plant that was recently completed in the EU that made iron without greenhouse gases. I will describe the plant in this post, but guess what it used to reduce the iron ore to iron. Yep, hydrogen.

https://energycentral.com/c/ec/i-smoke-and-lightning-heavy-metal-thunder-part-3

5.2. I Like Smoke & Lightning, Heavy Metal Thunder, Part 2

This paper is the second in a series about the metals industrial subsector, how these industries use energy and how they are evolving. There are several pieces of new news regarding the iron/steel and aluminum sectors in this industry. These will be covered in this part.

https://energycentral.com/c/ec/i-smoke-lightning-heavy-metal-thunder-part-2

5.3. 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

5.4. 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

5.5. 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

5.6. 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

5.7. 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

5.8. 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

5.9. 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

5.10. 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

5.11. 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

6. Large Facilities

6.1. 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

7. Aerospace Electric Vehicles

7.1. A Circular Jet Fuel

This paper will explore three interrelated issues. The first is the circular economy model. The second issue is greenhouse gas emissions, more specifically carbon dioxide (CO_2) emissions. The third and main issue is sustainable aviation fuel.

https://energycentral.com/c/ec/circular-jet-fuel

7.2. Air Taxis, Starting to Takeoff?

A bit over three years ago, I wrote a post on flying EVs. Although there are some flying EVs (as there were then), these have hardly become mainstream, but the title version of

these appear to (very slowly) taking off, and the amount of funds being pumped into them by major firms are taking off, big-time.

This post will review how air taxis from the earlier post have developed and review the current crop of air taxis most likely to quickly (and perhaps inexpensively) whisk you over the traffic in the next few years.

https://energycentral.com/c/ec/air-taxis-starting-takeoff

7.3. Baby Steps Move us forward when Walking on Air

One of the toughest challenges in moving to GHG-free mobility will be long-haul aviation. Initially we may need to be satisfied with "lower GHG", and offset the remaining GHG.

This post will be on a program that GE Aviation and Safran are creating to produce more sustainable aviation. It should be noted that these companies and a consortium they created many years ago are industry leaders in large jet transport powerplants (read: aviation combustion turbo-fans).

https://energycentral.com/c/ec/baby-steps-move-us-forward-when-walking-air

7.4. See "EV Application Shakeout" Part 2 under Section 19, Storage for BESS & Mobility

7.5. 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

8. Marine Electric Vehicles

8.1. Oceanic Solutions – Ships and Shipping

Much of the world's goods travel by container ships, the primary subject of this paper. A current challenge is modifying these vessels such that they operate sustainably. This paper will review two potential solutions: a short-term solution, and a limited solution.

https://energycentral.com/c/ec/oceanic-solutions-%E2%80%93-ships-and-shipping

8.2. Low-Carbon Ships

This will be a nautical paper of a different kind. Whereas my prior nautical post focused on electrically powered boats and ships that had already been built or were soon to be completed, this post will focus solely on the power source of ships, starting with the present, and defining possible future power plants and fuels that will let ships migrate to very low greenhouse gas (GHG) operation.

https://energycentral.com/c/ec/low-carbon-ships

8.3. 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

9. Mass Transit & Track Vehicles

9.1. California Rail Electrification - 2022 Update

I live in a state where we frequently walk alone, and this includes our current High-Speed Rail (HSR) project. However we still continue to make progress on the initial 171-mile segment through our Central Valley. Also making progress are the Northern California connector projects that will initially connect HSR into BART, ACE and the other commuter rail systems in the San Francisco Bay Area.

https://energycentral.com/c/ec/california-rail-electrification-2022-update

9.2. Hydrail

In July of last year I posted an update on California's various rail projects, including our High-Speed Rail (HSR, under construction, first segment is planned to be operational before 2030), and the Northern California and Southern California commuter rail systems that are planned to connect to the HSR.

The one word title of this post is an abbreviation for Hydrogen Rail, and I found much information about this subject for this post.

https://energycentral.com/c/ec/hydrail

9.3. California Rail Electrification - 2021 Update

This paper will use portions of a similar paper I posted in 2019, but contain enough new information to justify posting as a new comprehensive report. We (California) continue to move forward at a slow, steady pace. As in many things, we do not do this because we choose to, but because we must.

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 exclusively by auto or airlines. Although there are efforts to reduce the greenhouse gas from both of these transports, a viable rail system (powered by 100% renewable energy) between these two areas will contribute mightily to this effort.

https://energycentral.com/c/ec/california-rail-electrification-2021-update

9.4. SAV Some Time

This paper focuses several recent electric transit developments: (1) pandemic effects on public transit, (2) a potential end-of-line solution that is running trials in my area, (3) other

similar systems that are running trials throughout the U.S., plus (4) another innovative system that is being used for a short bridge routes. As we emerge from the pandemic these developments will be important.

https://energycentral.com/c/ec/sav-some-time

9.5. 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

10. Mobility Technology, Regulations & Specifications

10.1. 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

11. Road Vehicles

11.1. EVs Early Fall 2022

There is a huge amount of new information coming out on the title-vehicles. Thus, I felt it was best to start and schedule this post before this trove requires a multivolume post.

This paper will cover some additional clarifications to the Inflation Reduction Act tax credits for purchasing EVs, new battery and EV manufacturers building new battery plants in the U.S., some new information on "heavy" EV Manufacturers, puncturing a bogus argument about how charging EVs will impact the grid, the cost of charging various EVs and how do we can reduce that cost. The section on Future EVs focuses on Vans. The final section is on how California codified its future requirement to only sell light EVs after 2035 (vs. light vehicles mainly powered by gasoline or diesel engines).

https://energycentral.com/c/ec/evs-early-fall-2022

11.2. EV Late Summer 2022

This post is a mixed bag, consisting of new information on various EV manufacturers covered previously, starting and ending with a few “heavies,” information on federal government actions driving EV volume, new information on EV storage and chargers, a bit of new information on Tesla, and a raft of new reports on new and future EVs. Regarding the latter, I’m trying to stay with mid-priced personal EVs, as I have in other recent EV posts (first section below aside).

https://energycentral.com/c/ec/ev-late-summer-2022

11.3. Get your motor runnin'

This post is about axial-flux motor with a PCB stator. This design has been used in a number of machine designs, and will probably be critical in all types of electric vehicles (EVs) going forward, especially smaller lightweight EVs.

https://energycentral.com/c/ec/get-your-motor-runnin

11.4. EVs Mid-Summer, 2022

This has been a challenging but good year for road-going electric vehicles (EVs) so far as I start to write this paper. These EVs are definitely continuing to increase their volume and diversity.

In this post I will describe the ramping of EV production and diversity and look to the future: what 2023 (and later) should bring us.

https://energycentral.com/c/ec/evs-mid-summer-2022

11.5. EVs - Early Summer, 2022

This post will continue to explore my ongoing theme, and mainly focus of the low end of the EV Market, including exploring how we might get to $25K EV. Section 3 will look at two mid-range EV crossovers that are emerging from a familiar partnership. The last sections of this post will explore fleet electrification by a major utility and others.

https://energycentral.com/c/ec/evs-early-summer-2022

11.6. EVs, Late Spring, 2022

I started collecting information for this post shortly after I completed my last post on this Subject in March. However the one thing that I didn’t have is a main theme. In mid-April I found one, or actually decided to continue with one that I started at the beginning of 2022.

My theme is the continued staking-out submarkets in the U.S. Electric Vehicle (EV) Market. This is a complex market that includes both the final assemblers of EVs, EV-component manufacturers, and charging infrastructure developers.

https://energycentral.com/c/ec/evs-late-spring-2022

11.7. Electric Vehicles, Spring 2022

I started this document in early March, but then I ripped out part of it and posted it on March 10, and this is the remainder. This post will cover a range of subjects related to both electric cars, heavier vehicles and their components.

https://energycentral.com/c/ec/electric-vehicles-spring-2022

11.8. Electric Trucks and Buses in California

This paper is much longer that I like to post, but I thought it better to leave it together rather than splitting it. It is not just for my normal reader, but also for stakeholders of private and public organization that are involved in the title subject. Mostly in California, but also outside of our state. For more details, read on.

This post will take a deep dive into California requirements and incentives for medium and heavy electric trucks, buses and related technologies, and look at why California is doing this. This paper will also dive into truck and bus manufacturers and their products. And finally, we will review U.S. federal incentives for electric trucks and buses.

https://energycentral.com/c/ec/electric-trucks-and-buses-california

11.9. Electric Trucks & Buses, Early 2022

This post covers the latest truck, bus and other news from Ford, GM, Daimler, Tesla, Rivian, The U.S. Government and the Santa Clara Valley Transportation Authority (VTA). The latter is installing a solar-powered microgrid to power its fleet of electric buses.

https://energycentral.com/c/ec/electric-trucks-buses-early-2022

11.10. Tesla Early 2022

Although the next few months should be interesting for the title manufacturer, in the first month of the New Year there will probably be little to report, so this should be a short post.

https://energycentral.com/c/ec/tesla-early-2022

11.11. Clean Cars and Trucks

The transportation sector is responsible for 28% of greenhouse gas (GHG) emissions in the United States and has recently overtaken the electric power sector as the largest source of GHG emissions in the country. Because they generate no tailpipe emissions, electric vehicles (EVs) can play a critical role in achieving significant GHG emissions reductions, meeting aggressive climate goals and reducing localized air pollution. If charged with clean electricity, EVs can be almost entirely zero emission. Existing literature demonstrates that electrification can lead to reductions in light-duty GHG emissions of 36 to 50% by 2050. For heavy-duty vehicles, this projected reduction can range from 22 to 43% by 2050.

The above text comes from the report, “The State Transportation Electrification Scorecard” from The American Council for an Energy-Efficient Economy (ACEEE). This report ranks states’ efforts—identifying those that have taken comprehensive steps to

reduce barriers and others that are just starting. Every state can step up to enable equitable, electrified transportation for all.

This post is largely based on the results and recommendations of this report, and some related information.

https://energycentral.com/c/ec/clean-cars-and-trucks

11.12. V2G

The above title stands for Vehicle-to-Grid, and applies to Electric Vehicles (EVs) that are capable of using their batteries to support the grid, similar to battery energy storage systems (BESS). I have been focused on medium-to-large EVs (M/L EVs) lately, so a recent press release signaling a major commitment to V2G by these variants really got my attention and resulted in this paper.

This post will review the justification and recent developments in V2G.

https://energycentral.com/c/em/v2g

11.13. Bottom-up, Tesla's Component Edge

The best do sweat the small stuff. They get the seemingly insignificant details right. They have the discipline to shine at the baby things which they get gives birth to spectacular giant things." – Robin S. Sharma, Writer

In other words, they sweat the components.

In observing Tesla for the better part of a decade, I know they do this, because of their results, because they constantly tinker with everything, and they design their products so they can do this (consider their fully connected EVs).

This post will look at components that Tesla is working on currently, and suggest how these might impact their future products. It will also look at third quarter 2021 results and other Tesla news.

https://energycentral.com/c/ec/bottom-tesla%E2%80%99s-component-edge

11.14. Wireless Advanced Vehicle Electrification (WAVE)

The title of this paper is the name of an en-route wireless electric vehicle charging technology, and a company that makes it. It is really designed for medium to heavy electric vehicles, mostly buses, but also some trucks.

