Papers Directory, Fourth-Quarter 2024 Update

By John Benson

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Contents

1. Introduction 17

2. Climate Change Impacts & Mitigation 18

2.1. Fast Wildfires 18
2.2. Direct Air Capture of Carbon Dioxide 18
2.3. The Final Steps – The Complete Solution 18
2.4. The Second Steps - The Climate Capitalists 19
2.5. The Second Steps -- Big Oil's Transition 19
2.6. The Second Steps: Carbon Capture & Sequestration 19
2.7. The First Steps: Low-Carbon Cement 20
2.8. Wildfire Protection 20
2.9. Rapid Intensification – A Phrase that will Strike Fear 21
2.10. Geoengineering Delay of Climate Change Sea-Level Rise? 21
2.11. Two New Processes for Carbon Removal and a Monitor 21
2.12. Don't Blame the Petro-Guys for Climate Change 22
2.13. A Modest Proposal for Climate Models 22
2.14. The Cold Blob That's Heating Europe 22
2.15. Forest, Trees and Logging Wars 23
2.16. Past, Present & Future Danger 23
2.17. Roads to Removal, Part 2 23
2.18. Roads to Removal, Part 1 24
2.19. We Can Do This! 24
2.20. Climate Watchdog 24
2.21. In the pipeline 24
2.22. Two Important Climate Reports and a Hockey Stick 25
2.23. A Different Kind of Energy Company 25
2.24. Climate Change and Wildfires 25
2.25. Carbon Super-Eaters 26
2.26. Oceanic GHG Mitigation Hotbed in Cold Water 26
2.27. Pumping Heat 26

2.28. Tesla Master Plan Part 3 27
2.29. CCUS: The Final Path to Net-Zero 27
2.30. Too Much Water, Part 3 27
2.31. A Curious Journey to an Old Friend 27
2.32. Too Much Water, Part 2 28
2.33. Too Much Water! 28
2.34. Eddies in Time Foretell the Future 28
2.35. Measuring Greenhouse Gas Emissions 29
2.36. Pay Now or Pay Later 29
2.37. Ag-NET 29
2.38. Extreme Climate 30
2.39. They Just Keep on Coming 30
2.40. Oceanic Solutions – Coastal Sea-Level Mitigation 31
2.41. New Networks Compendium 31
2.42. Reasonable Transition Part 2, International Liquidity 31
2.43. Damn Satellite Part 3: Super-emitters and Ultra-emitters 32
2.44. Wet NET 32
2.45. Fire & Storms Part 5: Steam and Smoke 32
2.46. Good News & Bad News for Climate Change 32
2.47. NETMeth – Not 33
2.48. New NETWORKS, Part 5: Oxi-Fuel Combustion 33
2.49. Damn Satellite, Part 2 – Damn Airplane & CH_4 33
2.50. Fires and Storms Part 4, 2021 California & Alaska 34
2.51. New NETWORKS, Part 4 – Peridotite & Soil 34
2.52. Polar Vortex – Why Texas Froze 34
2.53. Good People and Bad People 35
2.54. Emerging Technologies to Mitigate Greenhouse Gases 35
2.55. Damn Satellite 35
2.56. Reversing Climate Change – Future Foundation 36
2.57. XPRIZE Carbon Removal 36
2.58. Recent Climate Change Effects 36
2.59. More than 2°C of Committed Warming 37
2.60. New NETWORKS, Part 3: Two Solutions 37
2.61. New NETWORKS, Part 2: Mineralization for GHG Capture 37
2.62. New NETWORKS, Part 1: BECCS 37
2.63. Fires and Storms – Part 1, Rev c 37

2.64. A journey of a thousand miles… 37
2.65. Tough Love – Part 1 38
2.66. Options for Mitigating Climate Change 38
2.67. Geologic Greenhouse Gas Sequestration Projects 38
2.68. Oceanic Solutions 38
2.69. Economics and Climate Change Refugees 38
2.70. Trees 39
2.71. The Path to Net-Zero, Rev B 39
2.72. Fires and Storms, Rev B 39
2.73. Climate and Energy Series, Parts 2 & 3, Rev B 39
2.74. Climate Change - When Time Runs Out 40
2.75. Fire – Costs and Repercussions 40
2.76. Unintended Consequences 40

3. Climate Science 40
3.1. How Science Beat Climate Change Denial 40
3.2. Long-Term Sequestration of Woody Biomass 41
3.3. Climate Complexity 41
3.4. Delicious Carbon Capture 42
3.5. MethaneSat et al 42
3.6. Exascale Breakthroughs 42
3.7. LLNL's Terraforming Soil Project and Related Posts 43
3.8. Geo-Engineering: Strong Incentive and Great Danger 43
3.9. Attribution of Worsening Weather Disasters 43
3.10. El Niño! Part 2 44
3.11. Too Much (Hot) Water! Part 4 44
3.12. Arctic Wildfires at a Tipping Point 45
3.13. El Niño! 45
3.14. Code-Red Tipping Points 45
3.15. Stuck 46
3.16. Coastal Storms 46
3.17. Climate and Energy Part 1: The Future 46
3.18. Accelerating Sea Level Rise 46
3.19. Positive Feedback Accelerates Sea Level Rise 46
3.20. Emerging Negative Effects of Climate Change 47
3.21. Accelerated Warming? 47
3.22. Methane Growth 47

3.23. In Hot Water 47
3.24. IPCC Special Report 48

4. Climate Change Politics & Regulations 48
4.1. U.S. Carbon Management Strategy 48
4.2. The Strongest Greenhouse Gases 48
4.3. Agreements without Teeth? 49
4.4. Transformer – How U.S. Clean Energy Happens 49
4.5. Repercussions 49
4.6. California Doing 50
4.7. Final IPCC Report (for now) 50
4.8. Petro-Greenies 50
4.9. Small Things 50
4.10. California's Electricity System of the Future 51
4.11. New Heavy Truck and Train Rules in California 51
4.12. DOD & Corporate Risk 51
4.13. Climate Risks & Large Corporations' Disclosures 52
4.14. Climate and Trade 52
4.15. DC Moves 52
4.16. California Adjusts 53
4.17. Climate Here and There: Part 2, U.S. Perspective 53
4.18. External Note: RE100 53
4.19. Climate, Here and There, Pt 1, California SB 100 Progress 53
4.20. A SORE Subject 54
4.21. Honest Accounting 54
4.22. Linking Trade and Sustainable Practices 54
4.23. Tough Love – Part 2 55
4.24. Renewably Into the Future 55
4.25. Financial Greenhouse Gas Reduction Incentives 55
4.26. Carbon Offsets – Rev b 55
4.27. Verification of Geologic Greenhouse Gas Sequestration 55
4.28. Climate Change: Two Challenges and Five Solutions 56
4.29. Meaningful Change Series 56

5. Large Industries 56
5.1. Two Words: Plastic Recycling 56
5.2. Increasing Ag Watts 57

5.3. Printed Words, Images, Life-Codes & Objects 57
5.4. 50-years Ago, When Everything Was Invented 57
5.5. Spacy Materials 58
5.6. Amazon Update 58
5.7. Rare and Precious Part 3, from abandoned mines 58
5.8. Rare and Precious Part 2 59
5.9. Niron Magnetics, Not So Rare & Precious 59
5.10. Rare and Precious 59
5.11. Betty Crocker It Is Not 59
5.12. Light & Power, Ongoing Revolution 60
5.13. Industrial Decarbonization Roadmap, Part 7, Further Analysis Needs 60
5.14. Industrial Decarbonization Roadmap, Part 6, Cement Manufacturing 60
5.15. Industrial Decarbonization Roadmap, Pt. 5, Petroleum Refining 61
5.16. Industrial Decarbonization Roadmap, Pt. 4, Food and Beverages 61
5.17. Industrial Decarbonization Roadmap, Part 3, Chemical Manufacturing 61
5.18. Industrial Decarbonization Roadmap, Part 2, Iron & Steel 62
5.19. Amazon Climate Moves 62
5.20. Industrial Decarbonization Roadmap, Part 1, Overview 62
5.21. I Like Smoke & Lightning, Heavy Metal Thunder, Part 3 63
5.22. I Like Smoke & Lightning, Heavy Metal Thunder, Part 2 63
5.23. Financial Systems and Climate Vulnerabilities 63
5.24. Good Chemistry 63
5.25. Oil & Gas, Present & Future 63
5.26. 20,000 Terabytes under the Sea 64
5.27. Concrete Greenhouse 64
5.28. I Like Smoke and Lightning, Heavy Metal Thunder 64
5.29. Clouds and Lightning - Data Centers and Energy 64
5.30. Disruption in U.S. Product Distribution Sectors 64
5.31. Imminent Unexpected Electric Loads 64

6. Large Facilities 65
6.1. Candidates for Advanced Energy Systems 65

7. Aerospace Electric Vehicles 65
7.1. Air Taxi Update 65
7.2. Fast and Sustainable 65
7.3. Medium-Priced Autonomous Drones 65

7.4. Aerial Express System 66
7.5. Future Sustainable Aviation-Fuels & Large Air-Transports 66
7.6. Regional Air Mobility and Electrified Aircraft 66
7.7. eDrone Air Cargo 66
7.8. A Circular Jet Fuel 67
7.9. Air Taxis, Starting to Takeoff? 67
7.10. Baby Steps Move us forward when Walking on Air 67
7.11. See "EV Application Shakeout" Part 2 under Section 19, Storage for BESS & Mobility 67
7.12. Flying Cathodes and Anodes Everywhere 67

8. Marine Electric Vehicles 68
8.1. Hydrogen On the Water 68
8.2. Decarbonizing Marine Transportation 68
8.3. Oceanic Solutions – Ships and Shipping 68
8.4. Low-Carbon Ships 68
8.5. Floating Anodes and Cathodes 69

9. Mass Transit & Track Vehicles 69
9.1. The Greenest Travel 69
9.2. BART, A Half-Century of Innovation 69
9.3. Zero-Carbon Trains 69
9.4. California Rail Electrification - 2022 Update 70
9.5. Hydrail 70
9.6. California Rail Electrification - 2021 Update 70
9.7. SAV Some Time 71
9.8. California Rail Electrification 71

10. Mobility Technology, Regulations & Miscellaneous 71
10.1. Paths to Lithium Nirvana 71
10.2. Oakland's Advanced Mobility Infrastructure 71
10.3. How Dry My Battery Is 72
10.4. New Materials for Tomorrows Energy Industry 72
10.5. EV Motors without Rare Earth Metals? 73
10.6. Transportation Decarbonization & NREL's Battery Breakthroughs 73
10.7. Fool Self-Driving – A Half-Baked AI-Technology 73
10.8. Autonomous eTractor Pull-off with AI 74
10.9. Four paths to Sustainable Mobility 74

10.10. Blueprint for Transportation Decarbonization 74
10.11. Low Carbon Fuel Standard & Low Emissions Provisions 75

11. Road Vehicles 75
11.1. Future EVs 75
11.2. EV News – Mid Summer 75
11.3. Charging Ahead 76
11.4. How China Makes EVs at a Fraction of US. Prices 76
11.5. Rivian Targets Tesla, Ford 76
11.6. Really Big Electric Trucks 76
11.7. Is the EV-Revolution Slowing Down? 77
11.8. Efficient Hydrogen Storage for Big Rigs 77
11.9. EVs, Late Fall 2023 77
11.10. EVs Early Fall 2023 77
11.11. EVs - Late Summer 2023 78
11.12. EVs Mid-Summer 2023 78
11.13. Charging Big Rigs 79
11.14. EVs, Early Summer, 2023 79
11.15. EVs Mid-Spring, 2023 80
11.16. Get Your Motor Runnin', Part 2 80
11.17. EVs Early Spring 2023 81
11.18. Participants in the Last Clean-Vehicle Segments Emerge 81
11.19. E85 81
11.20. Hydro-Honda Gets Help from Trains 82
11.21. EVs Late Winter, 2023 82
11.22. EVs Mid-Winter, 2023 83
11.23. EVs' Tough Road Ahead 83
11.24. EVs Early Winter 2023 84
11.25. Solid State Battery Breakthrough 84
11.26. EVs, Late Fall, 2022 84
11.27. Personal Vehicle Driver Assistance, Engagement & Privacy 85
11.28. EVs-Mid Fall, 2022 85
11.29. Future EV Batteries 85
11.30. EVs Early Fall 2022 85
11.31. EV Late Summer 2022 86
11.32. Get your motor runnin' 86
11.33. EVs Mid-Summer, 2022 86

11.34. EVs - Early Summer, 2022 86
11.35. EVs, Late Spring, 2022 86
11.36. Electric Vehicles, Spring 2022 87
11.37. Electric Trucks and Buses in California 87
11.38. Electric Trucks & Buses, Early 2022 87
11.39. Tesla Early 2022 87
11.40. Clean Cars and Trucks 87
11.41. V2G 88
11.42. Bottom-up, Tesla's Component Edge 88
11.43. Wireless Advanced Vehicle Electrification (WAVE) 88
11.44. 2021 Electric Truck & Bus Update, Part 3, Technology 89
11.45. 2021 Electric Truck & Bus Update, Part 2: Buses 89
11.46. 2021 Electric Truck & Bus Update, Part 1: Trucks 89
11.47. Tesla Environmental Impact 89
11.48. Mobility Diesel Emissions 90
11.49. Tesla 2021 Update 90
11.50. Interoperability 90
11.51. Road Trip 91
11.52. Electric Refuse Trucks & Battery-Electric Buses 91
11.53. Interstate eTrucking 91
11.54. eTrucking 92
11.55. Tesla, Inc. 92
11.56. Little and Big Electric Trucks & Charging Buses 92
11.57. Battery Electric Vehicle Reliability & Maintenance 92
11.58. Electric Vehicle Charging Networks 92
11.59. Toyota, Tesla & Schumer 92
11.60. Trucks and Teslas 93
11.61. Tesla 93
11.62. EV Update 2019 93
11.63. More Trucks and Cars 93
11.64. Trucks and Buses 93
11.65. EV Update 93
11.66. The Evolution of Battery Electric Vehicles and their Supply Equipment 93
11.67. Solutions for EVSE-Related Overloads 94

12. Biomass Generation 94
12.1. Small Steps to Mitigate Climate Change – Biomass – Pt 2 94

12.2. Small Steps to Mitigate Climate Change – Biomass 94
12.3. Biofuels Reboot 94
12.4. Biomass to Biogas to Biochar 95
12.5. NUTS 95

13. Hydrogen and Fuel Cells 95
13.1. Developments in Hydrogen Production 95
13.2. On the Road to H2 in California 95
13.3. A Solution for the Rest of Our Economy 96
13.4. Molecular Sponges for Hydrogen Storage 96
13.5. The Clean-Fuel Debate 96
13.6. New Colors of Hydrogen from the Depths 96
13.7. An Electrifying Chameleon 97
13.8. Economics of Green Hydrogen 97
13.9. Clean Backup Generation 97
13.10. Hydrogen Hubs 98
13.11. California Dreamin' about H_2 98
13.12. Cross Reference 98
13.13. Tech Race 98
13.14. Release the Crackers 99
13.15. Hydrogen's Role 99
13.16. Hydrogen Futures – Rev b 99

14. Microgrids 99
14.1. Strengthening the Grid's Edge Using Diversity 99
14.2. Microgrids for Critical Infrastructure 99
14.3. Neighborhood Virtually-Enabled Microgrids (NVEM) 100
14.4. The Future of Microgrids 100
14.5. Major Evolution of the Utility Paradigm 100
14.6. Microberg 101
14.7. The Five Dimensions of Microgrids 101
14.8. The Reemergence of Microgrids – Part 1, Rev b 101
14.9. The Reemergence of Microgrids – Part 2 101

15. Misc. Renewables 102
15.1. Battery Energy Storage, The Key to Renewables 102
15.2. Geothermal Energy Overcomes Major Obstacle 102
15.3. Hot Rocks Part 4, 2024 Update & Next Generation 102

15.4. Recent Books about Climate & Renewables 103
15.5. Renewable Tipping-Point 103
15.6. Expanding Hydroelectric Generation, the Easy Way 103
15.7. Hot Rocks Part 3 – Widespread Geothermal Power 104
15.8. Oceanic Solutions – Tidal Power 104
15.9. Hot Rocks, part 2 104
15.10. Hydro – Part 3, Small Hydroelectric Plants 105
15.11. Hydro – Management 105
15.12. Hydro – Beginnings: The Birth of the Grid 105
15.13. Hot Rocks – The Perfect Renewable Energy 105
15.14. The Other Major Renewables 106
15.15. Alternatives for Alternative Energy 106

16. Mixed Renewables 106
16.1. Wind & Solar Generation = Big Health Benefits 106
16.2. 5 Stages of Energy Production Viability 106
16.3. Long-Duration Energy Storage to Firm Windpower 107
16.4. Aftermath 107
16.5. US Funds Renewable Technology Development 108
16.6. Linear Thinking 108
16.7. Renewable Energy Expansion Exceeding all Estimates 108
16.8. The Edge of Electric Generation 108
16.9. Destructive Restoration Part 4 – Renewables 109
16.10. Cold Weather Renewables 109
16.11. Recent Developments in Storage, Wind and PV 109
16.12. Repowering 109
16.13. Future Grid - Sun, Wind and BESS 109

17. Politics & Economics of Renewables 110
17.1. Federal Reforms and The Interconnection Problem 110
17.2. California Future Renewables 110
17.3. Interconnection Graveyards – Where Renewable Projects go to Die, Pt 2 110
17.4. Interconnection Graveyards – Where Renewable Projects go to Die, Part 1 110
17.5. Rooftop Solar Energy Tug of War, Part 4, Final Resolution 111
17.6. Rooftop Solar Energy Tug of War, Part 3, Proposed Resolution? 111
17.7. Rooftop Solar Energy Tug of War – Resolution, Part 2 111
17.8. Rooftop Solar Energy Tug of War – Resolution, Part 1 112

17.9. Rooftop Solar Energy Tug of War 112
17.10. Infrastructure Investment and Jobs Act 112
17.11. Renewable Collaboration – Rev c 112
17.12. Future Energy Economics 113
17.13. Audacious Ambitions 113

18. Solar and Solar + Storage 113
18.1. California Residential Solar Firms 113
18.2. The Next-Generation Solar Technology? 113
18.3. Residential Solar Energy Consumer Protection 114
18.4. PV & Storage, Early Summer, 2024 114
18.5. PV & Storage, Mid Spring, 2024 114
18.6. Rooftop Solar Energy Tug of War, Part 7, implementation and results 114
18.7. PV & Storage, Early Spring, 2024 114
18.8. PV & Storage Early 2024 115
18.9. Next Generation Battery Emerges 115
18.10. Next Generation PV Draws Near 116
18.11. Rooftop Solar Energy Tug of War, Part 6, Selection, Survey & Design 116
18.12. PV & Storage Late-Fall 2023 116
18.13. Rooftop Solar Energy Tug of War, Part 5, Real World Project 116
18.14. PV & Storage Mid-Fall 2023 117
18.15. PV & Storage Late-Summer 2023 117
18.16. PV & Storage Mid-Summer 2023 117
18.17. PV & Storage Early Summer 2023 118
18.18. Rapidly Accelerating PV Deployment 119
18.19. PV & Storage, Spring 2023 119
18.20. Gen 3 Concentrating Solar Power 119
18.21. PV & Storage, Early 2023 119
18.22. Major PV & Storage Projects – 2021 vs. 2022 120
18.23. The Future of Solar Energy: 2nd Post… Plastics 120
18.24. PV and Storage, Fall 2022 120
18.25. Renewables and Natural Disasters 120
18.26. PV and Storage, Late Summer 2022 121
18.27. Major PV & Storage Projects, Early Summer 2022 121
18.28. PV and Storage Late Spring 2022 121
18.29. Degradation of Utility Scale PV 122
18.30. Project Nexus, Water & Energy Integration for the Future 122

18.31. PV and Storage, Spring 2022 122
18.32. PV and BESS, Early 2022 122
18.33. Photovoltaic & Storage, Late 2021 – Part 2 123
18.34. Photovoltaic & Storage, Late 2021 - Part 1 123
18.35. State-of-the Art PV Panels: “One word… plastics” 123
18.36. Future of PV, Batteries and More – At the Bleeding Edge 123
18.37. California PUC Distributed Energy Resource Plan 124
18.38. Photovoltaic & Storage for Fall 2021, Part 3, States, Megafactory 124
18.39. Photovoltaic & Storage for Fall 2021, Part 2, US and States 124
18.40. Photovoltaic & Storage for Fall 2021, Part 1, Roles 124
18.41. 2021 Photovoltaic & BESS Projects 125
18.42. Photovoltaic Advancements 125
18.43. 2020 Large PV and PV + Storage Update 125
18.44. Renewables Accelerating 125
18.45. Photovoltaic plus Storage 126
18.46. Photovoltaic Technologies – Past, Present and Future 126

19. Storage for BESS & Mobility 126
19.1. Tomorrow’s Energy Storage 126
19.2. Sodium-Ion Battery Energy Storage Systems 126
19.3. NanoElectroFuel Boosts Flow Batteries 127
19.4. Domestic Lithium 127
19.5. Li-Ion was good enough for many Breakthroughs 127
19.6. Lithium-Ion Battery Breakthroughs 128
19.7. A New Form of Energy 128
19.8. Storage as Transmission 128
19.9. The Golden State’s Future – Welcome to Lithium Valley 128
19.10. Weekly to Seasonal Energy Storage 129
19.11. Wildcards – the Path to 2050 129
19.12. Energy Storage Futures, Vol 5, Role and Impact in 2050 129
19.13. Energy Storage Futures, Vol 4, Distributed PV plus Storage 130
19.14. Energy Storage Futures, Vol 3, Diurnal Storage Economics 130
19.15. Energy Storage Futures, Volume 2, Model Input Data 130
19.16. Energy Storage Futures, Volume 1: Types and Services 130
19.17. The Perfect Rechargeable Battery? 131
19.18. Tesla, Second Quarter 2021 131
19.19. New Battery Technology 131

19.20. Future Long-Term Storage 132
19.21. Battery Energy Storage Projects & Developments 132
19.22. EV Application Shakeout Series 132
19.23. Battery Day – Part 2 133
19.24. Battery Day – Part 1 133
19.25. Long-Term Storage 133
19.26. Battery Breakthroughs 133
19.27. Elon's Amazing Adventures, Vol 1 133
19.28. Combustible Storage 134
19.29. Advances in Battery Energy Storage 134
19.30. Large Battery Energy Storage Systems 134
19.31. Energy Storage Survey 134

20. Wind Power 134
20.1. Off-Shore and On-Shore Wind Comparison 134
20.2. California's Plan for Offshore Wind 135
20.3. East Coast Offshore Wind Comes to Life 135
20.4. Altamont Pass Wind Farm 135
20.5. The Loftiest Vessels 136
20.6. Offshore Wind, Fall 2023 136
20.7. Offshore Wind Update, Early 2023 136
20.8. Offshore Wind, Fall 2022 136
20.9. Oceanic Solutions – Introduction & Offshore Wind 137
20.10. Offshore Wind Late Spring, 2022 137
20.11. Offshore Wind Early 2022 137
20.12. Fall, 2021 Offshore Wind Update 137
20.13. The Fish and the Wind-Turbines 138
20.14. 2021 West Coast Wind Update 138
20.15. 2021 East Coast Offshore Wind Update 138
20.16. 2021 Offshore Wind – West Coast, Turbines… 138
20.17. 2021 Offshore Wind – East Coast Projects 138
20.18. Wind Market & Technology 139
20.19. A Wet & Windy Post 139
20.20. 2020 Wind Energy Update 139
20.21. California Offshore Wind 139
20.22. Off-Shore Wind Update 139
20.23. Wind Power Update 139

20.24. Wind and Water 140
20.25. Large Wind, Small Wind and Future Wind 140

21. Grid Management 140
21.1. Intermittency Compatibility Toolkit, Part 2 140
21.2. Intermittency Compatibility Toolkit, Part 1 140
21.3. New Role for Regional Grid Managers 140
21.4. CAISO Part 6a – Expansion, Update 141
21.5. California Resource Adequacy Procedures, Community Choice Aggregators and Direct Access 141
21.6. California Independent System Operator 141

22. Utility Generation (Non-Renewable) 141
22.1. Fire, Utilities' First Technology 141
22.2. Reasonable Transition 142
22.3. Distributed Energy Resources Integration Roadmap 142
22.4. Virtual Power Plant Projects 142
22.5. Destructive Restoration – Part 3, Coal 143
22.6. Destructive Restoration – Part 1, The Klamath 143
22.7. Virtual Resources 143
22.8. Zero-Emissions Combined Cycle and Beyond 143
22.9. One company aims to reinvent the nuclear reactor 143
22.10. Old and New Cycles 144

23. Utility Market Forces 144
23.1. PICSI 144

24. Utility Resources 144
24.1. The Air We Breathe, Parts 2 & 3 144
24.2. The Air We Breathe 145
24.3. Human Data Acquisition & Control 145
24.4. Universal Coronavirus Vaccine 145
24.5. Water World 146
24.6. Light at the End of the COVID-19 Tunnel 146
24.7. A Renewable Career 146
24.8. Phase 3 COVID-19 Vaccines – Rev b 147
24.9. Phase 3 COVID-19 Vaccines – Rev a 147
24.10. Phase 3 COVID-19 Vaccines 147

25. Nukes 148
25.1. Pacific Fusion: The Third Path 148
25.2. Twisted Fusion: The Stellarator, Part 2 148
25.3. Nuclear Element 148
25.4. Nuclear Power Partnerships 148
25.5. Roadblock to Nuclear Expansion 149
25.6. Nukes Part 8 - Fast Breeders 149
25.7. Aneutronic Fusion Energy 150
25.8. Not so Distant Nuclear Fusion 150
25.9. Distant Nuclear Fusion – Update 150
25.10. Nukes, part 7 150
25.11. Twisted Fusion: The Stellarators 151
25.12. Nukes, Part 7: Micro Reactors 151
25.13. Nukes – Part 6 151
25.14. Nukes – Part 5 151
25.15. Distant Nuclear Fusion 152
25.16. Destructive Restoration – Part 2, Nuclear 152
25.17. Nukes – Part 4 152
25.18. Nukes – Part 3 152
25.19. Flying Nuke on Saturnian Moon Titan 153
25.20. Amazing Voyage 153
25.21. Nukes, Part 2: Little Nukes 153
25.22. Nukes 153

26. Utility Safety 153
26.1. Public Safety Power Shutoffs 153

27. Utility Technology – Overview 153
27.1. 100% Clean Electricity by 2035? 153
27.2. Sustainable Utilities 154
27.3. Four Decades of Accelerating Change 154

28. Utility Technologies 154
28.1. Long-Term Security-Constrained Optimum Dispatch 154
28.2. Transmission Backbone for Western Renewables 155
28.3. The Hardest Problems, Part 2 155
28.4. No Scientific Proof 155
28.5. Vegetation Control with a Twin Assist 156