This paper is a review of WAVE Technology, where it is applicable, and how it works.

https://energycentral.com/c/ec/wireless-advanced-vehicle-electrification-wave

11.15. 2021 Electric Truck & Bus Update, Part 3, Technology

This is Part 3 and focuses on the technology that will probably be used for medium and heavy on-road vehicles in the immediate future. Although I have some thoughts on this, I do not have the credibility to guess what technology will dominate.

The reason this post exists is that a team of highly credible analysts developed a suite of models that projected different future scenarios using different technologies for medium

and heavy transportation energy usage, and thoroughly analyzed each of these. The result is the “Comparison of Medium- and Heavy-Duty Technologies in California,” which was posted on the California Energy Commission’s Transportation Docket Log.

This post is primarily drawn from the described document (linked in the post).

https://energycentral.com/c/ec/2021-electric-truck-bus-update-part-3-technology

11.16. 2021 Electric Truck & Bus Update, Part 2: Buses

This is Part 2 and focuses on buses. Battery-electric buses are being deployed more rapidly than medium and heavy battery-electric trucks, mainly because of federal and state incentives.

The other major consideration, especially for electric utility professionals, is that battery-electric buses take a huge amount of energy to charge them. Also many of these vehicles will perform depot recharging en masse. This will be mostly overnight in transit depots. These facilities are currently not prepared for the massive load increase as their vehicles transition to electric operation.

Section 2 of this report will describe all major manufacturers of buses, their offerings and any new developments by those firms. Section 3 will describe how fleet managers can evaluate and remedy the overload risk described above.

https://energycentral.com/c/ec/2021-electric-truck-bus-update-part-2-buses

11.17. 2021 Electric Truck & Bus Update, Part 1: Trucks

The subjects of this post are starting to emerge, and it should be interesting to see these markets develop. A major consideration, especially for electric utility professionals, is that the vehicle types covered in this post take a huge amount of energy to recharge them. Also many of these vehicles will perform recharging en masse. This will be at logistic/distribution centers for trucks. These facilities are currently not prepared for the massive load increase as their vehicles transition to electric operation. Since logistic centers tend cluster around major highways and urban perimeters, the electric transmission and distribution networks in these areas will also need upgrading.

This post is on the progress to date of the medium-to-heavy truck and markets. We will also look at one area that has become a major logistic / distribution / fulfillment hub – San Joaquin County California.

https://energycentral.com/c/ec/2021-electric-truck-bus-update-part-1-trucks

11.18. Tesla Environmental Impact

Yes Mr. Musk is as rich as Midas, and maybe arrogant, but he is totally focused and very serious about everything he does. He also surrounds himself with the best engineers and other employees, and insists that they are just as dedicated as him. Given the quote at the beginning of this post, there can be no doubt that Tesla is a major force to move the world to a more viable future.

The document this post reviews is over 100 pages long, and is full of details. This post will provide a few words and figures, but if you are interested – you might considering downloading the full document, which is linked in this post.

https://energycentral.com/c/ec/tesla-environmental-impact

11.19. Mobility Diesel Emissions

There are two reasons that Energy Professionals should be interested in this subject. The first is that large vehicles that use diesels emit large amounts of greenhouse gas, and as a result will be phased out over the next couple of decades in California: by 2040 (buses) or 2045 (heavy-duty trucks). Most of their replacements will be battery electric vehicles, and since many of these are very large vehicles and are in large fleets, they will draw massive amounts of power when recharging. This will impact the electric grid at every level.

The second reason has to do with health and other impacts of diesels, which are dire.

https://energycentral.com/c/ec/mobility-diesel-emissions

11.20. Tesla 2021 Update

I am starting to write this about a month before I plan to post it, and only three months after my last post that dealt heavily with Mr. Musk's battery electric vehicle company. However, such is the pace of developments from said company that my "Tesla bucket" is close to overflowing, so I need to start putting these in a paper.

This post will focus on Tesla Mobility Products, but cover a wide range of subjects, including:

- Production Results
- Manufacturing and Components
- Future Vehicles
- Safety
- Berlin & Shanghai Gigafactories and Texas Terafactory

https://energycentral.com/c/ec/tesla-2021-update

11.21. Interoperability

The one-word title of this paper describes an extremely important function that is required to make relatively recent computer-based components play nice together, or interoperate, and it doesn't happen by magic.

This post is about one important example of interoperability testing among the many devices and systems that are responsible for battery electric vehicle (BEV) charging. These systems are also collectively known as electric vehicle supply equipment (EVSE). Although interoperability testing has been ongoing by manufacturers and industry organization since the first (modern) charger was plugged into the first (modern) BEV, this will be an important milestone in the testing because:

- The California Energy Commission (CEC) is sponsoring (and paying for) these tests.

- The CEC proposes to segment these tests into different types of BEVs (light, heavy, buses, etc.)
- The CEC proposes to look at advanced vehicle-to-grid interoperability functions.

https://energycentral.com/c/cp/interoperability

11.22. Road Trip

I write frequently about various electric vehicles and related subjects. Currently the most popular types of road-going electric vehicle are battery electric vehicles (BEVs). These are very practical for most applications, being extremely cost-effective and reliable. However, there is one class of consumer that may have an issue, those prone to take extended road trips.

The range of current state-of-the-art BEVs is 300 to 400 miles, furthermore there are many charging stations along most highways. But road trips are frequently longer than 300 miles, and note the “most”. Even in BEV-crazy California, I have noted some areas where there are few charging facilities, and those that exist have limited capabilities.

The above describes a problem and an opportunity.

https://energycentral.com/c/ec/road-trip

11.23. Electric Refuse Trucks & Battery-Electric Buses

I have posted before on battery electric buses (BEBs), as my sometimes employer (Microgrid Labs) makes optimization software and provides consulting services for fleets of these. Lately I noted that another type of large vehicle, refuse trucks have use-profiles that are similar to BEBs. Also, each of these markets have multiple large companies providing electric versions of each vehicle.

This post is a review of both of these two-vehicle types and considerations as they electrify.

https://energycentral.com/c/cp/electric-refuse-trucks-battery-electric-buses

11.24. Interstate eTrucking

Today I came across an article that led me to the MOU signed by 15 states (including California) and DC. The MOU, “Multi-State Medium- and Heavy-Duty Zero Emission Vehicle Memorandum of Understanding.

I’ve summarized the MOU in the article linked below.

https://energycentral.com/c/ec/interstate-etrucking

11.25. eTrucking

We are in the midst of a war-of-words over the future of trucking. The main event is Evil-Elon with his Tesla Semi vs. Mauler Mark Russell with his Nikola One, Two, Tre Punch. There are also many undercard bouts involving old-pros from the internal combustion (IC) Trucking Industry. The referee is likely to be the California Air Resources Board (CARB) Chairwoman Mary D. Nichols, with CARB’s Advanced Clean Trucks (ACT) rulebook for knocking out diesel emissions in the state.

In this paper we will review the latest information on the above bouts, the new rulebook, and how IC Trucks will be knocked out by the three-punch combination of ACT, eTrucks and H2Trucks.

https://energycentral.com/c/ec/etrucking

11.26. 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

11.27. Little and Big Electric 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

11.28. 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

11.29. 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

11.30. Toyota, Tesla & Schumer

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

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

11.31. 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

11.32. 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

11.33. 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

11.34. 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

11.35. 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

11.36. EV Update

Much in 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

11.37. 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

11.38. 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

12. Biomass Generation

12.1. Biomass to Biogas to Biochar

I write moderately detailed technical articles involving a number of subjects, and I read much material in trying to find leads to the articles. I spent much time researching several of these leads on emerging products recently, and afterwards I found a major potential flaw in each product. Then I found the subject for this article. I was skeptical at first, but the more I dug the better this looked.

Let's say you have a concept for a plant that turns trash into, not treasure, but useful and valuable products. A possible dead-end to this effort would be some serious environmental issues with air-pollution, or other emissions, since this is intended to be a green-tech product.

So where would you work on initial pilots and your first full-scale plant? How about the nation's largest natural gas utility, SoCalGas, with the participation of the South Coast Air Quality Management District (AQMD). And these organizations are supporting the full-scale waste to biogas thermochemical-conversion system on a SoCalGas site in the heart of central Los Angeles, one of the most tightly regulated air-sheds in the country. This pyrolysis system began processing feedstocks and producing products in August 2021.

https://energycentral.com/c/cp/biomass-biogas-biochar

12.2. 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

13. Hydrogen and Fuel Cells

13.1. An Electrifying Chameleon

Hydrogen. That is what this post is about. It all started with an article about a new method to produce it that looks really promising. But then we got to the question of what "color" is the hydrogen it produces. I frequently use the terms green hydrogen, gray hydrogen and sometimes blue hydrogen. Green hydrogen is produced via electrolysis using renewable electricity, but what is renewable electricity?

Various parties have invented other colors for hydrogen, but in my mind this is a futile effort. There are a huge number of ways to produce hydrogen. Which of these has the best economics and/or produces the least GHG frequently depends on the production and evaluation methods. I will just say that hydrogen is a Chameleon, and it can be any color it wants to.

This post will look at green hydrogen, and more specifically, the above question (what is renewable electricity?). Then it will look at the new method to produce hydrogen that I found.

https://energycentral.com/c/cp/electrifying-chameleon

13.2. Economics of Green Hydrogen

Most that have looked at the economics of the title fuel believe that it will play an important role in the transition to a greenhouse gas free economy in future years. However the big question is, when?

First of all this answer depends not only on the specific application of this fuel, and the technology to convert the fuel back to energy, but also the application profile and where it is being evaluated.

In this post we will look at the general case – how much is it likely to cost to produce and store green hydrogen at various points in the future. We will also look at other factors that reduce or increase these costs. Finally we will end with a brief section that contains links to various other publications that will let readers drill down for additional information regarding specific applications.

https://energycentral.com/c/cp/economics-green-hydrogen

13.3. Clean Backup Generation

This post is a brief description of current California diesel regulations, information about the current fleet of large diesel backup generation in California, and a couple of large corporations that starting the transitions away from diesel backup generation.

https://energycentral.com/c/pip/clean-backup-generation

13.4. Hydrogen Hubs

For roughly the last month or so, I've danced all around the subject / title of this brief paper with the posts referenced below. However, I've seemed to do this without bringing these together, as this post will do.

So what is a hydrogen hub? It is a major user of green hydrogen that will use renewable electricity from the grid to produce adequate supplies of green hydrogen via an electrolyzer and store this hydrogen in high pressure tanks. The storage might have several functions:

- The electrolyzer can be sized based on average demand rather than peak demand.
- Storage potentially disassociates times of production and use to allow the electrolyzer to use the least-cost renewable electricity for the former when it's available.
- Stored hydrogen can be used for backup when there is an electric outage.

https://energycentral.com/c/ec/hydrogen-hubs

13.5. California Dreamin' about H_2

Although I frequently write about my home state (see the title), this paper will focus entirely on the Golden State. This is because (1) my post on hydrogen fueled rail transportation two weeks ago had a major focus on my state and (2) there were many stories intended for that post that were left untold.

https://energycentral.com/c/ec/california-dreamin%E2%80%99-about-h2

13.6. Cross Reference

See “Future Long-Term Storage” under section 19, Storage for BESS and Mobility. This cover the use of hydrogen in Siemens combined cycle plants.

13.7. Tech Race

As we start our trip into the future, there are many promising technologies. Some of these will fall by the wayside – being killed by more practical alternatives, but some of these, although not the clear winner, will find niches where they are viable. Such might be the future for the many alternative methods to use hydrogen as a clean (non-greenhouse gas (GHG) emitting) fuel.

Some have suggested a “quick fix” to reduce the amount of GHG emitted by the use of geologically sourced natural gas would be to blend hydrogen into natural gas. While it is true many international experiments have demonstrated this can be done, it is not without its down-side.

However, there are at least two other paths to increase the compatibility of these two gases, while greatly reducing the amount of GHG emitted through combustion of natural gas. One of these methods is to use biomethane.

https://energycentral.com/c/cp/tech-race

13.8. Release the Crackers

This paper will investigate why ammonia is probably the best carrier for hydrogen, possibly can be used directly as a fuel, and the latest developments in ammonia technology including crackers.

https://energycentral.com/c/ec/release-crackers

13.9. 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

13.10. 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

14. Microgrids

14.1. Neighborhood Virtually-Enabled Microgrids (NVEM)

I frequently write about microgrids, and also about renewable energy sources at all scales. None of the existing neighborhood microgrid concepts really makes the two major benefits of microgrids widely available. These benefits are:

- Lower-electric costs
- Higher electric resiliency

In considering various concepts, I believe I have identified a potential method of doing this as described in this paper.

https://energycentral.com/c/pip/neighborhood-virtually-enabled-microgrids-nvem

14.2. The Future of Microgrids

I responded to a question from one of my colleagues at Energy Central, which caused me to think about the subject of this post. This brought up some interesting possibilities.

The California Electric Utility Culture has decided that microgrids will be very useful to prevent transmission lines that feed small isolated communities from starting wildfires.

This post expands on the possibilities for microgrids to expand into other segments once the wildfire mitigation market starts to saturate.

https://energycentral.com/c/ec/future-microgrids

14.3. Major Evolution of the Utility Paradigm

The electric utility industry has operated under the paradigm that big generators are sufficiently more efficient than small generators to justify the considerable expense of the T&D network required to get their energy to widely distributed loads. This has been the case since Tesla and Westinghouse invented the modern electric utility industry (to a lesser extent Edison, who actually invented DC microgrids). But what if this was not true, at least in some cases?

The answer to the above question appears to be: this assumption is no longer true in limited cases, and this will start an evolution of the grid's structure.

The title evolution will not be rapid, nor will it initially be universally applicable, but it will start in the next year or two, and it will progress relentlessly for the next few decades. For areas with widely dispersed small communities that are susceptible to wildfires and thus public safety power shutoffs (and other widespread outages), the California Utility organizations appear to have made the determination that these would be better served by microgrids rather than the traditional grid. This post is about this evolution and its implications.

https://energycentral.com/c/gr/major-evolution-utility-paradigm

14.4. Microberg

This post covers three subjects related to using microgrids to mitigate Public Safety Power Shutoffs (PSPS): (1) a bill on its way through California's Senate that hopes to help achieve this, (2) a recent ruling by the California PUC that "facilitates commercialization of microgrids across California, and strategies for procurement of backup power in advance of the wildfire season…", and (3) how microgrids and distributed power might operate cost-effectively.

https://energycentral.com/c/cp/microberg

14.5. 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

14.6. 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

14.7. 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

15. Misc. Renewables

15.1. Hot Rocks Part 3 – Widespread Geothermal Power

The title of this post indicated it's the third part in this series. The first part was posted a little over a year ago, and the second this spring. This post is about Enhanced Geothermal Systems (EGS).

The principal elements of heat, water, and permeability—when found together and in sufficient amounts—can support cost-competitive rates of geothermal energy extraction. Independent of water and permeability, thermal energy (heat) exists everywhere on Earth and increases with depth. At the most basic level, EGS are manmade geothermal reservoirs. Where the subsurface is hot but contains little permeability and/or fluid, pumping water into wells could stimulate the formation of a geothermal reservoir capable of supporting commercial rates of energy extraction.

https://energycentral.com/c/gn/hot-rocks-part-3-%E2%80%93-widespread-geothermal-power

15.2. Oceanic Solutions – Tidal Power

This is the second in this series of posts on oceanic solutions to our climate change crisis.

This post is on Tidal Power, that is, hydroelectric power plants that use ocean tidal currents to generate power. This should not be confused with wave power. Although many support the latter, I believe it will, at best, be a limited niche-solution used to support remote facilities.

Most sources of tidal power tend to be very predictable. The idea is simple, first, tides rise and fall predictably, relentlessly driven by the gravitational pull of the moon. Those traits combined make the tide an attractive proposition for powering the grid. The sun doesn't always shine; the wind doesn't always blow, but with tidal, we can tell you how much we will be generating two minutes past 3 in the morning a month from now or five years from now.

https://energycentral.com/c/cp/oceanic-solutions-%E2%80%93-tidal-power

15.3. Hot Rocks, part 2

The original “Hot Rocks” post focused on mainstream geothermal power, that is, hydrothermal resources, which are considered conventional geothermal resources because they can be developed using existing technologies. The natural formation of a hydrothermal resource typically requires three principal elements: heat, water, and permeability.

I called these the “low hanging fruit” because a large quantity of these have been identified and developed, but there are still many undeveloped hydrothermal resources still out there. Thus, in the first section below, we will focus on existing firms that develop all types of resources. In the following sections we will focus on unconventional geothermal resources.

https://energycentral.com/c/cp/hot-rocks-part-2

15.4. Hydro – Part 3, Small Hydroelectric Plants

As I frequently do in my posts, below I will focus on California, specifically what California defines as small hydroelectric plants: those that are 30 MW or smaller. Also, in California, facilities smaller than 30 MW capacity are generally considered an eligible renewable energy resource, and large hydroelectric facilities are generally not considered a renewable energy resource.

This post will start with a review of all hydro in California. Then it will review small hydro, including technology, followed by some resources for those considering a small hydro project.

https://energycentral.com/c/gn/hydro-%E2%80%93-part-3-small-hydroelectric-plants

15.5. Hydro – Management

Although hydropower is used nation-wide (see main image), it is somewhat proportional to the average amount of precipitation across a state, and a given state's land area to collect that precipitation.

Although most hydroelectric projects have reservoirs to buffer the river-flows that feed them, there is still a strong incentive to make optimal use of the water that flows through each project's generators, but this is complicated by differing definitions of "optimal," differing non-generation requirements and other constraints. This paper will review the applications that help each project's management deal with these requirements.

https://energycentral.com/c/gn/hydro-%E2%80%93-management

15.6. Hydro – Beginnings: The Birth of the Grid

This is the first part of a multi-post series on hydropower. This part will focus on the U.S. history of hydroelectric generation. Although using flowing water to perform various types of work dates to ancient times, using this renewable energy source to generate electric power was born gradually from many inventions by many early engineers and scientists. Then, around 1900, one major project with several parents demonstrated to the world what the modern grid would look like.

https://energycentral.com/c/gn/hydro-%E2%80%93-beginnings-birth-grid

15.7. Hot Rocks – The Perfect Renewable Energy

This post will start in my deep past, over 40 years ago and travel several decades into the future. The subject of this post is Geothermal Power, a renewable energy source that was first used to generate electricity in Larderello, Italy, in 1904, and thus is one of the oldest renewable energy sources. It has been used in my home state (California) to generate a significant amount of our electric energy since the early 1960s.

In 1985 I became heavily involved with the Geysers Geothermal Generating Field, what is now (still) is the largest in the world by several metrics.

However I have never posted a paper about Geothermal Power. I have decided to rectify this failure and write this post. As I started researching this, I found that this technology has not only been amazing in the past and present, it will be important to our efforts to overcome climate change in the future.

https://energycentral.com/c/cp/hot-rocks-%E2%80%93-perfect-renewable-energy

15.8. 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

15.9. 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

16. Mixed Renewables

16.1. Destructive Restoration Part 4 – Renewables

We imagine a world with renewable energy, electric vehicles and sustainable materials that power the future.

Climate change is a global problem that demands innovative solutions now.

Our industrial revolution led to pollution. And mountains of waste.

We believe that the future can be bright.

And we know that inventing circular supply chains, turning waste into profit and solving the environmental impacts of new products before they happen … will save our planet.

> Redwood Materials Home Page
>
> https://www.redwoodmaterials.com

This paper is about the processes used to recycle the market-leading renewable energy products, including PV panels, wind turbines blades and batteries.

https://energycentral.com/c/cp/destructive-restoration-part-4-renewables

16.2. Cold Weather Renewables

Going forward most regions must transition to very low greenhouse gas (GHG) electric generation (a.k.a. ‘renewables) in order to avoid the worst effects from climate change.

This paper is about the coldest regions in North America, and how they might implement renewables.

https://energycentral.com/c/cp/cold-weather-renewables

16.3. 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

16.4. 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

16.5. 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

17. Politics & Economics of Renewables

17.1. Rooftop Solar Energy Tug of War – Resolution, Part 2

This summary of this decision is very long thus it will require two posts, one yesterday, (12/21) and one today. Today's post will cover the main decision process.

If you have ventured into the Part 2 post without first reading part 1, it is strongly suggested that you start with Part 1. Part 1 was posted on 12/21/21, and part 2 a day later.

https://energycentral.com/c/pip/rooftop-solar-energy-tug-war-%E2%80%93-resolution-part-2

17.2. Rooftop Solar Energy Tug of War – Resolution, Part 1

This is the second post on this subject. The first was posted in September, and is below.

On December 13, 2021 the California Public Utilities Commission (CPUC) released the Proposed Decision for the Net Energy Metering Tariff (a.k.a. NEM 2.0) that will be used in the future for rooftop solar in our state. This decision is over 200 pages long, because of the complexity of net energy metering tariffs and the many stakeholders involved. This summary of this decision is also very long for the same reasons, thus it will require two posts, one today, (12/21) and one tomorrow. Today's post will cover discussions and findings of facts, and tomorrows will cover the main decision process.

https://energycentral.com/c/pip/rooftop-solar-energy-tug-war-%E2%80%93-resolution-part-1

17.3. Rooftop Solar Energy Tug of War

California has aggressively promoted photovoltaic systems for small and medium facilities – everything from the rooftops of single-family homes to solar parking lot covers for public campuses and private businesses, and medium-sized arrays on farms, ranches and industrial sites. By and large this program has been very successful. The following is from a post from an earlier paper.