28.6. The Hardest Problems 156
28.7. Alternative Desalination Process Better Suited for PV 156
28.8. Bright Developments 157
28.9. The Godfathers of Energy Efficiency, Part 3, Microwave 157
28.10. The Godfathers of Energy Efficiency, Part 2, Red 157
28.11. Laying down the Law – In Memory of Gordon Moore 158
28.12. Two Major HVDC Projects 158
28.13. Metamaterials 158
28.14. How California Beat the Heat 159
28.15. California's Water Challenges and Possible Solutions 159
28.16. The Body Electric 159
28.17. Electricity Past & Future 160
28.18. Wireless Power 160
28.19. Chips Dip 160
28.20. HVDC Transmission, Part 2, Major Projects 160
28.21. HVDC Transmission - Part 1 Technology 160
28.22. Power Industry 2022 Trends & Predictions 161
28.23. The Godfather of Energy Efficiency 161
28.24. California Agricultural Demand Response 161
28.25. New (Neuromorphic) Computing 162
28.26. AMI Part 5 – New Networks 162
28.27. Undergrounding – Part 2 162
28.28. Undergrounding 163
28.29. PG&E Distribution Hardening 163
28.30. Managing the Duck Curve and all of Its Foul Relatives 163
28.31. The Future of Electric Power in the United States – Part 3 164
28.32. The Future of Electric Power in the United States – Part 2 164
28.33. The Future of Electric Power in the United States – Part 1 164
28.34. Electric Decarbonization 164
28.35. DOE Solar Desalination Prize 165
28.36. The Scientific Method, Not 165
28.37. Connections to the Future 166
28.38. Chill 166
28.39. Grid Modernization – Preparing for the Future 166
28.40. Cyber-Security Basics – Rev b 166
28.41. Initial Resilience 166

28.42. Watts and Water 167
28.43. Squirrel up to No Good 167
28.44. Wide-Area Grid Security 167
28.45. Advanced Metering Infrastructure (AMI) 167
28.46. Supervisory Control and Data Acquisition (SCADA) 167

29. Overview of California Utilities 168
29.1. California Public Power 168
29.2. New / Old Major Municipal Utility 168

30. PG&E 168
30.1. PG&E Pitch Fest 2023 & the Rest of the Story 168
30.2. PG&E Network Hardening – 2022 Update 168
30.3. PG&E – Final Agreement and Bankruptcy Resolution 168
30.4. PG&E – Components of an Agreement 169
30.5. PG&E and Climate Changes 169
30.6. PG&E – Near the Finish Line? 169

31. California Utility-Related Disasters 169
31.1. California Wildfires, Utilities and Grid Resilience 169
31.2. Wildfire & 2019 Repercussions 170
31.3. PG&E – Reasonable Judgement 170

32. Special Issues 170
32.1. Trends & Predictions 2024 170

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 fourth quarter (December) of 2024.

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 title also appears in this document's table of contents (TOC), and can be quickly accessed as described below.

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 the TOC are automatically linked to the actual section and subsection headings in the document body. 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 or section title in the TOC, and you will be taken to the heading for the linked section, 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, for section 2, 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 perform a major update of 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. Fast Wildfires

Recently, I read a really important research article in Science. This was from a huge study regarding wildfires in the US from 2001 to 2020. Although I summarized much of this report (when printed, this article was 20 pages long, and that was without supplemental material), I tried to capture the essence of this article's most important findings. I also used much text from the original article while still staying below my normal maximum length. The following paragraph is from the source article.

The most destructive and deadly wildfires in US history were also fast. Using satellite data, we analyzed the daily growth rates of more than 60,000 fires from 2001 to 2020 across the contiguous US. Nearly half of the ecoregions experienced destructive fast fires that grew more than 1620 hectares (4,000 acres) in one-day. These fires accounted for 78% of structures destroyed and 61% of suppression costs ($18.9 billion). From 2001 to 2020, the average peak daily growth rate for these fires more than doubled (+249% relative to 2001) in the Western US. Nearly 3 million structures were within 4 kilometers of a fast fire during this period across the US. Understanding fast fires is crucial for improving firefighting strategies and community preparedness.

https://energycentral.com/c/ec/fast-wildfires

2.2. Direct Air Capture of Carbon Dioxide

Since the 2000s global emissions have continued to rise and Earth has gotten hotter. Scientists increasingly recognize that limiting warming to the Paris Climate Agreement goal of 1.5 degrees Celsius or even 2°C above preindustrial temperatures will require more than drastically cutting emissions—it will involve pulling hundreds of billions of tons of carbon dioxide out of the atmosphere this century. The most obvious way is planting trees. But even a trillion trees would not be nearly enough, and trees can burn or die of disease, emitting the carbon they've stored. In the 2000s the world wasn't ready for direct air-capture (DAC), but now we are too late to do without it.

https://energycentral.com/c/ec/direct-air-capture-carbon-dioxide

2.3. The Final Steps – The Complete Solution

This is the fifth and final paper in a five-paper series on Climate Change. Each of the former parts to this series are from the same book, and were about solutions that can mitigate climate change. This final part is about the whole process, and is from a different book by a different author, albeit one that you may have heard of.

https://energycentral.com/c/ec/final-steps-%E2%80%93-complete-solution

2.4. The Second Steps - The Climate Capitalists

As I'm starting this paper, I've finished the primary source, the book in reference 1 in this paper. I will have completed four papers in this series after this paper is posted.

You might ask what there is only one first step, and three second steps. The two types of actions ("steps") that mankind needs to take to mitigate climate change is (1) to convert all processes that produce greenhouse gas (GHG) to those that greatly reduce those emissions, and (2) remove much of the GHG from the atmosphere.

In the process of doing (1) we will displace major industries, and it seems that (2) might be a good destination (future work) for those industries. For instance, one obvious process we need to mitigate is the production and burning of fossil fuel, (coal and petroleum products). The primary process for accomplishing (2) is carbon capture and sequestration (CCS), and the petroleum industry developed this process, and it would be efficient for them to continue to host CCS and migrate from producing large quantities of combustible fuel to mostly carbon management.

https://energycentral.com/c/ec/second-steps-climate-capitalists

2.5. The Second Steps -- Big Oil's Transition

I am definitely not an apologist for the Petroleum Industry. This is mainly because there is really nothing to apologize for. For the large majority of the 20th and to date in the 21st Century, they provided valuable products to our society, and these products enabled a better quality-of-life among the industrialized world's citizens. When climate change was discovered in the latter half of the 20th Century, they argued strongly against it, which is exactly what any other large industry would in a capitalistic society do, when faced with a threat.

However, climate change is real, and it poses an existential threat to the world if we don't deal with it effectively. Major petroleum corporations have realized this, and many are attempting to provide solutions. This paper is about that, and also a major solution that they invented, that could well strongly mitigate our climate change crisis by pulling the primary long-lived greenhouse gas (carbon dioxide) out of the atmosphere and sequestering it for many Millenia.

Like in the first "The Second Steps…" paper this one has a protagonist. It is also taken from the same book, referenced in this post.

https://energycentral.com/c/og/second-steps-big-oil%E2%80%99s-transition

2.6. The Second Steps: Carbon Capture & Sequestration

The second steps are directly capturing the primary greenhouse gas (GHG) from either the exhaust of some process that emits it, or:

- Directly from the atmosphere, or
- The oceans & other large bodies of water

And sequestering it. The best sequestration method is injecting the gas in deep geological strata.

Carbon Capture & Sequestration (CCS) is a process with a long history. Unfortunately, that history is in the petroleum industry, and thus I'm going to change my style for this paper. This story has a strong protagonist, and I will seek to paint him in a positive light. It will be tough for my readers to trust the oilmen, so I'm presenting a more personal viewpoint in hopes of buying a bit of sympathy.

https://energycentral.com/c/ec/second-steps-carbon-capture-sequestration

2.7. The First Steps: Low-Carbon Cement

Important first steps in mitigating the current and future effects of climate change are moving to net-zero greenhouse gas (GHG) emissions. But assuming we don't wish to wait around for a millennium or two for Mother Nature to clear all of the human-caused GHG from our atmosphere, they are not enough. We also need to actively remove GHG from our biosphere.

This post is about one of the "Important first steps…" Making cement causes as much as 8% of global GHG emissions, and there aren't yet any economical technologies capable of significantly reducing the product's carbon footprint. Cement plants can last for fifty years or more, lowering the turnover rate for new technologies to enter the market. Cement is also a cheap and bulky product, which means plants have to be widely distributed geographically. One industry expert said that a cement plant is only able to meet the needs of customers within a 190-mile radius. That's because the cost of transporting a bulky product longer distances quickly becomes impractical. Thin profit margins have also forced consolidation within the industry, with a few companies controlling the vast majority of global production.

The cement industry also enjoys laxer regulations on emissions compared with, say, power plants. Greatly reduced cost for wind and photovoltaic and other renewable power plus declining cost for battery energy storage puts pressure on fossil-fueled generation, and zero-carbon power will eventually displace them. There aren't yet cleaner alternatives to cement, which remains vital to the economic growth of a country, and thus the industry doesn't feel under pressure to innovate.

Fortunately, Breakthrough Energy Ventures (BEV), a multi-billion-dollar fund has invested in over 100 climate startups, including companies that produce low-carbon cement, and thus low carbon concrete.

https://energycentral.com/c/ec/first-steps-low-carbon-cement

2.8. Wildfire Protection

Climate change will continue to intensify through the current century, and probably well beyond even if we are reasonably successful at mitigating its causes.

Thus, we will need to learn to deal with worsening effects of climate change for well past the end of this century. These include increasing warming which causes:

- Increased heat-related deaths and injuries
- Crop failures due to shortages of water and infrastructure for irrigation
- Dying wild flora and fauna due to the inability to adapt or migrate quickly.

- And because of the prior bullet, increased wildfires.

This post is about the last bullet, and new developments that will help firefighters protect human-built infrastructure from being destroyed by wildfires.

https://energycentral.com/c/gr/wildfire-protection

2.9. Rapid Intensification – A Phrase that will Strike Fear

Unless you are a Climate & Weather Geek like me, you are probably clueless as to what Rapid Intensification means. You will not be for long, especially if you live in coastal areas. Read the text below.

One of the widest hurricanes on record slammed into Florida's Gulf Coast on September 26 as a powerful Category 4 storm, inundating Florida's coast with meters-high storm surge and sending tropical storm–force winds as far as 500 kilometers from its eye. This was Hurricane Helene.

Just three days earlier, it was a disorganized cluster of thunderstorms off the eastern coast of Mexico's Yucatán Peninsula. Within just 60 hours, The National Hurricane Center predicted cluster would intensify at a record-breaking pace, going from winds less than 35 knots (about 40 miles per hour) to hurricane-force winds of at least 100 knots (115 miles per hour).

https://energycentral.com/c/ec/rapid-intensification-%E2%80%93-phrase-will-strike-fear

2.10. Geoengineering Delay of Climate Change Sea-Level Rise?

At current rates, global warming will force coastal cities to contend with about 1 meter of sea level rise by 2100, according to a 2021 report from the Intergovernmental Panel on Climate Change. But some researchers predict worse, warning that the ice sheets on top of Greenland and Antarctica, which store enough water to cause many more meters of global sea level rise, are already past tipping points. Even if humanity curbs emissions and warming slows, they say, these ice sheets may still collapse in the coming centuries. Better to begin research now on how to staunch sea level rise at its source, rather than spending billions to wall off coastal cities, says John Moore a glaciologist at the University of Lapland and an author of a white paper sponsored by the University of Chicago (UC) that proposes a radical solution.

The Whitepaper, released last week by glaciologists after a series of workshops and town halls, calls for boosting research into daring plans that would protect vulnerable ice sheets by building flexible barriers around them or drilling deep into them to slow their slippage into the sea.

https://energycentral.com/c/ec/geoengineering-delay-climate-change-sea-level-rise

2.11. Two New Processes for Carbon Removal and a Monitor

Virtually all experts on climate change mitigation agree that, in order to do this rapidly enough to avoid really major repercussions (like many coastal areas under water, mainly from melting Greenland and Antarctic Ice Sheets), we need to actively remove greenhouse gasses from the atmosphere. The main key for developing a viable technology it to reduce the net cost of doing this below $100 per ton of CO2 removed. Within viable pathways to this goal there are at least two approaches. One relies on a

boost from Mother Nature, and the other subsidizes the CO2-removal with a salable side-product. Those two approaches are examined in this post.

Also, there is a new innovative method for improved monitoring of greenhouse gasses described at the end of this paper.

https://energycentral.com/c/cp/two-new-processes-carbon-removal-and-monitor

2.12. Don't Blame the Petro-Guys for Climate Change

Recently United States House Committee on Oversight and Accountability completed its three-year investigation into how U.S. oil companies sought to avoid accountability for climate change.

The report — tellingly titled Denial, Disinformation and Double-Speak: Big Oil's Evolving Efforts to Avoid Accountability for Climate Change — explores Big Oil's decades-long campaign of deception and denial finding that:

"Documents demonstrate for the first time that fossil fuel companies internally do not dispute that they have understood since at least the 1960s that burning fossil fuels causes climate change and [that they] then worked for decades to undermine public understanding of this fact and to deny the underlying science".

Of course they did. If any major industry found out that their products damage the environment, consumers or any other major part of our economy, their first reaction is to go on offense, and deny, deny, deny. The major goals of the corporations that comprise this industry are to (1) generate profits, (2) funnel those profits to their employees and shareholders, and above all, keep doing (1) & (2) for as long as they can. Being unflinchingly honest is not in their playbook.

https://energycentral.com/c/cp/don%E2%80%99t-blame-petro-guys-climate-change

2.13. A Modest Proposal for Climate Models

This post started with the article in the May 3 issue of Science, "Climate modelers grapple with their own emissions." Note that I am a member of both the American Association for The Advancement of Science (AAAS) which publishes Science, and the Institute of Electrical and Electronic Engineers (IEEE) which published IEEE Spectrum. These organizations' publications provide much content for my writing.

Over the decades, supercomputer simulations of Earth's climate have yielded unprecedented insights into how the interplay of atmosphere, ocean, and land shapes the planet's response to rising levels of greenhouse gases. But as these climate models have grown in complexity, researchers have started to worry the simulations have a substantial climate footprint of their own. Running them can take weeks or longer on a supercomputer, consuming megawatts of electric power—some of it from fossil fuels.

https://energycentral.com/c/cp/modest-proposal-climate-models

2.14. The Cold Blob That's Heating Europe

Earth's climate / weather is an incredibly complex system. I would guess we are at least several years away from having models, powerful enough computer-fleets to process them and be able to predict the climate effects before they happen.