In 2006, then-Governor Schwarzenegger signed the Million Solar Roofs Initiative into law, which set a goal of building one million solar energy systems on homes, schools, farms, and businesses throughout the state. Now, the idea that once made international headlines for its “wow factor” is a reality…

As they celebrated the one million solar roofs milestone, solar advocates kept their focus on the future with a call for one million solar-charged batteries by 2025.

This post looks at the current battle taking place in the California PUC over continuing the state’s current generous program to encourage solar rooftops, versus the equity imbalance this has created.

https://energycentral.com/c/cp/rooftop-solar-energy-tug-war

17.4. Infrastructure Investment and Jobs Act

Note that this was posted as a normal text post, not a resource / PDF.

https://energycentral.com/c/pip/infrastructure-investment-and-jobs-act

17.5. 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

17.6. 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

17.7. 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

18. Solar and Solar + Storage

18.1. PV and Storage, Late Summer 2022

I keep seeing that there are amazing renewable and storage technologies, and I REALLY believe that California can meet its climate change mitigation goals. I just hope the rest of the world can follow in our path.

The most recent “PV and Storage” post was in early July, and this one is scheduled for late August.

As per my normal practice (usually) with these posts, Section 2 below is mainly on technical information about PV / Storage. Section 3 is about business developments for these renewables. Section 4 is about PV/Storage Projects. However, a bit of a different spin is that one of the projects uses a new scheme for a rather old storage technology, and it’s really big. The fact that my last post had a similar project is nothing but good news for intermittent renewables like PV.

https://energycentral.com/c/cp/pv-and-storage-late-summer-2022

18.2. Major PV & Storage Projects, Early Summer 2022

Section 2 is normally about interesting solar technology, and this section 2’s main subject is about PV’s role in snow country. Section 3 is about a bill recently passed by the California Assembly that will significantly expand community solar power, and also require these projects to include storage.

Section 4 highlights a planned major extremely powerful and long duration storage project in Utah. No, it’s not pumped storage, but since Utah is quite mountainous, that’s not a bad guess. Instead of mountains it uses a large caves, and green hydrogen. This is also a very complex project, but I’ve written about most of its elements in past posts.

Finally, the last section (5) is about major PV and/or storage projects.

https://energycentral.com/c/cp/major-pv-storage-projects-early-summer-2022

18.3. PV and Storage Late Spring 2022

Section 2 of this post will present a roadmap to decarbonization composed by a major California Utility and others. Section 3 will present major PV and/or storage projects in the U.S. that were announced recently.

https://energycentral.com/c/cp/pv-and-storage-late-spring-2022

18.4. Degradation of Utility Scale PV

Most of this post is based on a Lawrence Berkeley National Lab (LBNL) Paper that studied the title subject. This was released earlier this month as I’m starting to write this (March 2022), and is an update of a similar study that was released two years ago: In this updated study, which samples 50% more capacity than the original and adds two additional years of operating history, we assess the performance of a fleet of 631 utility-scale PV plants totaling 31.0 GWDC (23.6 GWAC) of capacity that achieved commercial operations in the United States from 2007-2018 and that have operated for at least two full calendar years.

This paper is a summary of the above paper, and I will add some additional information and an opinion in the last section of this post about the implications of these findings.

https://energycentral.com/c/cp/degradation-utility-scale-pv

18.5. Project Nexus, Water & Energy Integration for the Future

It's impossible. How do a take a state with a land area of 163,696 square miles, most of which is covered by mountains, deserts or large metropolitan areas, 2/3rds of the remaining area is incredibly arid with frequent droughts, and turn it into the most productive agricultural state in the Union? Then take the man-made resource that made this happen, make it more efficient. Oh yes, and also make it generate 13 gigawatts of renewable power.

https://energycentral.com/c/rm/project-nexus-water-energy-integration-future

18.6. PV and Storage, Spring 2022

The Technology & Business (Section 2) part of this paper updated to latest photovoltaic (PV) cell/module technologies, a possible revival of concentrated solar power from NREL, and possible extension of PV project lifetimes. As usual, the last part of this paper (section 3) covered recent large (100 MW per technology) PV and/or storage projects in the U.S.

https://energycentral.com/c/cp/pv-and-storage-spring-2022

18.7. PV and BESS, Early 2022

This year I will try to post these "PV (photovoltaic) and BESS (battery energy storage systems)" reports frequently enough to where I can get them each into a single post (in 2021 I did a total of six posts). I will also try to make the first part of each post on any technology or business development and the last part will cover major projects.

This year I will also try to use the following criteria for what constitutes a major project:

- PV-only: larger than 100 MW output
- BESS-only: larger than 100 MW output
- Combined PV and BESS – larger than 100 MW for either source

https://energycentral.com/c/cp/pv-and-bess-early-2022

18.8. Photovoltaic & Storage, Late 2021 – Part 2

This part will cover projects. Each section below is for a single state, and the sections are in alphabetical order by state. My criteria is that a given project can either be battery energy storage system (BESS) project, a photovoltaic (PV) project, or a project that incorporates both of these systems, however at least one of the project's technologies must be at least 150 MW.

https://energycentral.com/c/cp/photovoltaic-storage-late-2021-%E2%80%93-part-2

18.9. Photovoltaic & Storage, Late 2021 - Part 1

The last post on this subject was in September, just two short months from when I'm starting to work on this post. In that post I opined: Solar Energy's amazing development and rapidly exploding deployments can only lead me to believe that it will accept a lion's share of renewable energy's displacement of greenhouse gas (GHG) emitting electric energy sources. No different opinion at this point.

This first post will be on non-project related developments, for Photovoltaic and Battery Energy Storage Systems (BESS). The second post, two days after this one, will be for all recent or upcoming projects in the U.S. of at least 150 MW.

https://energycentral.com/c/cp/photovoltaic-storage-late-2021-part-1

18.10. State-of-the Art PV Panels: "One word… plastics"

Discussion of the title subject will populate sections 2 and 3 of this post. The reason is that, although the current design for photovoltaic (PV) modules (a.k.a. panels) have been widely deployed, there are still many places where they will not work, because:

- They are too heavy
- No flat surfaces on the top surfaces of the target structure (or vehicle)
- They are too difficult to recycle

Several manufacturers are starting to produce modules that solve these problems, and the key to their design is (you guessed it), plastics.

https://energycentral.com/c/cp/state-art-pv-panels-%E2%80%9Cone-word%E2%80%A6-plastics%E2%80%9D

18.11. Future of PV, Batteries and More – At the Bleeding Edge

Ptychography is a computational method of microscopic imaging. A recent advancement allowed this technique to examine three dimensional non-organic compounds at the atomic-scale. This will greatly expand our understanding of these materials and allow engineers to better model how they will behave.

This post is about the above new tool and the breakthroughs in important renewable technologies that it might hasten.

https://energycentral.com/c/cp/future-pv-batteries-and-more-%E2%80%93-bleeding-edge

18.12. California PUC Distributed Energy Resource Plan

In recent decades California has strongly supported Distributed Energy Resources (DER). This is part of our formula for moving the state to net-zero greenhouse gas electricity by 2045.

This post looks a DER as described by the California Public Utility Commission (CPUC), and preliminary plans guiding the regulation of this important resource.

https://energycentral.com/c/um/california-puc-distributed-energy-resource-plan

18.13. Photovoltaic & Storage for Fall 2021, Part 3, States, Megafactory

This is Part 3 of a Three-Part Series photovoltaic (PV) and battery energy storage system (BESS) projects in the U.S.

https://energycentral.com/c/cp/photovoltaic-storage-fall-2021-part-3-states-megafactory

18.14. Photovoltaic & Storage for Fall 2021, Part 2, US and States

This is the second post in the three part series. My last post on this subject was in mid-June, and it was a real chore.

Because of the above described issue, I have made some slight changes to the process I use on this paper. The first is the duration of project and information accumulation period (3 months). The second change is that my criteria: a given project can either be battery energy storage system (BESS) project, a photovoltaic (PV) project, or a project that incorporates both of these systems, however at least one of the project's technologies must be over 100 MW. The other change is, I'm including the link for all information sources for projects, and verifying this link, but not putting in a full footnote reference for projects. Each link will be immediately under the information quoted from the article.

https://energycentral.com/c/cp/photovoltaic-storage-fall-2021-part-2-us-and-states

18.15. Photovoltaic & Storage for Fall 2021, Part 1, Roles

This is First-Part of a Three-Part Series of posts. It started out as a single post, but quickly grew to twice my preferred length for a post. Then I discovered an amazing (and huge) report on the future of Solar Energy.

This report is based on a conclusion that I have held for several years: Solar Energy's amazing development and rapidly exploding deployments can only lead me to believe that it will accept a lion's share of renewable energy's displacement of greenhouse gas (GHG) emitting electric energy sources.

This post is a summary of DOE's "Solar Futures Study," the report described above.

https://energycentral.com/c/cp/photovoltaic-storage-fall-2021-part-1-roles

18.16. 2021 Photovoltaic & BESS Projects

It has been over a year since I posted the last paper similar to this one. This paper looks at large photovoltaic, photovoltaic plus storage and storage projects. 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 2024.

The number of projects that fit the above criteria has grown by 80% in this paper vs. the 2020 paper. There also seems to be quite a bit more geographic diversity for this post, with major projects in 15 states, and many more in the Midwest and Southeast. This paper is also much longer than I prefer (over 5,000 words), but this was necessary to describe relevant details for each project.

https://energycentral.com/c/cp/2021-photovoltaic-bess-projects

18.17. Photovoltaic Advancements

This paper was posted in November of 2020. Before that, the last deep dive I did on photovoltaic (PV) technology was about a year and a half earlier. However PV technology is had been advancing rapidly since the earlier post.

The post linked below covers:

- PV Economics, including typical costs of major project components
- Description of power production of each module (PV panel)
- Wafers and their form factors
- Cell technologies and module efficiencies
- PERC (Passivated Emitter Rear Cell) Technology
- Bifacial Technology (power produced from both the front and rear of the module)
- Trackers
- Inverters

https://energycentral.com/c/cp/photovoltaic-advancements

18.18. 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

18.19. 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

18.20. 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

18.21. 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

19. Storage for BESS & Mobility

19.1. The Golden State's Future – Welcome to Lithium Valley

Most of my readers know that my home state is California. This is also called the "Golden State" mainly because of the Gold Rush of 1849. Ditto the "Golden Gate," which is the entry into San Francisco Bay. At the south end of this bay is Silicon Valley. Also most electric vehicles circulating in the U.S. come from Fremont's Tesla Mothership Factory (also at the south end of the bay), and use Lithium-Ion batteries. Thus our distant past was shaped by a golden metal, but our present and future were and will be shaped by the above two silver metals.

The fact that you probably don't know is that California has huge lithium deposits. However, like our original golden metal, it will be neither easy nor safe to extract. This post is about these deposits, and the extraction process.

https://energycentral.com/c/ec/golden-state%E2%80%99s-future-%E2%80%93-welcome-lithium-valley

19.2. Weekly to Seasonal Energy Storage

Various electrochemical battery energy storage technologies will work to mitigate renewable variability, up to a point. Where that point is depends on the climate when the mitigation is needed, and the amount of mitigation (MWh) required in a given event. A large majority of large BESS procured by investor-owned utilities in California are lithium-ion batteries with a 4-hour run-time at their rated output.