However, I will keep reporting new findings as they come to light. The latest comes from a recent issue of science and helps us understand the title effect.

https://energycentral.com/c/ec/cold-blob-%E2%80%99s-heating-europe

2.15. Forest, Trees and Logging Wars

Frequently, I start a post by reading an article in one of my data-sources as I did for this one. The source was the April Issue of Scientific American, and the excellent article was called Last Stand. This article was well-written and readable. It also took on a very important issue. In this post, I will take on this issue myself, and although I will not advocate a position, I will present the facts, and let my readers decide.

https://energycentral.com/c/rm/forest-trees-and-logging-wars

2.16. Past, Present & Future Danger

One of my major information sources is Scientific American. They send me a daily newsletter called "Today in Science." Today's issue, as I'm starting to write this post (Feb 9, 2024) alerted me to an amazing document and organization. The main goal of both of these is to work with local communities and local governments to address their newly understood vulnerabilities to climate change.

Shortly after Hurricane Sandy devastated the Northeast ten years ago, Rebuild by Design was born. The organization began as an initiative of the federal government that coupled innovation and global expertise with community insight to develop implementable solutions to the region's most complex needs. At the heart of the process was a collaborative research and design challenge that called for the best minds of the world to work with local communities and local governments to address their newly understood vulnerabilities to climate change…

Ninety percent of U.S. counties have experienced a federal climate disaster between 2011-2021, with some having as many as 12 disasters during that time. In 2021 alone, the U.S. experienced 20 separate billion-dollar climate disasters with over 688 direct or indirect fatalities. We can do better.

https://energycentral.com/c/rm/past-present-future-danger

2.17. Roads to Removal, Part 2

In 2020, my viewpoint that the GHG removal would be needed in the long run was a minority opinion. Most thought that simply ceasing the emission of GHG was sufficient. Now the consensus is strongly shifted to the viewpoint that GHG removal will be necessary, even among the most respected research institutions in the U.S.

"There is an urgent need to remove carbon dioxide (CO_2) from the atmosphere to ensure climate security and resilience. In 2022, the United States set a goal of developing carbon dioxide removal (CDR) pathways that will remove CO_2 from the atmosphere and store it at the gigaton scale (at least a billion tonnes per year)." -roads2removal.org

https://energycentral.com/c/ec/roads-removal-part-2

2.18. Roads to Removal, Part 1

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https://energycentral.com/c/ec/roads-removal-part-1

2.19. We Can Do This!

It's a bit ironic. I write frequently about climate change, and on Thursday, Jan 4, shortly after starting to write this post, I will post my summary ("In the Pipeline") of an important paper on that subject by Dr. James Hansen' team. Just before posting it, I am being hit by a flurry of articles regarding 2023 being (globally) the hottest year on record, certainly not good news…

Then, as I was reading my current copy (Jan '24) of Scientific American, I came across an extremely optimistic fact-based article about how good mankind is at overcoming serious environmental challenges. In order to balance the ledger, this post is a summary of that article.

https://energycentral.com/c/cp/we-can-do

2.20. Climate Watchdog

If an information source that I plan to use for a paper is about climate change, then I've probably written about it before. From the title, you can probably tell that this paper is about that subject, and I have, thrice. The first and second similar posts were in 2021, and there was a third in 2022. The titles of these all started with the words "Damn Satellite."

This paper has a bit different spin as we focus on one organization: Climate Trace. This is the watchdog in this paper's title, and it's becoming central to monitoring the world's emissions of greenhouse gasses (GHG), and each significant GHG-emitter in the world. At the end of this report is a link that will let you explore how detailed Carbon Trace is in monitoring all of these emitters (Hint: they are already really, really thorough).

https://energycentral.com/c/rm/climate-watchdog

2.21. In the pipeline

I'm writing these words in a paper that is a brief summary of a recent highly influential document from a team headed by Dr. James Hansen.

Over the last one or two years I have come to believe that the effects of climate change would get much worse over future decades, before humankind could even begin mitigating it.

The last few days, I've been reading this paper, and now I still have the belief described in the above paragraph, but now know why, with many details. This paper will be a very brief summary, and I encourage readers to drill though this to the main document, linked in my paper.

https://energycentral.com/c/rm/pipeline

2.22. Two Important Climate Reports and a Hockey Stick

When you are on a very long journey, and you are not sure if you will ever reach your destination, there are two ways of looking at it. The first is to celebrate progress, and mark every major milestone. The second is to understand how much further you need to travel, and note how many missed past and hopeless future objectives there are on the journey. Which viewpoint you choose might depend on whether you are an optimist or a pessimist.

Being a realist, I enlist both viewpoints, as each performs important functions. Thus, when I checked my news-feeds, I found the two title reports. Each of these seemed to lean towards either the optimist or pessimist view at first reading, so I thought it was important to present them together. However, at the end of the day an article brings up a dataset that ends the discussion with a really big stick.

The two sections below focus on each of these reports. Section 4 is the stick.

https://energycentral.com/c/ec/two-important-climate-reports-and-hockey-stick

2.23. A Different Kind of Energy Company

There is an incorrect assumption that large corporations are fleeing our state in droves. A few are moving their headquarters out of California (I would guess because our taxes are rather high), but continue to have major facilities in our state (read: Tesla).

But what about Energy Companies? After graduation, I started my career with Rockwell Atomics International in Southern California. After a couple of years I moved to GE Nuclear near Livermore, CA. Both of these were major energy companies, and still participate in this sector. GE moved most of its nuclear business to the east coast as part of a consolidation two or three decades ago. Also we are creating a new type of Energy Company in California, the Energy Company of the future.

https://energycentral.com/c/og/different-kind-energy-company

2.24. Climate Change and Wildfires

It is two days before this paper is due to be posted (Sun 8/13) and I need to add a brief paragraph to this summary. As of this morning, 93 people have died in the Hawaiian wildfires (99 just before posting on 8/15), making this the deadliest US wildfire in more than 100 years. If any of my good readers know someone that is influential in Hawaiian wildfire management, they might forward this PDF or link to them. Also, I believe they can benefit from my state's (California's) experience in this field, and will send this to some contacts I have in our state government with some suggestions.

It is a no-brainer that the two subjects of this post are strongly related to each other.

A warmer atmosphere will make droughts worse and vegetation dryer. These by themselves will make wildfires worse. But the whole story is much more complex, and worse-still.

https://energycentral.com/c/gr/climate-change-and-wildfires

2.25. Carbon Super-Eaters

It is widely recognized that old-growth trees in normal forests are excellent way to sequester carbon for hundreds of years. One variant of this technique is to harvest mature trees and use them to build long-lived structures. Another variant is to harvest woody biomass (which could even include wood from structures at the end of their lives) burn it, and geologically sequester the CO_2 and other greenhouse gasses emitted by the combustion.

Most or all of the above techniques would benefit from tree-like plants that have accelerated growth-rates. This post is about two variants of these carbon super-eaters: bamboo and genetically modified variants of normal trees.

https://energycentral.com/c/ec/carbon-super-eaters

2.26. Oceanic GHG Mitigation Hotbed in Cold Water

The ocean-waters off of the California Coast are cold. Although this has been a hotbed of surfing almost as long as Hawaii, the surfers today mostly wear wet-suits.

However lately the oceans around Los Angeles have been for a hotbed for carbon dioxide (CO_2) removal. I've known for many years that much of the CO_2 humans pump into the atmosphere, ends up in the oceans and wreaks havoc there. If we start to remove CO_2 from the oceans, the oceans will mostly continue to absorb this greenhouse gas (GHG) at volumes close to todays until we get the level mostly down to pre-industrial levels. In the meantime we can use the ocean to absorb and transport CO_2.

There are at least two major CO_2 removal ventures in Southern California, each was spawned from a major university, and this post will cover their technologies, and pathway to success.

https://energycentral.com/c/ec/oceanic-ghg-mitigation-hotbed-cold-water

2.27. Pumping Heat

I am a strong believer in energy-efficiency, and I've done everything to my primary residence (in Livermore, CA) to make it as efficient as I can, but my energy bills keep increasing. This was mainly due to steadily rising electric rates. In spite of the mild climate in Livermore (it rarely gets below freezing). I have noted that my winter-heating bills have also been rising, as the price we pay for natural gas has been steadily increasing.

Fixing my high heating bills will require a new system of the type that is the subject of this post.

https://energycentral.com/c/ec/pumping-heat

2.28. Tesla Master Plan Part 3

Like many others, I occasionally find Mr. Musk's oversized ego a bit irritating. However this is a trait he shares with many other great scientists and engineers (Edison, Ford and Tesla to name three).

This post will be a four page summary of the title paper, which is described by Tesla below.

"Today, we are publishing Master Plan Part 3, which outlines a proposed path to reach a sustainable global energy economy through end-use electrification and sustainable electricity generation and storage. This paper outlines the assumptions, sources and calculations behind that proposal. Input and conversation are welcome."

https://energycentral.com/c/cp/tesla-master-plan-part-3

2.29. CCUS: The Final Path to Net-Zero

In case you are wondering what the above acronym means, it is Carbon Capture, Utilization, and Storage, and my home state (California) is embarking on an ambitious plan to develop this technology on a statewide scale. This emerging plan will even move ahead of the current environmentally-friendly federal administration (won't be the first time).

https://energycentral.com/c/ec/ccus-final-path-net-zero

2.30. Too Much Water, Part 3

The part 2 post in this series was mostly about atmospheric rivers. However, where the prior "Too Much Water" post focused on the atmospheric rivers and similar storms that impacted California this winter, as well as their impact on the electric infrastructure, this one will mostly examine the potential causes of this unusual set of storms. In the prior post we also defined the primary cause (climate change), in this post we will dig a bit deeper.

The wet and snowy conditions for the West Coast continue, even though our current Pacific climate pattern (La Niña) is mostly known for dryer than normal years. However we are (officially) transitioning out of the La Niña pattern and into a neutral pattern. What's next? Read this paper.

https://energycentral.com/c/ec/too-much-water-part-3

2.31. A Curious Journey to an Old Friend

I normally don't cross over the border to cover Canadian Startups, but this company (Svante) is heavily invested in U.S technology and personnel as well as venture capital. They also appear to have a well-developed process similar to one developed by UC Berkeley working with ExxonMobil on an eight year project. I reported on the UCB-EM project in 2020, and this is the old friend.

Svante's technology: Solid sorbents, particularly metal-organic frameworks (MOFs), are a step change for the carbon capture industry. Their energy efficiency, resistance to degradation in the face of post-combustion flue gas impurities, and low cost of ownership make them ideal for carbon capture. That's why Svante's team of scientists and engineers elected to use them in the first place.

https://energycentral.com/c/ec/curious-journey-old-friend

2.32. Too Much Water, Part 2

The following description came from the original "To Much Water!" posted about a month ago (immediately listed below).

"If we are taking about the Planet-Earth, the title of this paper is absurd. In general our planet has an almost fixed amount of water. But what isn't static is the water's state. At any given time it may be solid, liquid or gas (water-vapor), and it has a habit of changing from one to the others at all times."

Although the subject of this paper is quite different from the original, I will follow-up one the above quote by asking what happens when rivers leave the surface, and start flowing in the sky?

https://energycentral.com/c/gr/too-much-water-part-2

2.33. Too Much Water!

If we are taking about the Planet-Earth, the title of this paper is absurd. In general, our planet has an almost fixed amount of water over any reasonably short period (say centuries to millennia). But what isn't static is the water's state. At any given time, it may be solid, liquid) or gas (water-vapor), and it has a habit of changing from one to the others at all times. This habit is obviously driven by temperature, but it's also driven by many other causes. The deeper you delve into "the water-cycle," the more complex this system becomes. Even though we've been studying this for decades to centuries, fully understanding this still challenges our best climatologists using huge simulation-suites running on our most powerful supercomputers. However we are making progress, and we'd better: a large percentage of people on our planets live in coastal areas and other regions beset by floods. All too soon an increasing percent of these people will get to experience the title of this paper firsthand.

This post will explore immediate threats, specifically how and when sea level will rise. Also, I'm not looking at coastal floods happening centuries in the future, but those ranging from a few decades hence to the end of this century. In other words, where we still have time to mitigate the severity.

https://energycentral.com/c/ec/too-much-water

2.34. Eddies in Time Foretell the Future

In case you haven't noticed, approximately 71% of Earth's surface is covered by water. To say that oceans, rivers and other large bodies of water have a major effect on weather and climate is an understatement. However, until recently we have been flying-blind when it comes to one major characteristic of these bodies: what's happening in the third dimension (the depths). If everything goes right, in about six months this gap will be illuminated.

Major electric utility organizations' (like independent system operators (ISOs) and Regional Transmission Operators (RTOs)) short-range planning starts with models that simulate operations for several days. The most important non-utility inputs to these models are weather forecasts. The major advance described in this post will result in

much more accurate short-term and longer term weather forecasts. The latter will enable these utilities to extend their planning horizon.

Also, of course, climate change is, or should be, important to everyone. Different models are used to predict future effects of climate change. These too will benefit greatly from the new tool described in this post, and enable more accurate and longer-range forecasts.

https://energycentral.com/c/gr/eddies-time-foretell-future

2.35. Measuring Greenhouse Gas Emissions

Many of the papers I have written about climate change attempt to quantify various effects of this human-made modification of the world's climate. Since all of the world's people share an atmosphere, it is really difficult to measure where greenhouse gases (GHG) are coming from. In the past couple of years I have written a three part series on new technologies that can define individual sources.

One of my primary sources is Science Magazine, and the November 4 issue had an excellent editorial by Al Gore that alerted me to a major new development that globally identifies GHG emissions sources. I've excerpted this editorial in Section 2 of this post. Section 3 will delve into the new organization that defines GHG sources and review their website, which I also reference.

https://energycentral.com/c/cp/measuring-greenhouse-gas-emissions

2.36. Pay Now or Pay Later

Sometimes we need a reminder. Three or four years ago, when there were still a few climate change mitigation advocates parroting the goal of holding the global warming increase to 1.5°C, my main response was: "ha-ha, how about 5°C." Since then, although they occasionally mention their original goal, they have mostly shifted to 2°C.

The good news is that some major countries are starting to show some significant commitment to really reducing the amount of greenhouse gas being pumped into our global atmosphere.

The bad news is that many counties have not experienced the above described attitude adjustment and are determined to keep to a "business as usual" path.

This post will consist of several pieces of evidence that the cost of not participating in climate change mitigation will be high indeed.

https://energycentral.com/c/cp/pay-now-or-pay-later

2.37. Ag-NET

This paper mainly discusses agricultural negative emissions technology (thus its name). The recently passed Inflation Reduction Act (IRA) provides substantial funding for this practice. However the potential problem with this is that it's currently difficult to quantify the effectiveness of Ag-NET, but IRA recognizes this and includes significant funding to develop better measurement methods.

The big problem with Ag-NET is that the processes for plants and soil absorbing and releasing CO_2 are really complex. Furthermore, these processes are different for

different locations, climates, crops, soil-types, etc. It's relatively easy to measure the CO_2 (and other greenhouse gases), released by smokestacks or tailpipes, but not so much for the releases and absorption in soils, plants, and livestock.

https://energycentral.com/c/ec/ag-net

2.38. 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

2.39. 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

2.40. 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

2.41. 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

2.42. 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

2.43. 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

2.44. 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

2.45. 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

2.46. 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

2.47. 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

2.48. 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

2.49. Damn Satellite, Part 2 – Damn Airplane & CH_4

"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 (CH_4) can be identified.

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

2.50. 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

2.51. 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

2.52. 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

2.53. 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

2.54. 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

2.55. 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

2.56. 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

2.57. 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

2.58. 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

2.59. 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

2.60. 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

2.61. 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

2.62. 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

2.63. 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

2.64. 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

2.65. 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 4.23.

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

2.66. 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

2.67. Geologic Greenhouse Gas Sequestration Projects

Earlier I posted Verification of Geologic Greenhouse Gas Sequestration (see section 4.27). 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

2.68. 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

2.69. 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

2.70. 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

2.71. 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

2.72. 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

2.73. 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

2.74. 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

2.75. 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

2.76. 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. How Science Beat Climate Change Denial

“It's a very strange experience to watch a play in which you are a character- and to shake hands with the person who plays you. I did both this past July while attending a performance of Kyoto at the Swan Theater in Stratford upon Avon in England. The moment meant more, of course, than just a glimpse of oneself on history's stage. The play shows how science won out over climate denial in a critical face-off between scientists and industry over the future of the planet.”

“Kyoto is about the Kyoto Protocol, an agreement made more than 25 years ago that, as summarized by the United Nations, committed "industrialized countries and economies in transition to limit and reduce greenhouse gases (GHG) emissions in accordance with agreed individual targets." Written by Joe Murphy and Joe Robertson, the play provides

a dramatic retelling of a historic meeting in December1997 in Kyoto Japan, where the protocol was finalized.

The above quote is from Dr. Ben Santer, a resident of England, that also worked at LLNL and also lived or lives in California. This post is about the dramatic events surrounding the Kyoto Protocol and “Kyoto” the play.

https://energycentral.com/c/ec/how-science-beat-climate-change-denial

3.2. Long-Term Sequestration of Woody Biomass

A recent discovery may give us a short-cut to isolate biomass from the biosphere for a very long time without extensive processing.

Limiting climate change requires achieving net-zero carbon dioxide emissions. Although substantial reduction in fossil fuel emissions is essential, it is insufficient for achieving the international goal of restricting global warming to 1.5° or 2°C above preindustrial levels. Achieving net-zero necessitates approaches that remove carbon dioxide from the atmosphere, known as carbon dioxide removal (CDR).

Engineering CDR methods, such as direct air capture, are expensive and energy-intensive. Nature-based CDR, such as reforestation and afforestation, are cheaper but face land-use competition, scalability, and carbon leakage risks.

Forests are central to climate change discussions because of their critical role as a dominant land carbon sink in natural carbon cycles. They sequester carbon from the atmosphere through photosynthesis. This carbon is stored in wood with ∼50% carbon content that varies by species. The carbon is released back to the atmosphere through burning (forest fires or prescribed burning for fire risk management) or decomposition of woody biomass.

This paper describes a pathway to making deadwood carbon storage a reality. The authors present a CDR approach involving the burial of sustainably sourced wood in an underground engineered structure called a “wood vault” to prevent wood decomposition.

https://energycentral.com/c/ec/long-term-sequestration-woody-biomass

3.3. Climate Complexity

I was recently reminded that all activities of humanity, which impact all areas of science, are much more complex than scientists have learned to deal with. Shortly thereafter I read an article that was within one of the areas that I write about: climate change (a.k.a. global warming), and sure enough, the same story.

For the past year, alarm bells have been going off in climate science: Last year’s average global temperature was so high, shooting up nearly 0.3°C above the previous year to set a new record, that human-driven global warming and natural short-term climate swings seemingly couldn’t explain it. Now, a new series of studies suggests most of the 2023 jump can be explained instead by a familiar climate driver: the shifting waters of the tropical Pacific Ocean…

https://energycentral.com/c/ec/climate-complexity

3.4. Delicious Carbon Capture

I subscribe to many information sources, but occasionally, a lead for a really good paper comes from our local paper in the Livermore Valley, “The Independent.” This paper covers the usual breaking news, sports and community events, but also covers major government facilities in the valley, like Lawrence Livermore National Lab (LLNL) projects.

Your author enjoys a few glasses of wine and occasionally beer. However, I tend to favor the beverage made from grapes, because (1) in my earlier years I was an amateur winemaker, and (2) the Livermore Valley is a major Winery Region, with over 40 wineries.

You ask: “What the heck does Wine have to do with carbon capture or National Labs? Ah-ha, Gotcha!

https://energycentral.com/c/cp/delicious-carbon-capture

3.5. MethaneSat et al

SpaceX successfully launched a game-changing satellite on Monday March 4. Called MethaneSAT, the new satellite is in orbit tracking methane leaks from oil and gas companies worldwide.

Methane is a critical driver of climate change. When it comes to trapping heat inside Earth's atmosphere, methane is over 28 times more powerful than carbon dioxide. Tracking methane leaks will help identify the most egregious emitters.

The Environmental Defense Fund developed MethaneSAT, and Google has partnered with the organization to create its first global methane map by the end of the year for all to see, ushering in a new era of climate accountability.

MethaneSAT, as the new satellite is called, is the latest to join more than a dozen other instruments currently circling the Earth monitoring emissions methane. But it won’t be the last. Over the next several months, at least two additional methane-detecting satellites from the U.S. and Japan are scheduled to join the fleet.

https://energycentral.com/c/ec/methanesat-et-al

3.6. Exascale Breakthroughs

Early in my career I worked in a position where I modeled hydrodynamic and thermodynamic systems. The technique we used in that work was generally called finite-element modeling, where we broke each system down into a large number of cells, and used equations for each cell that described the liquid-flow (hydrodynamic) and/or heat-transfer (thermodynamic) in and out of each cell.

Many of the techniques we used back then (late 1970s) were very primitive, but the basic finite-element technique remains in place, and in use for modeling the largest system we deal with currently – Our Planet’s Biosphere.

My across-town neighbors (and others) recently won a major award for computer model-building, and described some breakthroughs they made in winning this prize.

A Lawrence Livermore National Laboratory (LLNL)-led effort that performed an unprecedented global climate model simulation on the world's first exa-scale supercomputer has won the first-ever Association for Computing Machinery (ACM) Gordon Bell Prize for Climate Modelling, ACM officials announced Thursday (Nov 16).

https://energycentral.com/c/rm/exa-scale-breakthroughs

3.7. LLNL's Terraforming Soil Project and Related Posts

The Terraforming Soil Energy Earthshot Research Center (EERC) may sound minor on the surface (pun intended), but it is both major and critical to mitigating climate change.

While the United States' 410 million acres of agricultural soils have lost a vast amount of carbon in the past century due to cultivation and erosion, there is clear potential to reverse this trend and actively manage agricultural lands with strategies that capture CO2 from the atmosphere. The Terraforming Soil Energy Earthshot Research Center (EERC) at Lawrence Livermore National Labs will research new bio- and geo-engineered techniques to understand, predict and accelerate scalable and affordable CO2 drawdown in soils, via both organic and inorganic carbon cycle pathways.

https://energycentral.com/c/ec/llnl%E2%80%99s-terraforming-soil-project-and-related-posts

3.8. Geo-Engineering: Strong Incentive and Great Danger

I have written about the subject of this post, climate change, frequently in the past, and shall also do so this time with a different spin, the hyphenated word in the title of this post.

Climatologists get a bad case of the cold sweats when someone suggests this solution, because they believe that the humans that caused climate change, will just make things worse by trying to engineer the climate more than they already (unintentionally or otherwise) have. I am hard-pressed to disagree with them.

However, I also believe we are just starting to see major effects of climate change, and these are likely to get much worse over time. If geo-engineering has the potential to give us more time to stop pumping greenhouse gas (GHG) into the atmosphere and start to draw down the concentration of GHG we have pumped in already, we need to bring it to the table, and start evaluating it.

https://energycentral.com/c/rm/geo-engineering-strong-incentive-and-great-danger

3.9. Attribution of Worsening Weather Disasters

Perhaps you have noticed the weather in early summer has been a little too exciting, with many record heat waves, also record rainfall leading to flooding, and then there are the wildfires in Canada, leading to widespread smoke, and Hawaii, leading to over 100 deaths.

Do you have some eggs to cook? If you live in Florida, you might try plopping them in the ocean (101°F). In Texas and Arizona, a nearby sidewalk will probably work.

Also, you may have noted it's a bit windy, and what's that hitting our roof?

June and July combined yielded 528 reports of hail larger than golf balls (two inches in diameter or greater) across the country. The previous record for an entire summer, defined as June, July and August, was 378 reports in 2009. It's worth noting that bookkeeping only dates back to 2004 for hail reports, but it's a remarkable number regardless…

There were exactly 150 tornado and severe thunderstorm watches issued, the most July watches since 2003.

I might guess that your primary question is what is causing this strange weather. The best answer might come from an international team of scientists called the World Weather Attribution (WWA) group, and this paper is mostly about this group.

https://energycentral.com/c/ec/attribution-worsening-weather-disasters

3.10. El Niño! Part 2

I started the original "El Niño!" with a quote. Below is another quote – my layman's guess in the original "El Niño!" as to the next phase of this future powerful weather system (El Niño! Southern Oscillation, or ENSO).

"My guess is that after this summer that our climate will swing into an El Niño phase..."

There was just one error in the above prediction, but first some explanations. The winter of 2022/23 was a La Niña phase, and also the last of a triple-header La Niña (three years in a row of La Niña winters). Normally when we are transitioning from a La Niña to an El Niño, this happens in the summer: first spring into summer we transition from La Niña to ENSO-neutral conditions, and then from summer into fall into El Niño. This year was not "normal."

June 8, from the NOAA ENSO Blog: "El Niño conditions have developed, as the atmospheric response to the warmer-than-average tropical Pacific sea-surface kicked in over the past month…"

https://energycentral.com/c/ec/el-ni%C3%B1o-part-2

3.11. Too Much (Hot) Water! Part 4

Our endless procession of Atmospheric Rivers in California settled down in mid to late April and we actually had a couple of weeks of relatively dry weather. However, as I'm starting to write this in early May, I found that scientists all over the world are concerned about water of a different sort:

A recent, rapid heating of the world's oceans has alarmed scientists concerned that it will add to global warming.

This month, the global sea surface hit a new record high temperature. It has never warmed this much, this quickly.

Scientists don't fully understand why this has happened.

https://energycentral.com/c/ec/too-much-hot-water-part-4

3.12. Arctic Wildfires at a Tipping Point

I have written on this subject before. Arctic amplification is a secondary effect of climate change, where global warming in the summer increases the temperature by more than twice as much in Polar Regions. A major concern from this is that it accelerates melting of the polar ice caps.

Unfortunately, rising oceans are not the endpoints of the risk from arctic amplification. Another effect, with a strong positive feedback element, may even be worse in the long run. Two recent articles and papers in Science describe this effect. The following text is from a summary of the main paper.

Vast amounts of organic carbon are stored in Arctic soils. Much of this is in the form of peat, a layer of decomposing plant matter. Arctic wildfires release this carbon to the atmosphere as carbon dioxide (CO_2) and contribute to global warming. This creates a feedback loop in which accelerated Arctic warming dries peatland soils, which increases the likelihood of bigger, more frequent wildfires in the Arctic and releases more CO_2, which further contributes to warming. Although this feedback mechanism is qualitatively understood, there remain uncertainties about its details.

https://energycentral.com/c/ec/arctic-wildfires-tipping-poin

3.13. El Niño!

Most of my readers (sort of) know what El Niño is. I've written before about this, and I also am known to frequent a blog that covers the dynamic climate system El Niño is part of. At the beginning of their November Post they had some good descriptions of this system, and well as some information that will probably start to have some serious effects on the World's Weather. I will start this in Section 2 below, mostly use their words, and fill in with mine and those of a respected climatologist's as needed.

https://energycentral.com/c/pip/el-ni%C3%B1o

3.14. Code-Red Tipping Points

Merriam-Webster defines a tipping point as: "The critical point in a situation, process, or system beyond which a significant and often unstoppable effect or change takes place."

An example is when a microphone and amplifier start experiencing positive feedback, and the slightest noise sets off an ear-splitting howl.