Without going into gory details about this, where I live (Northern California), these battery energy storage systems (BESS) work well to mitigate most of the daily variability that comes with photovoltaic arrays. However wind-power has variability that is much less predictable and sometimes has low-output durations of several days to over a week. Currently this does not cause a major problem because there is still enough gas-fired generation to offset the wind-variability, but as this is retired in the future years, it would be good to have more long-term storage options.

https://energycentral.com/c/gn/weekly-seasonal-energy-storage

19.3. Wildcards – the Path to 2050

Two weeks ago, I completed a five-volume series of posts that were summaries of the six section NREL Storage Future Study and report (SFS). This study strongly suggests

that we have at least one clear path to Net-Zero greenhouse gas (GHG) by 2050. Furthermore, SFS took a really conservative approach in that it largely used existing technologies, and safe estimates of price reductions by 2050. But there may be multiple alternative paths, and some of these will come from new technology.

This paper will demonstrate that (1) a revolutionary new technology can be developed in approximately 20 years and (2) such new technologies frequently have major spin-offs.

https://energycentral.com/c/ec/wildcards-%E2%80%93-path-2050

19.4. Energy Storage Futures, Vol 5, Role and Impact in 2050

The National Renewable Energy Laboratory (NREL) over the last year released a multi-section study titled “Storage Futures Study,” hereafter SFS. The high-level goal of this is to model energy storage systems’ implementation out to 2050.

SFS section 6 reports the final result of this study, and our Volume 5 is a summary of this section and my final summary-volume for this series.

https://energycentral.com/c/cp/energy-storage-futures-vol-5-role-and-impact-2050

19.5. Energy Storage Futures, Vol 4, Distributed PV plus Storage

The National Renewable Energy Laboratory (NREL) over the last year released a multivolume study titled “Storage Futures Study,” hereafter SFS. The high level goal of this is to model energy storage systems’ implementation out to 2050.

My current intent is to track each of these volumes with a much shorter one of my own.

Section 4 of this study’s report evaluates distributed storage. Because distributed storage is almost always paired with photovoltaic (PV) solar generation, this form of generation comes along for the ride. Our Volume 4 of Energy Storage Futures is a summary of this section.

https://energycentral.com/c/cp/energy-storage-futures-vol-4-distributed-pv-plus-storage

19.6. Energy Storage Futures, Vol 3, Diurnal Storage Economics

The National Renewable Energy Laboratory (NREL) over the last year released a multivolume study titled “Storage Futures Study,” hereafter SFS. The high level goal of this is to model energy storage systems’ implementation out to 2050.

Section 3 of this report evaluated the economic potential of diurnal storage. As storage systems penetrated the utility-scale storage market over the last decade, they first penetrated the ancillary services market, which was rather small, then the market for peaking power which was much larger. The next step in this process is to evaluate the economic potential diurnal storage, which is defined as storage with a duration of up to 12-hours. Our Volume 3 of Energy Storage Futures is a summary of Section 3.

https://energycentral.com/c/cp/energy-storage-futures-vol-3-diurnal-storage-economics

19.7. Energy Storage Futures, Volume 2, Model Input Data

The National Renewable Energy Laboratory (NREL) over the last year released a multivolume study titled “Storage Futures Study,” hereafter SFS. The high level goal of this is to model energy storage systems’ implementation out to 2050.

There are currently six volumes in this series, and a seventh is planned sometime later in 2022. As I start to write this series my current intent is to track each of these volumes with a much shorter one of my own.

Section 2 of this report collects and refines data to use as an input for the model of the future of storage system out to 2050.

https://energycentral.com/c/cp/energy-storage-futures-volume-2-model-input-data

19.8. Energy Storage Futures, Volume 1: Types and Services

The National Renewable Energy Laboratory (NREL) over the last year released a multivolume study titled “Storage Futures Study.” The high-level goal of this is to model battery storage systems’ (BESS) implementation out to 2050. However it also takes a deep dive into how these systems are currently used, will be used in the future, the economics and technology surrounding their use along the way.

There are currently six volumes in this series, and a seventh is planned sometime later in 2022. As I start to write this series my current intent is to track each of these volumes with a much shorter one of my own (Volume 1 of SFS is 50 pages long). Since I recently stopped posting a second paper every week, I will complete each BESS Futures paper, go through my normal proofing process, and then post each on a following Thursday.

This paper summarizes Part 1 of the Storage Futures Study.

https://energycentral.com/c/gr/energy-storage-futures-volume-1-types-and-services

19.9. The Perfect Rechargeable Battery?

From a chemical standpoint one battery chemistry, lithium-sulfur appears to be perfect, except for several major issues that made it totally non-viable in the past.

Now a Company has designed a fix for all of these problems, by designing a completely new cathode material, and they will begin limited production of these batteries by the end of the this year.

This post is about this development, how it as the potential to be a game-changer for a number of industries, and how this development is different than every other “battery of the future.”

https://energycentral.com/c/ec/perfect-rechargeable-battery

19.10. Tesla, Second Quarter 2021

When I write about Tesla, I write (mostly) about their battery electric vehicles (BEVs). Rarely do I suffer from a lack of material regarding this subject, but I guess we are currently in the summer doldrums, because I am running short of new news for the Tesla BEVs. About a week ago, I thought I might need to push this out a bit. However suddenly, some material on major Tesla Battery Energy Storage Systems (BESS) have

come to light. Then several interesting pieces about the BEVs popped up, and suddenly I have enough material for a post (albeit a minor one).

I already started out this month with articles on new vehicle shipments, and I will lead with this in Section 2, then the BESS News, then the rest of the BEV News.

https://energycentral.com/c/ec/tesla-second-quarter-2021

19.11. New Battery Technology

In this post we will look at two more lithium-ion battery designs that include solid electrolytes and metallic lithium anodes and a third similar design that was reviewed earlier. All three of these designs have progressed enough to where they should be in EVs that are on the road by 2025, but it has been a long road to these new designs.

https://energycentral.com/c/ec/new-battery-technology

19.12. Future Long-Term Storage

The hot technology now is Short-Term Storage (read: lithium-ion battery energy storage systems or BESS), and I write about these frequently.

However there are really two or three types of energy storage systems from a duration (discharge time) standpoint. Li-ion BESS typically have a one to four-hour discharge period at full-output. Although it really hasn't found a strong market, a BESS based on flow-battery technology can economically provide a duration of up to eight hours.

And finally we have the subject of this post. Long-Term storage potentially provides a duration longer than could be economically provided by a Flow-BESS. In this post I will cover pumped storage, also I will cover a technology for long-term storage based on green-hydrogen, and finally a couple of emerging technologies that might provide long-term storage in the future.

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

19.13. Battery Energy Storage Projects & Developments

With this post we focused on new grid-scale BESS projects and other developments for BESS technology.

https://energycentral.com/c/cp/battery-energy-storage-projects-developments

19.14. EV Application Shakeout Series

When two or more technologies compete, society wins. Everyone assumes that the best technologies will emerge, but it's rarely that simple. In many cases, the most cost-effective and market-appropriate technologies will claim the largest segments of a given market, whereas other technologies will occupy smaller niches, and others may not survive. Also, technologies may merge and create hybrid solutions in order to effectively address complex markets or market segments.

I currently believe all of the above is the case for the overall electric vehicle (EV) market. Here we will look at a market that includes ALL significant electric vehicle segments in this two-part series, including the following:

- Road-going vehicles - Part 2
- Off-road vehicles (construction and agricultural) – Part 1
- On-track vehicles – Part 1
- Flying vehicles – Part 2
- Marine vehicles – Part 1

In this series we will address storage technology for electric vehicles, and how I believe that competing technologies will shake out in the next decade or two. Our overall goal is to greatly reduce greenhouse gas (GHG) emissions from the mobility sector.

In Part 1 we focused on simple and hybrid technologies, and the above indicated market segments,. A link to Part 1 is below.

https://energycentral.com/c/ec/ev-application-shakeout-%E2%80%93-part-1

In Part 2 we focused on (1) Road-going vehicles; (2) Flying electric vehicles and how recent developments by Tesla may bootstrap this stalled market, (3) other recent developments by Tesla and (4) a potential Tesla competitor. A link to part 2 is below.

https://energycentral.com/c/ec/ev-application-shakeout-%E2%80%93-part-2

19.15. Battery Day – Part 2

In Part 2 of this paper, I covered: other (non-Tesla) battery developments, the new current largest battery energy storage system (BESS) in the world (also non-Tesla), the upcoming new largest BESS (Tesla), and finally any other recent or near future major BESS projects (mainly in California).

https://energycentral.com/c/cp/battery-day-%E2%80%93-part-2

19.16. Battery Day – Part 1

Since Elon finally had Battery Day on September 22, I am posting Part 1 today and cover this event and other Tesla information. Part 2, on October 6, will cover: other (non-Tesla) battery developments, the new current largest battery energy storage system in the world (also non-Tesla), the upcoming new largest BESS (Tesla), and finally any other recent or near future major BESS projects.

https://energycentral.com/c/cp/battery-day-%E2%80%93-part-1

19.17. Long-Term Storage

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

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

19.18. Battery Breakthroughs

Elon Musk keeps suggesting that “Battery Day” will be really big. Originally he indicated it would be in April, delayed it to May. Then he said it will be sometime in June. As I’m starting to write this on June 20, he said that it will be combined with the upcoming

shareholder meeting, which was scheduled for July7, but he is delaying that also. He now says that this combined event will be on September 22.

So I'm diving into this subject without him. I am describing the Lithium Ion chemistries he is currently using in Section 2. In Sections 3 and 4 I will discuss new findings regarding advanced technologies and materials that Elon may use. In section 5 we will look at a reasonable projection of future battery pricing. In the last section, I will briefly repeat some information from the last section of my last Elon post, and relate it to earlier information in this post.

https://energycentral.com/c/gn/battery-breakthroughs

19.19. 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

19.20. 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

19.21. 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

19.22. 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

19.23. 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

20. Wind Power

20.1. Oceanic Solutions – Introduction & Offshore Wind

This subject is the ultimate elephant in the room – 71% of the earth's surface is covered by oceans, and this percentage is growing pretty rapidly. This series is on solutions that use the oceans, and this post is an introduction to this series, and a brief summary of recent posts on offshore wind.

Rain forests may be known as the planet's lungs, but it's when standing before the seas, with their crashing waves and ceaselessly cycling tides, that we feel the earth breathe. The ocean, say scientists, is the source of all life on earth. It is also, say philosophers, the embodiment of life's greatest terror: the unknown and uncontrollable.

https://energycentral.com/c/cp/oceanic-solutions-%E2%80%93-introduction-offshore-wind

20.2. Offshore Wind Late Spring, 2022

The last post on this subject was on the first day of March. This one is posted on the last day of May.

There is no significant new news for any of the projects covered in the last post. The first new East Coast projects will not send their first power ashore until mid to late next year. However there is much new news for future projects. The Bureau of Ocean Energy Management (BOEM) has held two important East Coast auctions, and tentatively scheduled the first West Coast auction.

https://energycentral.com/c/cp/offshore-wind-late-spring-2022

20.3. Offshore Wind Early 2022

This post will focus on East Coast Offshore Wind projects that will either be commissioned by 2025 and/or are very large and important projects that will generate substantial first-power in 2025.

Each section starting with section 2 will cover a single project.

https://energycentral.com/c/cp/offshore-wind-early-2022

20.4. Fall, 2021 Offshore Wind Update

Summary: I've seen evidence that the projects covered in similar earlier posts are making progress. I've also found an excellent DOE Source on Offshore Wind, linked below, and this will provide much of the content in this post.

https://www.energy.gov/sites/default/files/2021-08/Offshore%20Wind%20Market%20Report%202021%20Edition_Final.pdf

This post is linked below.

https://energycentral.com/c/cp/fall-2021-offshore-wind-update

20.5. The Fish and the Wind-Turbines

The first major U.S. offshore windfarm, Vineyard Wind, has received final approval. There will be about a dozen more major windfarms on the East Coast by 2025, and probably a few more (plus expansions of the initial projects) thereafter. The offshore buildout on the West Coast will probably start in a few years.

In this work the offshore wind developers have faced several foes. The most credible of these are probably the fishermen. The developers appear to be using a familiar tactic: assemble a consortium of groups that support their development, and simply steamroller their opponents. This may be good for the fish, but, I fear, not for our nation.

I would suggest a different tactic – a bit of political horse-trading.

https://energycentral.com/c/iu/fish-and-wind-turbines

20.6. 2021 West Coast Wind Update

I was not totally surprised when I heard that the current administration was opening up two new areas for California to build offshore wind farms. The signals have been there that the state wanted to do this for several years, and a few of these projects are in the early planning stage.

The new administration is taking a positive approach to permitting offshore wind projects. President Biden's VP, Ms. Harris is a former Senator (etc.) from California, so opening our state's waters was just a matter of time.

This post will describe the latest news on political and other progress on the West Coast Projects.

https://energycentral.com/c/cp/2021-west-coast-wind-update

20.7. 2021 East Coast Offshore Wind Update

This post is an update the subject projects that will be completed by mid to late 2020s, and it is short. The entry for each project includes power production, currently stated first power and/or completion date and a link to the project web site. There is a brief section on Vestas at the end of this paper.

https://energycentral.com/c/cp/2021-east-coast-offshore-wind-update

20.8. 2021 Offshore Wind – West Coast, Turbines…

This post will cover West Coast activity, a new Mid-Atlantic leadership organization, and recent developments for off-shore turbines.

https://energycentral.com/c/cp/2021-offshore-wind-%E2%80%93-west-coast-turbines-and-other-developments

20.9. 2021 Offshore Wind – East Coast Projects

This is the first post of a 2-part paper and only covers the subtitle subject.

https://energycentral.com/c/cp/2021-offshore-wind-%E2%80%93-east-coast-projects

20.10. 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

20.11. 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

20.12. 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

20.13. 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

20.14. 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

20.15. 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

20.16. 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

20.17. 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

21. Grid Management

21.1. Intermittency Compatibility Toolkit, Part 2

Part 2 will look at a tool that will enable power to flow from region to region in North America, allowing more dispatching flexibility to mitigate both intra-regional and inter-regional variability. We will also look at another tool that provides flexible dispatching for existing AC transmission lines.

https://energycentral.com/c/gr/intermittency-compatibility-toolkit-part-2

21.2. Intermittency Compatibility Toolkit, Part 1

A primary resource in combatting climate change is renewably produced electric power. Even though these technologies have progressed far in the last couple of decades, and it appears that this trend will continue well into the future, we are still only at the start of this journey, and we will encounter many obstacles along the way. A major barrier is the first word in the title of this paper – intermittency.

Many states will have major problems as they attempt to reach net-zero greenhouse gas. Also as intermittent renewables scale up, some intermittence problems will be more wide-scale, effecting whole regions. How will we deal with these?

Part 1 of this series will look at the Planning Tools that will alert us to looming intermittency problems, when there is still enough time to have several options to deal with them.

https://energycentral.com/c/gr/intermittency-compatibility-toolkit-part-1

21.3. New Role for Regional Grid Managers

Last weekend there was a major lightning storm in and around the San Francisco Bay Area. This post contains the whole story, and a new role that grid managers should perform to evaluate the future likelihood of similar perfect storms.

https://energycentral.com/c/gr/new-role-regional-grid-mangers

21.4. 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

21.5. 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

21.6. 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

22. Utility Generation (Non-Renewable)

22.1. Reasonable Transition

I try to read from a wide range of sources, in an attempt to better target future papers to my primary readers (members of Energy Central and the therein members of the Energy Industry). Since this audience is also part of the general public it is reasonable that, if the general public is confused about a given energy-related issue, this is also a subject I should write about.

There is a debate in Europe regarding what constitutes a renewable electricity source, and specifically whether natural-gas fired plants should be considered “renewable” under reasonable conditions. Natural Gas is labeled as a “transition fuel”, and investments in a natural gas plant will count as “green power” if:

The plant emits no more than 270 grams of CO_2 equivalent greenhouse gas (GHG) per kWh of electricity produced

The natural gas plant must replace a plant with higher GHG emissions per kWh

The key point here is this discussion regarding natural gas seems to be an “either or” discussion. In fact, a modern combined cycle plant fueled with geologically sourced natural gas can evolve to very low GHG emissions in the future. I had researched this subject about a year ago and put a few of paragraphs on this subject in a post.

Unfortunately I had buried these deeply in a paper that was really on a (somewhat) different subject. I will put these subsections in this post and add some additional information.

https://energycentral.com/c/gn/reasonable-transition

22.2. Distributed Energy Resources Integration Roadmap

The title document was sponsored by the California Energy Commission and created in a project that included a technical assessment of DER and barriers to efficient adoption, development of a prioritization method to assess research opportunities that relieve those barriers, and execution of that method to identify high-value research.

This post is a summary of that document.

https://energycentral.com/c/pip/distributed-energy-resources-integration-research-roadmap

22.3. Virtual Power Plant Projects

In August of last year I posted a paper on this subject. The prior paper explored the history and possible evolutionary path of this technology. I also reviewed a virtual power plant project that Tesla had started in Australia. Note that the prior paper and this one specifically focus on virtual power plants that use distributed battery storage (although there may be other elements).

I have been tracking these since the Virtual Resources Paper, and this paper will look at additional projects using this technology.

https://energycentral.com/c/gn/virtual-power-plant-projects

22.4. Destructive Restoration – Part 3, Coal

Coal-burning power plants are worst offender when it comes to greenhouse gas (GHG) emissions. They also have other emissions that seriously worsen health effects (Sulphur Dioxide, Mercury, and other toxic metals). And then there is the coal ash, which contains contaminants like mercury, cadmium and arsenic. Coal ash is typically stored in ponds, which risk pollution of water tables and can destroy down-stream communities in the event of a dam-break.

Coal plants also are much less cost-effective than gas-fired plants (especially combined-cycle, which are also much cleaner), and many renewables. This is mainly due to the costs for coal-shipping, handling, and processing, and coal-ash storage.

Given the above, it is not surprising that many coal-fired plants are being decommissioned. This post is about the proper process for decommissioning these plants and related facilities.

https://energycentral.com/member/profile/200777/activity

22.5. Destructive Restoration – Part 1, The Klamath

Every machine made by humans reaches the end of its useful life. This will be the first post in a short series on what should happen to electric generation projects when it is no

longer economical to restore, repurpose, nor continue to use them for their intended purpose.

However this first post is special. It is partially drawn from my deep past and partially an agreement to restore a natural resource and everything around it through the creative destruction of a series of old projects near the California-Oregon Border.

https://energycentral.com/c/ec/destructive-restoration-%E2%80%93-part-1-klamath

22.6. Virtual Resources

This paper is about the latest spin on virtual power capacity systems, which are also known as virtual peaking capacity, virtual power plants, and so forth. These systems are still being produced, but the company producing the latest spin on these virtual systems is generally known for a spin of a different type.

https://energycentral.com/c/cp/virtual-resources

22.7. 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

22.8. 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

22.9. 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

23. Utility Market Forces

23.1. PICSI

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/picsi

24. Utility Resources

24.1. Human Data Acquisition & Control

I have spent most of my career in the electric utility industry in three technologies that are all about data acquisition and control: supervisory control and data acquisition (SCADA), advanced metering infrastructure (AMI) and protective relaying.

This post will cover a different type of data acquisition and control which is used for humans, and more specifically their diseases. However, there is huge difference in timing. Whereas the above utility technologies are a better part of a century old, the technologies we will review below are much younger.

https://energycentral.com/c/rm/human-data-acquisition-control

24.2. Universal Coronavirus Vaccine

In December of 2020, I thought I had retired from my brief career as a virological writer. Many times since then many of us have thought we were done with COVID-19, but COVID-19 was not done with us.

I would really like to be rid of COVID! I religiously read Science and Scientific American. Somewhere in doing this I read that at least one firm was working on a universal COVID vaccine. I started researching the universal vaccine and other COVID matters. I found the results very enlightening, and thought my readers might also, and thus this post.

https://energycentral.com/c/rm/universal-coronavirus-vaccine

24.3. Water World

Although a large percentage of my posts are about energy, I have written about water utilities before. Energy is required to process water, pump water and otherwise make it suitable for use. Also, guess which sector is the largest user of water? The main image for this post might help you.

This chart is part of a roadmap created to “make nontraditional sources of water (i.e., brackish water; seawater; produced and extracted water; and power sector, industrial, municipal, and agricultural wastewaters) a cost-effective alternative.”

If you look at the beginning of section 2, you will see that the organization that authored the roadmap was created by the U.S. Department of Energy, so I think I’m on firm ground.

This paper will focus on methods and projects to use water more sustainably.

https://energycentral.com/c/rm/water-world

24.4. Light at the End of the COVID-19 Tunnel

The Pfizer COVID-19 Vaccine Emergency Use Authorization was approved by the FDA today (Dec 11). It will start to be distributed on a priority basis in the next few days. The FDA hearing on the Moderna Vaccine is on December 17.

The questions most have are:

When will conditions start to return to normal?

When will conditions return to “pre-pandemic normal”?

Since the first is a vague question, I can provide some information based on the potential volume of vaccine that will be available over time. It will be assumed that all of the doses until mid-year will find ready takers.

Since the answer to the second will be another question, that is, when will we reach herd immunity? This depends on you, me and most other people getting vaccinated.

This paper will provide some information on both questions, and also information on a system that might help accelerate herd immunity.

https://energycentral.com/c/um/light-end-covid-19-tunnel

24.5. A Renewable Career

It appears that we will have a new administration in DC, and one that is very friendly to efforts to mitigate the effects of climate change. Also the Pandemic has deprived the citizens of our country of much employment. I saw Ms. Harris (a.k.a. VEEP-Elect) in a press conference today. When asked what the new administration’s top three priorities would be, she responded: JOBS, JOBS, and JOBS. I concur.