I frequently write about the primary, secondary and higher-order effects of climate change. Within the matrices of these effects are numerous tipping points, and therein lies extreme danger. Since the world's climate is a huge system, the effects of positive feedback don't happen within seconds as with the above example, but decades to centuries. This means we don't completely understand that we've passed these points until it is too late to easily fix them.

Our (the world's) society also experiences tipping points though major attitude adjustments, and these are needed to address our climate's tipping points.

This post is about recently identified and characterized tipping points in our attitude and climate.

https://energycentral.com/c/ec/code-red-tipping-points

3.15. 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 post linked below is an update of the above paper and includes additional content from Dr. Hansen's recent paper (7/13/2021). There are also words on the same effect from other sources.

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

3.16. 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

3.17. Climate and Energy Part 1: The Future

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, and a third update in December 2022. 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

3.18. 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

3.19. 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, and one of these involves beavers' revenge.

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

3.20. Emerging Negative Effects of Climate Change

Climate change is caused by greenhouse gases (GHG), primarily carbon dioxide (CO_2) 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 CO_2 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

3.21. 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

3.22. 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

3.23. 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

3.24. 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. U.S. Carbon Management Strategy

The title describes a DOE document I came across recently. Since I have presented other viewpoints on this subject, I decided that I needed to summarize the title document, which is referenced in this paper. The text below is from this document.

The U.S. Department of Energy's (DOE's) Carbon Management Strategy ("Strategy") provides a comprehensive roadmap for the remainder of the decade that outlines the diverse tools and approaches DOE will use to develop and deploy carbon management solutions in line with President Biden's climate, economic, and social priorities. Carbon management—an umbrella term that encompasses the suite of technologies used for capturing, transporting, converting, and storing carbon dioxide (CO2), as well as removing it directly from the atmosphere—is a critical component of the DOE's climate change mitigation strategy.

https://energycentral.com/c/cp/us-carbon-management-strategy

4.2. The Strongest Greenhouse Gases

I seriously doubt that the compounds known as hydrofluorocarbons (HFCs), chlorofluorocarbons (CFCs), hydrochlorofluorocarbons (HCFCs) and nitrogen oxides (NOx) are literally the title of this paper, but they are the most widely produced very strong greenhouse gases (hereafter GHG).

HFCs, CFCs and HCFCs are three generations of refrigerants. Let's say you own a house or a car with air conditioning. Further, the former has central air conditioning. If you needed to replace it (as I did a few years ago), you are probably looking at laying out mid four-figures to low five-figures. The primary reason I replaced it was for improved efficiency but assume the only reason you need to replace it is that needs to be recharged with one of the above refrigerants. Do you think you would be willing to pay a high enough price for that refrigerant to where there might be a strong black market.

NOx is mainly produced by agricultural fertilizers, combustion and various industrial processes. With modern gasoline-fueled autos, catalytic converters are highly effective in reducing NOx emissions. They achieve conversion efficiencies ranging between 90% and 99.9%1. But large diesel trucks are a different matter.

https://energycentral.com/c/rm/strongest-greenhouse-gases

4.3. Agreements without Teeth?

Nearly 200 countries agreed in December at the United Nations's 28th Conference of the Parties climate summit to "transition away from" fossil fuels. Some observers called it a political milestone. But many climate scientists described the nonbinding pledge—which asks countries to develop new plans within 2 years to curb greenhouse gas emissions, including methane—as barely a step forward.

"It's like promising your doctor that you will 'transition away from doughnuts' after being diagnosed with diabetes."

- Michael Mann, University of Pennsylvania in The Guardian

"With every empty promise, millions more people will enter the front line of climate change and many will die."

- Friederike Otto, Imperial College London, in The Guardian

As I pointed out in an earlier post, we have been down this road before, and there is some reason to be optimistic.

https://energycentral.com/c/cp/agreements-without-teeth

4.4. Transformer – How U.S. Clean Energy Happens

This paper will answer an important question: how does the U.S. Government make major decisions about our energy future? A major part of the answer comes from an unlikely source: an Assistant Professor of Mechanical and Aerospace Engineering and the Andlinger Center for Energy and the Environment at Princeton University.

During the high-stakes negotiations over what became the Infrastructure Investment and Jobs Act and the Inflation Reduction Act, the Princeton's ZERO LAB led by Professor Jesse Jenkins, and the San Francisco-based consultancy Evolved Energy Research operated a climate-modeling war room that provided rapid-fire analyses of the likely effects of shifting investments among a smorgasbord of clean-energy technologies. As legislation worked its way through Congress, Jenkins's team provided elected officials, staffers, and stakeholders with a running tally of the possible trade-offs and payoffs in emissions, jobs, and economic growth.

https://energycentral.com/c/cp/transformer-%E2%80%93-how-us-clean-energy-happens

4.5. Repercussions

On one hand I've always felt that we should find a future roles for the petroleum and coal industries, and have described some of these potential roles in my writings. On the other hand all people and other entities (like large corporations, including their officers) should be held accountable for past crimes. Note that I'm an engineer, not a lawyer, so any of my own text in this writing is definitely not a legal opinion.

However, the first section of this paper states a legal opinion by entities that are lawyers, and have armies of other lawyers.

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

4.6. California Doing

I have lived in the title state for most of my adult life. Yes, our state is really complicated, but we really need to be:

The economy of the State of California is the largest in the United States, with a $3.598 trillion gross state product (GSP) as of 2022. It is the largest sub-national economy in the world…

I have worked with our state's agencies for over two decades, and have a pretty good understanding of their processes, including their functions. Whereas most states might have one or two agencies that are responsible for Energy and Utilities, California has at least four major agencies…

The actions by many of these agencies frequently extend beyond California state-boundaries, impacting regional and even national energy-related policies. This Paper will explore actions that my state is taking to propel us towards climate-related goals.

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

4.7. Final IPCC Report (for now)

I have reviewed several earlier IPCC (the UN's International Panel on Climate Change) documents starting in 2018. The latest report that this post summarizes is likely to be last for some time.

I'm trying to eliminate any text that is repetitive, an opinion or otherwise not suitable for my readers. However, even with these deletions, and condensed summaries, this still requires three posts (volumes): two that are over 4,000 words, and one that is much shorter. I will post these consecutively over about a week.

https://energycentral.com/c/cp/final-ipcc-report-now-volume-1

https://energycentral.com/c/cp/final-ipcc-report-now-final-ipcc-report-now-vol-2

https://energycentral.com/c/cp/final-ipcc-report-now-final-ipcc-report-now-vol-3

4.8. Petro-Greenies

Frequently in past posts I have argued that we must find roles for fossil-fuel industries after removing petroleum and coal from the ground and burning it is no longer required nor acceptable. I have advocated this position for several years, and have even suggested some roles that large corporations that produce petroleum and coal products can move into.

I am glad to say, in a recent Time article, I've found another large organization that is migrating to the above position: the U.S. Federal Government. Read on for more details.

https://energycentral.com/c/og/petro-greenies

4.9. Small Things

"Great things are not done by impulse, but by a series of small things brought together."

~ Vincent Van Gogh

Like Mr. Van Gogh, I am a believer in taking small, positive steps. Even if one does not aspire to do great things, these frequently happen with small, positive steps.

When it comes to mitigating climate change, this is especially true. Our national leader (President Biden) has recently said this, and that is what this post is about.

The Biden administration is poised to unveil its most ambitious effort yet to roll back planet-warming pollution from the nation's thousands of power plants — an effort that's certain to bring a legal and political attack from conservatives but may disappoint some supporters of the president's climate agenda.

The proposal from EPA was unveiled on the week of May 8. It makes key trade-offs in its efforts to slash the power industry's greenhouse gas output without running afoul of a skeptical Supreme Court, according to four people briefed on the upcoming regulations.

https://energycentral.com/c/cp/small-things

4.10. California's Electricity System of the Future

I'm proud to be a Californian, and one (of many) reasons why, is that we are leading the charge in the battle to mitigate climate change. I decided many years ago that human caused climate change is the greatest challenge humans will face in this century.

On May 25th Governor Newsom released "Building the Electricity Grid of the Future: California's Clean Energy Transition Plan," This document is linked in the main paper. Although we have already made great progress in rapidly expanding the amount of zero-greenhouse gas (GHG) generation powering our electric grid, California ultimate goal is 100% clean electricity by 2045. When combined with other major goals that will reduce our greenhouse gas emissions, this should allow our state move our economy to be net-GHG-emission-free by 2045.

https://energycentral.com/c/ec/california%E2%80%99s-electricity-system-future

4.11. New Heavy Truck and Train Rules in California

The California Air Resources Board (CARB) is almost always the first-mover when it comes to regulations that reduce greenhouse gases and other sources of pollution. CARB recently approved world-leading regulation to phase out the sales of medium and heavy-duty greenhouse gas emitting trucks in California by 2036.

CARB also approved first-in-the-nation regulation to limit train pollution.

https://energycentral.com/c/ec/new-heavy-truck-and-train-rules-california

4.12. DOD & Corporate Risk

This will be a strange post / paper. I will treat the U.S. Department of Defense NOT as the defender of our nation (and quite a few others), but as a huge enterprise. I know the military can be rather "distinct" as compared to other enterprises. This is mainly because of their unique focus on their main mission (see above), and the unique management elements and organization needed to accomplish this mission.

However, the military is also very focused on keeping their organization, supply chains, and infrastructure intact:

"The Department of Defense (DOD) has identified climate change as a critical national security issue and threat multiplier and top management challenge. Climate change will continue to amplify operational demands on the force, degrade installations and

infrastructure, increase health risks to our service members, and could require modifications to existing and planned equipment. Extreme weather events are already costing the Department billions of dollars and are degrading mission capabilities. These effects and costs are likely to increase as climate change accelerates. Not adapting to climate change will be even more consequential with failure measured in terms of lost military capability, weakened alliances, enfeebled international stature, degraded infrastructure, and missed opportunities for technical innovation and economic growth."

Since I'm treating DOD as a large corporation, I will use DOD documents, cherry-picking actions to mitigate climate change that are most applicable to large enterprises / corporations.

https://energycentral.com/c/rm/dod-corporate-risk

4.13. Climate Risks & Large Corporations' Disclosures

This is a really complex issue, but an October 28 Issue of Science had an article that I found clearly explained these risks as they apply to large corporation, especially in energy industries.

Investors have known about climate change for decades. Yet it is only recently that several countries—including France, Japan, New Zealand, and the United Kingdom—have developed policies requiring large public companies to regularly disclose information about climate-related financial risks. In March 2022, the US Securities and Exchange Commission (SEC) proposed a climate disclosure rule that, distinctively, would affect all firms publicly traded in the United States regardless of their size or country of incorporation. With the policy's broad scope, the large size and exceptional liquidity of the US financial market, and the SEC's influence on securities regulations worldwide, this presents a major opportunity.

https://energycentral.com/c/pip/climate-risks-large-corporations%E2%80%99-disclosures

4.14. 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

4.15. 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

4.16. 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

4.17. 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

4.18. 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.”

4.19. 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

4.20. 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.

https://energycentral.com/c/ec/sore-subject

4.21. 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

4.22. 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

4.23. 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 2.65).

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

4.24. 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

4.25. 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

4.26. 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

4.27. 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

4.28. 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

4.29. 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. Two Words: Plastic Recycling

Plastics are one of the primary packaging materials used by our consumer economy. This paper’s title function is a difficult process, mainly due to the great number of different types of plastic, along with methods used to recycle each. It is hoped that this post will bring some clarity to this confusion.

Without recycling, consumer plastic ends up being plastic pollution (frequently microplastic pollution), or in a landfill. In the latter case the plastic requires several decades to several centuries to completely degrade and can easily end up as microplastic pollution along the way.

https://energycentral.com/c/rm/two-words-plastic-recycling

5.2. Increasing Ag Watts

The agriculture and electric power industries have crossed paths many times in the past Century. The major event that started our relationship began in the 1930s.

As late as the mid-1930s, nine out of 10 rural homes were without electric service. Farmers milked cows by hand in the dim light of a kerosene lantern, and families relied on the wood range and washboard for cooking and cleaning.

The idea of providing federal assistance to accomplish rural electrification gained ground rapidly when President Roosevelt took office in 1933. On May 11, 1935, Roosevelt signed Executive Order No. 7037 establishing the Rural Electrification Administration (REA). It was not until a year later that the Rural Electrification Act was passed and the lending program that became the REA got underway.

https://energycentral.com/c/gr/increasing-ag-watts

5.3. Printed Words, Images, Life-Codes & Objects

Most of the content for this article comes from an article in the April 2024 issue of IEEE Spectrum. My main work will be to shorten this to try to keep my paper / post under my preferred length, and perhaps add additional content. The article is about the most useful tool in my office (and I'm sure many of my readers' offices), after my laptop: my multifunction inkjet printer. However, if you read the title above, and the title of the first reference, you will see that this peripheral technology does much more than humble office-duty.

In the early 1980s, offices were noisy places, filled with the sound of metal striking inked ribbons to mark characters on paper. IBM Selectric typewriters clacked, daisy wheel printers clattered, and dot-matrix printers made loud ripping sounds. Today, those noises are gone. And though we do spend more time reading on screens, we haven't stopped printing on paper. The main reason for the quiet? The inkjet printer. While laser printers do the big printing jobs in commercial settings, the inkjet has become the printer most of us use at home and at the office.

https://energycentral.com/c/um/printed-words-images-life-codes-objects

5.4. 50-years Ago, When Everything Was Invented

It happens periodically, a sudden revolutionary cluster of new products are released that changes everything. It happened about 50 years ago in the 1970s. The core technology that made all of these inventions possible was the development of advanced digital network techniques. The major resulting world-changing products were:

- Internet wide-area network which led to the World-Wide Web (WWW).

- Ethernet local area network which brought in-facility connectivity to every computer and networked peripheral in a business center and most other facilities.