Given the above, I would suggest that any of my fellow citizens in need of future employment should look to the title of this post. The subject of this post will be three renewable areas that should be happy hunting grounds for future employment:

- Wind Energy Professionals
- Solar Energy Professionals
- Electrical Professional

https://energycentral.com/c/cp/renewable-career

24.6. Phase 3 COVID-19 Vaccines – Rev b

In Rev b, I believe that at least the top three vaccine candidates’ manufacturers (Moderna mRNA-1273, Pfizer / BioNTech BNT162b2 and Oxford / AstraZeneca's AZD-1222) and other stake-holders are starting to form a reasonable estimate of when the vaccines’ trials might show any positive results, and how they might be allocated when released. I’ve added this additional information while retaining content from Rev a.

https://energycentral.com/c/um/phase-3-covid-19-vaccines-%E2%80%93-rev-b

24.7. Phase 3 COVID-19 Vaccines – Rev a

It is very difficult for utility business leaders to plan future projects and resource allocations when they do not know when the COVID-19 Pandemic will end. Currently it seems to be getting worse every day.

The only future good news will be when a COVID-19 Vaccine is available in millions of doses.

What the original post of this document did was define firms and partnerships that had entered Phase 3 trials for their COVID-19 vaccines as its posting date (July 31). In this post I will describe progress by those developers, and additional developers that will likely offer vaccines in the U.S. in large volumes before the end of 2020 or early 2021.

https://energycentral.com/c/pip/phase-3-covid-19-vaccines-%E2%80%93-rev

24.8. Phase 3 COVID-19 Vaccines

It is very difficult for utility business leaders to plan future projects and resource allocations when they do not know when the COVID-19 Pandemic will end. Currently is seems to be getting worse every day. To make matters worse, as I write this (the last day of July) a hurricane is targeting the southeast U.S. coast, and a significant earthquake has hit Southern California. We are a couple of months away from flu season in the U.S., and wildfire season in California. So planning is very much in limbo.

The only potential good news will be when a COVID-19 Vaccine is available in millions of doses.

What this document attempts to do is define firms and partnerships that have entered Phase 3 trials for their COVID-19 vaccines as of today. I will attempt to only describe products that likely will be available in the U.S. in large volumes before the end of 2020 or early 2021.

https://energycentral.com/c/pip/phase-3-covid-19-vaccines

25. Nukes

25.1. Nukes, Part 7: Micro Reactors

Nukes part 7 is about Micro Reactors. Per energy.gov, a single (micro reactor) unit typically generates 1 to 10 megawatts-electric.

Micro reactors are simply smaller, factory-built systems that can be easily transported by trucks, ships, airplanes or railcars.

Some micro reactors can be set up in days, not years, to provide reliable heat and power to a host of places, ranging from residential and remote areas to military bases.

I believe the real promise for micro reactors is in the far north, where they will displace diesel generation for remote villages, industrial sites and other remote facilities.

https://energycentral.com/c/gn/nukes-part-7-micro-reactors

25.2. Nukes – Part 6

I will start this Nukes Part by disagreeing with myself. In Nukes Part 4 I said: “A class of reactors is generally called advanced reactors. They do not use water for cooling, heat transfer, and reactivity control, but instead use some other fluid.

“In spite of claims by the above companies that the above designs are intrinsically safe, I don’t buy it. I’m not going to review any advanced reactor designs in future Nukes, unless they are able to define a true breakthrough design that I can believe.”

I just spent several hours researching TerraPower, and feel like they have the resources to pull off a successful design, certification and first project, and this post will review this innovative design.

https://energycentral.com/c/gn/nukes-%E2%80%93-part-6

25.3. Nukes – Part 5

This paper is a 2021 update on (1) Small Modular Reactors (SMRs) from U.S. Reactor Manufacturers that are at least somewhat likely to be built before 2030 (although not necessarily in the U.S.) and a fusion near-commercial power plant that is at least somewhat likely to be built before 2040 (probably in the U.S.).

https://energycentral.com/c/pip/nukes-%E2%80%93-part-5

25.4. Distant Nuclear Fusion

There are currently two experiments that are designed to reach “break-even” fusion within the next several years, but this means that the experiment will inject as much energy into the inner, or core process as comes out in the form of high energy neutrons. Forget any energy-conversion efficiencies outside of the core – no electric energy will come out of these initial facilities in spite of huge amounts going in.

One of these two projects, the International Thermonuclear Experimental Reactor (ITER) is in Saint-Paul-lez-Durance, France. The other, the National Ignition Facility (NIF) is here in my home town of Livermore, California.

This post is a brief review of the former and a more thorough review of the latter, including its distant past and distant future.

https://energycentral.com/c/cp/distant-nuclear-fusion

25.5. Destructive Restoration – Part 2, Nuclear

This is the second in a three-part series on the right way to decommission electric generation plants where it is no longer economical to restore, repurpose, nor continue to use them.

https://energycentral.com/c/gn/destructive-restoration-%E2%80%93-part-2-nuclear

Note that parts 1 & 3 of this series are under section 22.

25.6. Nukes – Part 4

In the prior Nukes Papers, I indicated that (1) Gen 3 Nukes could not compete with other renewable generation technologies, (2) Small Modular Reactors (SMR) appeared to have the ability to compete with these where they were required, and (3) there are (at least) three SMR manufacturers that seem to have the ability to achieve economic viability.

In this post we will look at the progress that the three U.S. SMR manufacturers have made, and identify any other potential SMR or other nuke manufacturers.

https://energycentral.com/c/pip/nukes-%E2%80%93-part-4

25.7. 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.

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

25.8. 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

25.9. Amazing Voyage

This paper is on the future of space nuclear power systems, and how these might find a role on earth.

https://energycentral.com/c/pip/amazing-voyage

25.10. 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

25.11. 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

26. Utility Safety

26.1. 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

27. Utility Technology – Overview

27.1. 100% Clean Electricity by 2035?

Mitigating climate change is important, really important, and the sooner, the better. The first major step in this process is converting our electricity to 100% greenhouse gas (GHG) free generation. This is because all other major producers of GHG plan to use electricity as their future energy-source in lieu of their current GHG-producing methods. As an example, all types of vehicles will need to evolve to either use electricity directly or use GHG-free fuels (like hydrogen) that are produced with electric energy and/or carbon capture and sequestration. This is a process that will take several decades to reach zero-net-GHG, so it is good that we have already started and the sooner we can make electricity zero-GHG, the less GHG we will pump into the atmosphere.

My home state (California) has an official goal of reaching zero GHG electricity by 2045. However a recent report from the National Renewable Energy Laboratory (NREL), "Examining Supply-Side Options to Achieve 100% Clean Electricity by 2035," suggests that the 2035 goal is achievable.

This post will examine the possibility of achieving net-zero GHG energy by 2035.

https://energycentral.com/c/cp/100-clean-electricity-2035

27.2. Sustainable Utilities

If we parse the title of this paper we end up with two words that may or may not be related. "Sustainable," in the context used here means "…relating to, or being a method of harvesting or using a resource so that the resource is not depleted or permanently damaged." A utility (again, in this context) means "A commodity or service, such as electricity, water, or public transportation that is provided by a public utility."

Given the above definitions, I would say that a sustainable utility provides a commodity or service using methods so that resources are not depleted or permanently damaged.

https://energycentral.com/c/pip/sustainable-utilities

27.3. 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

28. Utility Technologies

28.1. California's Water Challenges and Possible Solutions

Our climate has changed. We are experiencing extreme, sustained drought conditions in California and across the American West caused by hotter, drier weather. Our warming

climate means that a greater share of the rain and snowfall we receive will be absorbed by dry soils, consumed by thirsty plants, and evaporated into the air. This leaves less water to meet our needs.

This is our new climate reality, and we must adapt.

As I'm starting to write this in late August, my state has just released California's Water Supply Strategy document. Section 2 of this post will cover this. Later sections will reference other posts with information related to this subject, the latest news on the U.S. DOE Desalination Prize, and some early adopter communities that are building desalinization systems.

https://energycentral.com/c/rm/california%E2%80%99s-water-challenges-and-possible-solutions

28.2. The Body Electric

This post and the related updates were started when an associate at Energy Central asked me to participate in an upcoming call for papers, and this paper will be posted in mid-September so as to coincide with scheduling of that. I believe that the three subjects briefly described below respond to those in the call for papers.

I've been a member of Energy Central for about ten years, and have been posting papers to this site for about half of that time. Early in these postings (2018) I posted a series of papers each on supervisory control and data acquisition (SCADA) and advanced metering infrastructures (AMI). More recently I posted paper on protective relays. Associated with this post I am updating the papers on all three subjects. I will add comments on each of those subjects below as well as links to those papers. Note that I have reviewed all of my papers linked in this paper, and corrected any errors, old information or bad links in those papers where reasonable (without complete rewrites).

https://energycentral.com/c/gr/body-electric

28.3. Electricity Past & Future

My June IEEE Spectrum had an interesting chart in it, and I've used this as the main image for this post.

This is obviously the U.S. Electric consumption over time. There was also some interesting commentary on this, some of which I've excerpted in this post. But what I'm really interested in is what this tells us about the future, which is also covered.

https://energycentral.com/c/cp/electricity-past-future

28.4. Wireless Power

The two words in the title of this paper don't normally go together. Wireless communication, yes, but to transmit real power, like megawatts, you need a grid, made with wires, thus precluding the first word of this title. However the primary inventor of the modern grid might disagree with you.

https://energycentral.com/c/gr/wireless-power

28.5. Chips Dip

Everyone probably has heard about the chip-crisis that the auto industry (and others) has been experiencing. I have been looking for a really good explanation of this that I could share with my readers. I finally found one.

You probably thought that the Electric Utility Industry was immune from this. Ha! Read Section 2 of this post.

https://energycentral.com/c/iu/chips-dip

28.6. HVDC Transmission, Part 2, Major Projects

This is a two part series on HVDC Transmission. Part 1 of this series looked at specific applications where HVDC Transmission excels, other applications that may not be as suitable, and the geographic area in the U.S. Grid where they have, and will continue to be used extensively. Part 1 also looked at the technology used to implement HVDC lines.

This part will look at major HVDC Transmission projects that are currently being implemented in the U.S.

https://energycentral.com/c/tr/hvdc-transmission-part-2-major-projects

28.7. HVDC Transmission - Part 1 Technology

In general, an HVDC line tends to be used for specific critical and/or long-distance applications whereas an HVAC line tends to be part of a large AC network composed of many synchronized AC lines that operate at various voltages.

Part 1 of this series will look at specific applications where HVDC Transmission excels, other applications that may not be as suitable, and the geographic area in the U.S. Grid where they have and will continue to be used extensively. Part 1 will also look at the technology used to implement an HVDC line.

https://energycentral.com/c/gr/hvdc-transmission-part-1-technology

28.8. Power Industry 2022 Trends & Predictions

My colleagues at Energy Central asked me to participate in the title predictions. After considering this, I offered to review three areas where I post frequently, and consider myself qualified. These areas are:

- U.S. growth in electric vehicle (EV) deployments
- U.S. progress in transitioning to fossil-fueled generation to utility-scale photovoltaic (PV) and battery energy storage systems (BESS)
- Deployment of the first large-scale offshore wind projects.

I track all of the above with posts on a regular basis, so, in general I will follow this process:

- I will start with trends from 2021 posts
- I will look at other factors that could accelerate or decelerate growth

- Make projections on growth for the next few years in the above markets.

https://energycentral.com/c/ec/power-industry-2022-trends-predictions

28.9. The Godfather of Energy Efficiency

There has been much discussion of Energy Efficiency lately. Every time I see a discussion of energy efficiency, my thoughts go to a gentleman that shares a title with this paper, which I am posting to scratch this itch (and give myself a nice Thanksgiving present).

His name is Dr. Arthur Rosenfeld, and I had the honor to work with him on a couple of projects shortly after Y2K.

https://energycentral.com/c/um/godfather-energy-efficiency

28.10. California Agricultural Demand Response

California has issues with climate change that cause frequent droughts. Although we also have a very well-developed water resources system with many reservoirs and aqueducts, it is currently being stretched to the limit by these droughts.

When our water resources system cannot supply the water that farmers need, they tap their groundwater, and this too is becoming overextended.

As with many problems, this one described above also comes with an opportunity. This one is for the electric grid. Groundwater pumping has a strong potential for demand response. By creating incentives for farmers that implement demand response, the state will help them offset some of the expenses that will result from implementing better groundwater management practices.

This paper has four subjects: (1) current California agricultural production, (2) agricultural demand response systems, (3) water management techniques, and (4) some systems that will implement the second and third subjects.

https://energycentral.com/c/em/california-agricultural-demand-response

28.11. New (Neuromorphic) Computing

I spent most of my career working on computers using various software, some of which I developed myself. However, I really don't consider myself a computer (or software) professional, as I've always remained focused on the application or end product, not the computing system or language that helps me achieve it.

In fact I tend to be very dismissive of phrases like smart grid and artificial intelligence. Yes I understand some of the devices that use AI have achieved useful results, but with several major drawbacks.

Finally, a relatively new class of AI described in the title may achieve a degree of intelligence, and in any case is a major advance in computing. Why? Look at its name, it imitates the human brain.

https://energycentral.com/c/iu/new-neuromorphic-computing

28.12. AMI Part 5 – New Networks

The present is built from many pasts.

The future will be built from many presents.

To understand the present and possible futures, understand the past.

The first four parts of this series were posted over three years ago. I just reviewed them and they are still OK (about half of the references' links have issues), and will prep the readers to read this post. These are linked below.

https://www.energycentral.com/c/iu/advanced-metering-infrastructure-ami-part-1-roots

https://www.energycentral.com/c/iu/ami-%E2%80%93-part-2-creating-demand

https://www.energycentral.com/c/iu/ami-part-3-technology-basics

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

Part 5 is linked below.

https://energycentral.com/c/gr/ami-part-5-%E2%80%93-new-networks

This post is being written because a major network that is required for AMI has evolved away from past technology and there are future networks that are already present.

28.13. Undergrounding – Part 2

Being a utility professional I've always noted the design of the distribution system on my street (see the main image).

Yes we have power poles, but they perform multiple jobs, as can be see above:

- They carry our street lights.
- Near the top, they carry the medium-voltage circuit conductors that feed our neighborhood (note that there are just two-conductors).
- Note the pole in the distance has a more pronounced bulge on top than the one in the foreground, this is the distribution transformer that converts the medium voltage to low voltage (120/240 split phase).
- The pole then carries the LV to its underground path to the residences.

The problem: our neighborhood is about 55 years old – the underground LV cables are starting to fail. Thus PG&E's Underground Contractor, (MGE Underground) has been busy in our neighborhood digging up our streets and sidewalks, and replacing underground cables. Since my office is in the front of the house, and views a major focus of this work, I got to see much of this process. Unfortunately we accidentally got involved in another way.

https://energycentral.com/c/pip/undergrounding-%E2%80%93-part-2

28.14. Undergrounding

This post is all about overhead verses underground power lines, and the costs, advantages and disadvantages of each approach.

Note that this post was updated in September, 2021, mainly due to a 2021 change in California Rule 20 by the CPUC. Rule 20 is a primary rule used for Undergrounding.

https://energycentral.com/c/pip/undergrounding

28.15. PG&E Distribution Hardening

PG&E is my local utility for both my primary residence (Livermore, California) and my other residence (Arnold, California). My primary residence has minimal risk from wildfires, but my other residence is not so lucky, as it is in a Tier 3 (Extreme) High Fire Threat District (HFTD). Thus I have an interest in the subject of this post.

PG&E's main wildfire document is their Wildfire Mitigation Plan, a detailed document that is updated every year.

On July 26 PG&E announced a major new initiative to expand the undergrounding of electric distribution power lines in High Fire Threat Districts (HFTD) to further harden its system and help prevent wildfires.

This post will cover two areas related to the above:

- Why PG&E feels that undergrounding the distribution lines is now viable, and
- What their Wildfire Mitigation Plan (WMP) says about the subject of distribution line hardening

https://energycentral.com/c/gr/pge-distribution-hardening

28.16. Managing the Duck Curve and all of Its Foul Relatives

Electric utilities have been fighting the mismatch between when power generation is available and when the loads need the resulting electricity since Edison, Tesla and Westinghouse invented the modern electric utility industry.

The "Duck Curve" is a somewhat new species for this issue, but I'm sure we will be seeing more of its flock-mates as the grid-supply evolves.

This paper will address mismatches between electric supply and demand. I will do this for my home-state (California) and others can do the same for their home state.

https://energycentral.com/c/gr/managing-duck-curve-and-all-its-foul-relatives

28.17. The Future of Electric Power in the United States – Part 3

This is the third post that summarizes a really impressive volume. The title source is referenced in each of the three parts of this paper. If you have not reviewed Part 1 of this series, it suggested that you start there, and there are links to Part 1 and Part 2 in the Intro to Part 3. Note that this review required three posts and some of the posts are rather long.

Part 3 covers how we might achieve a more secure and resilient power system in the future.

https://energycentral.com/c/gr/future-electric-power-united-states-%E2%80%93-part-3

28.18. The Future of Electric Power in the United States – Part 2

This is the second post that summarizes a really impressive volume. The title source is referenced in each of the three parts of this paper. If you have not reviewed Part 1 of this series, it suggested that you start there, and there is a link to Part 1 in the Intro to Part 2.

Note that this review will require three posts and some of the posts are rather long. Part 3 of this paper will be posted on 4/27.

https://energycentral.com/c/gr/future-electric-power-united-states-%E2%80%93-part-2

28.19. The Future of Electric Power in the United States – Part 1

Occasionally, I come across an information source that is really, REALLY good, but (sort of) overwhelms me. I did so in Early March. The good news is that I have very wide editorial freedom with Energy Central, and can choose what I write about. Or more to the point, feel that I am qualified to write about. In this instance, the subjects I don't feel I should write about are primarily issues that are difficult to quantify (like cultural, regulatory or societal issues) or difficult to predict (future financial and legal considerations).

The title source is referenced in each of the three parts of this paper. This is a monster document, but well worth reading. I completed this task (with much skimming) and will summarize about half of it in this paper and those that follow. I will also note the sections I am not covering. You can download this document and read both yourself.

Note that this review will require three posts and some of the posts are rather long. The three parts of this paper will be posted on the weeks of 4/19 and 4/26.

https://energycentral.com/c/um/future-electric-power-united-states-%E2%80%93-part-1

28.20. Electric Decarbonization

My home-state (California) has a goal to use "…renewable energy resources and zero-carbon resources…" to supply 100 percent of retail electricity sales and electricity procured to serve all state agencies by 2045.

The statute (AB 100) calls upon the California Public Utilities Commission (CPUC), California Energy Commission (CEC), and the California Air Resources Board (CARB) to use programs under existing statutes to achieve this policy and issue a joint report on the policy to the Legislature by January 1, 2021, and every four years thereafter. This post briefly covers the first of the above reports.

https://energycentral.com/c/cp/electric-decarbonization

28.21. DOE Solar Desalination Prize

The Solar Desalinations Prize is a four-round completion among developers of innovative technologies that will be used in the future for less expensive and more flexible desalination system.

Removing salt from water takes a lot of energy! Many of the largest untapped water resources in the US and around the world cannot be cost-effectively used because of high concentrations of dissolved salts.

Water treatment processes, like reverse osmosis, are efficient when salt concentrations are low, but can't treat high-salt waters like those that are produced from oil and gas wells, concentrated brines, and some industrial and agricultural wastewaters.

Novel thermal desalination technologies can purify water with very high salt content without dramatically increasing the amount of energy required. By using solar thermal as the energy source, desalination technologies could be used in a variety of important environments, especially in arid areas with high sun exposure, where water purification is especially important.

Note that the Quarterfinalists were announced September 28, 2021. There is a link to a site with the names and locations of these below the link to the paper.

https://energycentral.com/c/um/doe-solar-desalination-prize

https://www.energy.gov/eere/solar/american-made-challenges-solar-desalination-prize-round-2

28.22. The Scientific Method, Not

What is the energy industry and why does it exist?

What I'm defining as the energy industry are electric utilities and products. These were created by science, and it was born from an explosion in scientific knowledge that happened primarily from the 1700s to the present. Electric science and related technologies were developed in this period, by many individuals of science.

But what is science? We are pretty sure that it is responsible for the explosion mentioned to the prior paragraph, and this has enriched all of our lives.

More specifically, what is the scientific method? I have heard this term used frequently in the past, but when I tried to find a reasonable definition, I came up empty so I stopped looking. Then I recently came across a really good book that explained everything.

This post is a brief review of that book.

https://energycentral.com/c/ec/scientific-method-not

28.23. Connections to the Future

Recently the California PUC posted a decision that clearly defines the standards and interfaces that will be required for virtual power capacity systems to inter-operate and operate with utilities. This paper is about those standards.

https://energycentral.com/c/cp/connections-future

28.24. Chill

This paper is about superconductivity, what it is, technologies that use superconductivity and how we might expand these technologies in the future.

https://energycentral.com/c/tr/chill

28.25. 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

28.26. 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

28.27. 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

28.28. 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 desalinization, and a third is a technology for extracting water from the atmosphere.

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

28.29. 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

28.30. 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

28.31. 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

28.32. 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

29. Overview of California Utilities

29.1. California Public Power

This post will look at the public utilities in California in two ways: by the numbers and by their character, and more specifically what differentiates them from the big three IOUs.

https://energycentral.com/c/um/california-public-power

29.2. 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

30. PG&E

30.1. PG&E Network Hardening – 2022 Update

PG&E released an annual update to their Wildfire Mitigation Plan earlier this year. This post will be an updated summary for that document and provide other information on PG&E's efforts to harden their transmission and distribution networks, and thus reduce wildfire risk in their service territory.

https://energycentral.com/c/gr/pge-network-hardening-%E2%80%93-2022-update

30.2. 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

30.3. 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

30.4. 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

30.5. 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

31. California Utility-Related Disasters

31.1. 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

31.2. 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

31.3. 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