The above two developments facilitated the emergence and evolution of multiple secondary developments described in this post.

https://energycentral.com/c/iu/50-years-ago-when-everything-was-invented

5.5. Spacy Materials

There is an expression in the engineering world: “that device is made out of solid Unobtainium.” According to Wikipedia: “Unobtainium" is a term used in fiction, engineering, and common situations for a material ideal for a particular application but impractically difficult to obtain.”

There are multiple types of Unobtainium. First, there is material that an artificial intelligence (AI) analysis suggests exists, but we don’t know how to make. Second, there are materials that we have actually made, but it’s so expensive to make (using current techniques) that it cannot be cost-justified for any fitting application. Finally, there is a small class of materials that we have made, but we cannot get the yield of suitable-purity high enough to allow pure material to be cost-justified. In the latter case some of those materials could have higher yields if they were made in microgravity (read: in space), and some of those are used in space That is the subject of this post.

https://energycentral.com/c/rm/spacy-materials

5.6. Amazon Update

The year was 2017. In November of that year, I posted one of my earliest papers to Energy Central: “Disruption in U.S. Product Distribution Sectors.” There is a summary and link to this earlier paper in “Amazon Update.”

In the above paper, many of the “disruptions” were being implemented by Amazon, although their rapid growth over the last five years have encouraged similar businesses to emulate them.

I can’t say my wife and I have not visited Amazon since then. In fact, we almost visit them daily, being loyal Amazon Prime Members. I also know that they have been amazingly successful but haven’t really tracked them since the above paper. This paper will remedy that.

https://energycentral.com/c/ec/amazon-update

5.7. Rare and Precious Part 3, from abandoned mines

This didn’t start out as a three part series. Finding Rare Earth and other critical elements is serious. We need these constituents for modern devices required to mitigate climate change, like electric vehicles (EVs) and battery energy storage systems (BESS). I would have been really happy if I was able to create one good paper about this search. As it turned out, I wrote the original paper, which outlined this issue and discussed a conventional approach to finding these elements. Shortly thereafter a second source that used an advanced approach (artificial intelligence) to perform the same task appeared. Shortly thereafter I found the information for this third post – a completely different approach as described in the title.

https://energycentral.com/c/rm/rare-and-precious-part-3-abandoned-mines

5.8. Rare and Precious Part 2

About a week before the original “Rare and Precious” was scheduled to post, I received my hardcopy of my monthly IEEE Spectrum. It took me a few days thereafter to read through this issue until I saw the paper version of the source article for this paper.

I knew right away that this covered similar ground to the original “Rare and Precious.” The subject was the same: the search for critical (rare and precious) elements.

These posts complement each other by covering different parts of, and different methods for this search.

https://energycentral.com/c/ec/rare-and-precious-part-2

5.9. Niron Magnetics, Not So Rare & Precious

My last post (reference and linked in this post) described the extraordinary efforts the federal government is pursuing to find and extract rare-earth and other critical elements,

However, there is frequently more than one road to Rome. One of the largest users of rare-earth elements are industries that use these to make permanent-magnets, and these are used in high performance motors that are needed for electric vehicles and also in wind turbines.

The alternate road in this case, is to use a very common compound but modify its molecular structure such that it performs much like a permanent-magnet that uses rare-earth elements, but without the rare-earth elements.

https://energycentral.com/c/rm/niron-magnetics-not-so-rare-precious

5.10. Rare and Precious

I have recently spent much time delving into new materials: “Many of my papers start with a chemists identifying a material that performs a particular function much more effectively than the incumbent material.”

However there is one type of material that chemists cannot create, elements. There are currently 118 elements. Other than using nuclear physics to create them (one atom at a time) there are only two ways to obtain elements: (1) recycle used materials to obtain their component elements, or (2) mine the ore containing the element, and refine it.

https://energycentral.com/c/rm/rare-and-precious

5.11. Betty Crocker It Is Not

I just started a paper with the following words: “Many of my papers start with a chemists identifying a material that performs a particular function much more effectively than the incumbent material.”

I completed the first draft of the above mentioned paper, and started reading my latest issue of Science Magazine, and encountered a new technology that will substantially accelerate the development of these new compounds.

Imagine a cookbook with 150,000 tempting dishes—but few recipes for making them. That's the challenge facing an effort at the Lawrence Berkeley National Laboratory (LBNL) known as the Materials Project. It has used computers to predict some 150,000 new materials that could improve devices such as battery electrodes and catalysts. But the database's users around the globe have managed to make just a fraction of these for testing, leaving thousands untried.

Now, LBNL has married artificial intelligence (AI) and robotics to eliminate that bottleneck. The AI system makes a best guess at a recipe for a desired material and then iterates the reaction conditions as robots try to create physical samples. The new setup, known as the A-Lab, is already synthesizing about 100 times more new materials per day than humans in the lab can manage…

https://energycentral.com/c/ec/betty-crocker-it-not

5.12. Light & Power, Ongoing Revolution

Many of my papers start with a chemists identifying a material that performs a particular function much more effectively than the incumbent material. For instance, I spent much my career working in an area widely known as Silicon Valley. While silicon is well-entrenched as the best material for low-power, high-speed, microelectronic computing applications, two new materials have been displacing it in medium-to-high-power and lighting applications for a couple of decades, and this revolution continues.

https://energycentral.com/c/ec/light-power-ongoing-revolution

5.13. Industrial Decarbonization Roadmap, Part 7, Further Analysis Needs

While the source Roadmap lays a preliminary foundation for an overall U.S. industrial decarbonization strategy, the underlying scenario modeling was limited to five subsectors, with additional scope-limiting assumptions, to allow for a manageable scope. Additional analysis—including scenario modeling for additional industrial subsectors, inclusion of non-CO_2 greenhouse gases and additional process emissions, and examination of other aspects of decarbonization not yet covered in this roadmap—will be needed to develop a comprehensive and holistic strategy for the entire industrial sector. Examples of those analysis needs are detailed in this part.

https://energycentral.com/c/cp/industrial-decarbonization-roadmap-part-7-further-analysis-needs

5.14. Industrial Decarbonization Roadmap, Part 6, Cement Manufacturing

Occasionally I come across a document that is overwhelming in scope and information-content. This requires me to adjust how I post papers based on this document if it falls within the scope of subjects that I normally write about and contains information my readers would want to read. The DOE Industrial Decarbonization Roadmap is one of those documents.

As I was skimming through the primary document, I decided pretty quickly that this would require multiple papers to cover, and thus a series. Part 6 is on Cement Manufacturing. In 2020, the United States produced 87 million metric tons (MT) of

Portland cement and 2.3 million MT of masonry cement at 96 plants in 34 states. Of those, 86 plants employed the dry kiln process and nine used the wet kiln process. In 2020, sales of cement were around $12.7 billion and consumption was about 102 million MT. Texas, Missouri, California, and Florida have the highest cement production, in that order, and they account for about 45% of U.S. cement production.

https://energycentral.com/c/ec/industrial-decarbonization-roadmap-part-6-cement-manufacturing

5.15. Industrial Decarbonization Roadmap, Pt. 5, Petroleum Refining

Part 5 is on Petroleum Refining. In my first review on the source document, I found that there are two adjacent sectors that are tightly connected to Petroleum Refining:

- Oil & Gas Extraction: Actually the initial stages of refining occur in the Oil/Gas Well fields, so it's probably inevitable that the source document will cross-over into these areas.
- Mobility: Although many industries use the output of Petroleum Refining, Mobility is one of the largest users. Also these vehicles are rapidly transitioning to electric power, and quickly reducing their demand for petroleum-sourced products. Ironically, mobility may represent one future path for Petroleum Refining – producing plant- and electricity-based fuels with little-to-no net greenhouse gasses.

I have not written a post that was specifically about Petroleum Refining, although I have probably mentioned their products in other posts.

https://energycentral.com/c/og/industrial-decarbonization-roadmap-pt-4-petroleum-refining

5.16. Industrial Decarbonization Roadmap, Pt. 4, Food and Beverages

This is the fourth part of this series and is about Food & Beverage Manufacturing.

The source document and section for this paper does not appear to delve into farming and ranching, but only the food and beverage manufacturing process after harvesting.

Although I have occasionally touched briefly on farming practices in earlier posts, I don't believe that I have ever delved into the Food & Beverage Manufacturing Subsector.

https://energycentral.com/c/ec/industrial-decarbonization-roadmap-pt-4-food-and-beverages

5.17. Industrial Decarbonization Roadmap, Part 3, Chemical Manufacturing

This is the third part of this series and is about Chemical Manufacturing. The diversity, complexity, and deep capital investment of the chemical manufacturing subsector make it one of the most difficult industrial segments to decarbonize. However the leaders in this segment realize they must find a reasonable path to sustainability.

The first sections in this post review potential paths to decarbonization, and the last section reviews the first sustainable chemical plant to be built in the U.S.

Note that both the subject of this post and the post itself are real monsters. Preparing this paper easily took triple the time of a typical paper, but if you are interested it what it will take to decarbonize the toughest industry in our economy, and (especially) if you are involved in the chemical industry, this is a “must read.”

https://energycentral.com/c/cp/industrial-decarbonization-roadmap-part-3-chemical-manufacturing

5.18. Industrial Decarbonization Roadmap, Part 2, Iron & Steel

Occasionally I come across a document that is overwhelming in scope and information-content. This requires me to adjust how I post papers based on this document if it falls within the scope of subjects that I normally write about and contains information my readers would want to read. I decided pretty quickly that this would require multiple papers to cover, and thus a series.

Part 2 is about Iron and Steel Production Industries. I intend start with the primary document, and also use prior posts as they interject useful information into the narrative.

https://energycentral.com/c/ec/industrial-decarbonization-roadmap-part-2-iron-steel

5.19. Amazon Climate Moves

Effectively combating climate change will involve many small, imperfect steps where no other progress is immediately available. On the other hand, when opportunity presents them giant leaps can and should be made. This post is about a major firm that is combining both of these to move as fast as they can to fight climate change.

From the title of this post, you can probably guess who the “major firm” is, but you probably cannot guess how fast they (and others) are moving.

https://energycentral.com/c/cp/amazon-climate-moves

5.20. Industrial Decarbonization Roadmap, Part 1, Overview

Occasionally I come across a document that is overwhelming in scope and information-content. This requires me to adjust how I post papers based on this document if it falls within the scope of subjects that I normally write about and contains information my readers would want to read. The DOE Industrial Decarbonization Roadmap is one of those documents. It also covers subjects that I spent far more time researching and writing about several years ago, than I do currently.

The DOE Site that led me to the title document had an excellent graphic that defined the scope of this document, and this is the primary image for this post.

As I was skimming through the primary document, I decided pretty quickly that this would require multiple papers to cover, and thus a series. How are we going to do this? I will start with this post and post other papers in this series as I complete them. These will be interleaved with other posts covering other subjects, but all parts of this series will start with “Industrial Decarbonization Roadmap.”

I believe that anyone that is interested in curing climate change should be interested in this series, as eliminating greenhouse gas from industrial processes will be an important part of this cure, and also one of the most difficult parts.

https://energycentral.com/c/cp/industrial-decarbonization-roadmap-part-1-overview

5.21. 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

5.22. 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

5.23. 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

5.24. 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

5.25. 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

5.26. 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

5.27. 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

5.28. 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

5.29. 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

5.30. 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

5.31. 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. Air Taxi Update

It has been a couple of years since I covered the title emerging market. For those of you that don't know what this product is, it is a vertical takeoff and landing (VTOL) aircraft that is intended to address short distance hops, like from a large airport to an urban-center. The minimum (safe) range appears to be around 40 miles round-trip (without recharging).

https://energycentral.com/c/ec/air-taxi-update

7.2. Fast and Sustainable

I write about all types of mobility. That includes aviation and even space-travel. This post is about two parts of the aviation industry, and I've written about one previously, but not about the other. The latter is what may be the first supersonic airliner to enter service in the U.S.

…Boom Supersonic, a private company based in Colorado, aims to bring commercial supersonic flights back to US airlines by 2029. When completed, its passenger aircraft, Overture, is expected to fly at speeds up to Mach 1.7, which is about 1,300 miles per hour—or twice as fast as today's passenger planes.

The former part of the aviation industry is Sustainable Aviation-Fuels (hereafter SAF). I wrote about this most recently (Aug. 2023) in the post described and linked in this paper.

https://energycentral.com/c/ec/fast-and-sustainable

7.3. Medium-Priced Autonomous Drones

Small drones are everywhere. At times I think they blot out the sun. And they are very inexpensive -- The highly rated Black Falcon 4K camera drone only costs $99 to $199.

But this paper is not about low-end drones, it is about medium sized high-performance drones that cost anywhere from $tens-of-thousands to $hundreds-of-thousands. Their primary customers are various defense agencies, but they also have many interesting civilian applications. An article in Forbes alerted me to these and what is probably the builder of the most advanced design, which is just starting to take off.

https://energycentral.com/c/rm/medium-priced-autonomous-drones

7.4. Aerial Express System

There are basically two types of aircraft categorized by what they carry: passenger aircraft and cargo aircraft. The former has much more stringent certification rules, so the latter may reach production more rapidly. When it comes to vehicles, I mostly tend to focus on electric vehicles (EVs), because (1) they emit little or no greenhouse gases (GHG) and thus help mitigate climate change, and (2) they will impact the electric utility industry strongly with their increasing demand for electricity. Thus, I periodically write posts on electrically powered aircraft that carry both passenger (like Air-Taxis) and Cargo.

This post is about EV cargo carriers. The drone manufacturer we will cover in this paper has several major differences vs. those that I covered in earlier posts. Also, we will cover two very large merchant corporations with existing fulfillment operations that are starting to use drone fleets.

https://energycentral.com/c/ec/aerial-express-system

7.5. Future Sustainable Aviation-Fuels & Large Air-Transports

This post is on the large aircraft and "clean fuels." Some of these fuels are reasonable analogs for existing jet fuels, and thus will not require significant airframe modification, but some (read: hydrogen) will require significant redesigns.

https://energycentral.com/c/ec/future-sustainable-aviation-fuels-large-air-transports

7.6. Regional Air Mobility and Electrified Aircraft

I write frequently about electric mobility. Of course there are many flavors of electric mobility, and depending on volume of EVs for a particular type, I might write about it once a month (or more frequently) to once a year (or less frequently). This is about the latter, as you can probably guess from the title. Also, "electrified aircraft" will only be viable for a tiny subset of all aircraft, at least for the next two decades. All other aircraft will rely on clean-fuel to reduce their greenhouse gas (GHG) emissions during this time, and most will still be propelled by turbofans burning this fuel. I (and many others) call the "tiny subset" Air Taxis, and I last wrote about these a bit more than a year ago.

This post is about a document recently released earlier this year addressing the Air Taxi segment. This document was issued by the National Renewable Energy Laboratory (NREL). This paper will be a brief review of that document.

https://energycentral.com/c/ec/regional-air-mobility-and-electrified-aircraft

7.7. eDrone Air Cargo

Most people do not realize how truly huge the transportation vehicle segment is. One way to emphasize this is to slice and dice this segment into sub-segments:

- Road vehicles
- Airborne vehicles
- Water vessels
- Off-road vehicles
- Rail vehicles

As you've probably already guessed, we will be looking at airborne vehicles. Drones are generally considered unmanned and non-passenger vehicles. Drones can perform many functions. The small ones are mainly limited to surveillance and other imaging, but that is not what we are looking at here. Medium-sized drones have been used for cargo transport, and that is the main subject of this post (as you can probably tell by the title). However, a side-subject is crop-spraying by drones.

https://energycentral.com/c/ec/edrone-air-cargo

7.8. 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

7.9. 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

7.10. 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

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

7.12. 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. Hydrogen On the Water

I write about this subject once or twice a year. Weaning maritime applications from diesel fuel to mitigate climate change will be a tough job, but a necessary one. Probably the initial drop-in solutions will involve biodiesel or some other green fuel. Using an electric power-plant will require some significant changes to vessel's design but may be the ultimate solution.

There are two approaches to electrification: battery-electric, and hydrogen-fuel-cell electric. The bad news about the former is that batteries are heavy, have limited energy-storage and need a long full-recharge time. Using hydrogen fuel-cells increases the energy storage, but this comes with its own challenges, as described in this article.

https://energycentral.com/c/cp/hydrogen-water

8.2. Decarbonizing Marine Transportation

I've visited this topic before, but a recent excellent article in IEEE Spectrum induced your author to take another dive into the sustainable ocean.

There is no doubt that the title challenge is the most difficult to address of all of the transportation technologies that currently emit greenhouse gases and hence is a major causes of climate change.

A modern Marine Transportation System is critical to national and economic security. About 99% of U.S. overseas trade, by weight, enters or leaves the U.S. by ship. This waterborne cargo and associated activity contribute more than $500 billion to the U.S. GDP and sustains over 10 million U.S. jobs. Global maritime emissions account for about 3% of total greenhouse gas emissions each year. Decarbonizing the Marine Transportation System is integral to decarbonizing the transportation sector, as well as the broader economy, and will strengthen the competitiveness of the industry through technology innovations, training a new generation of mariners and shipbuilders, and the adoption of new, clean energy sources.

https://energycentral.com/c/cp/decarbonizing-marine-transportation

8.3. 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

8.4. 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

8.5. 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. The Greenest Travel

The Mayer of San Francisco. London Breed, is in China as I'm writing this (late April). She rode on a high-speed rail line while there. China has invested extensively in their high-speed rail system. Thus, I thought it was a good time to update the information on HSR. My last post on this was about two years ago, and we are steadily making progress.

Northern California already has an extensive infrastructure for commuter rail, and this is being modified and extended to connect with HSR, and in some cases, share track segments, including that end-segment (to be shared with Caltrain) traveling to Ms. Breed's City by the Bay.

https://energycentral.com/c/ec/greenest-travel

9.2. BART, A Half-Century of Innovation

Currently, the first segment of the California High Speed Rail (HSR) System is being built in our Central Valley. When this segment is complete, it will run from Merced in the North to Bakerfield in the south. I've been tracking this (and posting) for several years, so I know much political "sausage-making" was required to make this happen.

Since I'm an old dude, I had a front row seat on another huge project that went through a similar process, and it's included in the title of this post. The hubbub over HSR seems familiar, but this post is not about HSR, it's about BART.

https://energycentral.com/c/ec/bart-half-century-innovation

9.3. Zero-Carbon Trains

In my writings I tend to classify electric vehicles and other vehicles that match the above title by their location in our transportation networks. That is:

- Road Vehicles
- Tracked Vehicles
- Aircraft
- Maritime Vehicles (a.k.a. ships and boats)

World-wide most tracked vehicles are already electrified. If a government agency is going to the trouble of laying a track system, it is not that much more expensive to put in an electric supply and equip the locomotives and/or train-cars to tap into that supply. Also, once this is done the operating cost is generally much lower than fossil-fueled trains.

The reason that diesel-electric (a generator driven by a diesel-engine driving electric traction motors) is dominant in the US (etc.) is that we have very long distances between metro-areas in many regions, and having just passive tracks in these stretches reduces the cost of installing and maintaining these tracks by a huge amount. Also, these sections are mostly used for freight, not passengers.

https://energycentral.com/c/ec/zero-carbon-trains

9.4. 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

9.5. 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

9.6. 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

9.7. 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

9.8. 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 & Miscellaneous

10.1. Paths to Lithium Nirvana

Many are sweating how we are going to supply enough lithium to meet the demands of a growing number of electric vehicles. This number needs to expand hugely over the next few decades to reduce our greenhouse gas (GHG) emissions from burning petroleum products.

The supply of lithium is not a critical issue currently, and there are many alternative sources of this abundant element, as I found out in several articles that I came across lately, thus this post.

The US has always had a copious supply of lithium at hand. An epic case of bad timing is one way to characterize the supply problem. Lithium mining in the US dwindled down to practically zero by the early 2000s, just when the newborn EV industry was beginning to send demand skyrocketing.

https://energycentral.com/c/rm/paths-lithium-nirvana

10.2. Oakland’s Advanced Mobility Infrastructure

This post is about a major school district (Oakland Unified School District) that just acquires a large fleet of Electric School Buses through a partnership with Zum, a company that provides the full infrastructure around electric buses.

Early on, I heard or read that Zum uses the fleet of School buses as a Virtual Power Plant (VPP) to help companies displace peak power pricing. It took me a while to find some text on the VPP, but I finally did.

Imagine if the nation's fleet of school buses could serve as batteries, providing power back to the grid. School buses have predictable daily schedules and are typically used only a few hours each day, sitting idle during peak power usage times—making them an ideal resource for communities. At Zum we've recently partnered with AutoGrid's Virtual Power Plant technology (VPP) platform to deploy 10,000 electric school buses in the next four years to create over one gigawatt of flexible capacity when the electricity grid is overloaded. When fully deployed, this is expected to be one of the largest VPPs in the world.

This post also briefly mentions other electric mobility technologies employed in Oakland.

https://energycentral.com/c/ec/oakland%E2%80%99s-advanced-mobility-infrastructure

10.3. How Dry My Battery Is

Lithium-Ion Technology is the current 900-pound gorilla in the energy storage and electric vehicle markets. However, don't believe that it doesn't have room for continued development. Not only is this a very new and very complex technology, but major manufacturers are pouring many mega-dollars this technology's continued development. This injection of cash is driving improvements that lower battery-prices and drive continued expansion of these lithium-ion battery markets. This post is about one major emerging breakthrough, and an earlier breakthrough that is coming to fruition.

https://energycentral.com/c/ec/how-dry-my-battery-special-issue-road-electrification

10.4. New Materials for Tomorrows Energy Industry

Many of my posts start with a new material that accelerates an application. This is one of those posts. However, this post started by an Editorial in the May 17 issue of Science pointing out the need for new materials, so that is where we will start.

The decreasing cost of electricity worldwide from wind and solar energy, as well as that of end-use technologies such as electric vehicles, reflect substantial progress made toward replacing fossil fuels with alternative energy sources. But a full transition to clean energy can only be realized if numerous challenges are overcome. Many problems can be addressed through the discovery of new materials that improve the efficiency of energy production and consumption; reduce the need for scarce mineral resources; and support the production of green hydrogen, clean ammonia, and carbon-neutral hydrocarbon fuels. However, research and development of new energy-materials are not as aggressive as they should be to meet the demands of climate change.

https://energycentral.com/c/ec/new-materials-tomorrows-energy-industry

10.5. EV Motors without Rare Earth Metals?

A large majority of current road-going electric vehicles use two new technologies. One is Lithium-Ion Batteries, and the other is electric traction motors. I've written about the former extensively, and my recent major paper on these is described and linked in this paper.

I have also written about EV motors, but not recently. This post will fix this tardiness.

Like Lithium-Ion Batteries, traction motors have a materials problem, rare-earth metals. There is no question that the lightest, most efficient, most long-lived motors use rare-earth metals, mainly by using neodymium-iron-boron permanent-magnets. Neodymium is the rare earth element here, but boron is also increasing in price. The latter is due to demand by a number of widespread markets, with automotive being one.

https://energycentral.com/c/rm/ev-motors-without-rare-earth-metals

10.6. Transportation Decarbonization & NREL's Battery Breakthroughs

Our modern transportation systems are both a benefit and a hindrance for today's civilizations. They are a benefit in that they enable many more activities that would be impossible in the past. During my career, I traveled all over the world helping electric utilities automate their processes and collaborating with peers. Without modern international air travel this would not be possible. About a decade before retirement, I purchased a second home in California Seirra-Nevada Mountains, and now I spend a significant of time up there recreating and working on my papers. The travel between my primary- and mountain-home is a 2-1/2-hour drive (one-way).

The hinderance for the world's economies is, the transportation systems are the single largest emitter of greenhouse gas, and thus a primary driver of climate change. The world's economies need to electrify these systems ASAP.

https://energycentral.com/c/cp/transportation-decarbonization-nrel%E2%80%99s-battery-breakthroughs

10.7. Fool Self-Driving – A Half-Baked AI-Technology

I find the idea of AI driving a one-ton on-road vehicle a bit scary, but kept these thoughts to myself, until an article that confirmed this fear appeared in my October IEEE Spectrum, with an author much more qualified to voice (or pixilate) these fears than I.

"The lack of technical comprehension across industry and government is appalling. People do not understand that the AI that runs vehicles—both the cars that operate in actual self-driving modes and the much larger number of cars offering advanced driving assistance systems (ADAS)—are based on the same principles as ChatGPT and other large language models (LLMs). These systems control a car's lateral and longitudinal position—to change lanes, brake, and accelerate—without waiting for orders to come from the person sitting behind the wheel…"

https://energycentral.com/c/ec/fool-self-driving-%E2%80%93-half-baked-ai-technology

10.8. Autonomous eTractor Pull-off with AI

A tractor that is capable of carrying a driver (or driverless), and also capable of carrying other things is definitely a vehicle. If it is battery-powered, it an electric vehicle. The company making the title EV is Monarch Tractor, and they are on the other side of Livermore, CA where I have lived for over 30 years.

If you are curious about the "AI" in the title of this post, Monarch Tractors also makes a software package called Wingspan AI. This package does much more that control tractors, and this post is about Monarch's Tractors and their AI.

https://energycentral.com/c/ec/autonomous-etractor-pull-ai

10.9. Four paths to Sustainable Mobility

These are paths, not end-points. At any point along our journey a new technology may alter these paths or provide an additional path. In the U.S. with our freedom-of-choice, the different paths will allow us, as a whole, to move forward more quickly without forcing government edicts. I believe this is a strength in our free-enterprise economy, and allows our future journey to follow the most efficient path for each future development.

The paths listed below are in progress to various degrees for all forms of mobility.

- Battery-Electric
- Green-fuel
- Grid-tied-Electric
- Hybrid

https://energycentral.com/c/ec/four-paths-sustainable-mobility

10.10. Blueprint for Transportation Decarbonization

I write about the title subject frequently. There are several reasons I do this:

- In spite of my frequent posts on this subject, it is my most popular subject (based on the number of views per post.)
- The transportation sector is the largest source of greenhouse gas emissions in the United States.
- One of the most important tools will use to accomplish the title task is to convert this sector from petroleum-based fuels to electric energy or clean fuels that are mostly generated using electric energy.
- I post on Energy Central, and implementing the prior bullet will force the greatest changes in the history of the energy segment.

When I discovered that the U.S. Federal Government had released an extremely important document regarding the title subject in January, I decided that I must create a post summarizing this document.

https://energycentral.com/c/cp/blueprint-transportation-decarbonization

10.11. 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. Future EVs

I have been writing about electric vehicles since late 2017. I often focus my writings on California, as I have done for this category.

Based on a chart in the introduction to this paper means is, that EVs will eventually become mainstream in California, and your author will lose interest in them, but not right now. However, with almost every significant manufacturer making at least some EVs, since this paper focuses on future EVs, I will do a lot of pruning. In this paper, I will just focus on new EVs that I consider interesting.

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

11.2. EV News – Mid Summer

First of all, my reporting on EVs is evolving. On a few of my categories of posts, I post a periodic paper with a few major catchall subjects that are consistent from post to post. With EVs I have had a different subject for each post. Although I will not abandon the latter posts in the immediate future, with this paper, I am adding a periodic catchall. There are two reasons for this:

- The pace of development in EVs is accelerating and much new and important news is coming across my desk almost every day.
- Within the broad subject of EVs live a diverse set of technology and business news, and it's becoming increasingly difficult to glue these together into single-subject posts

For now, these will use the following format:

- Technology
- Manufacturer News
- Government

https://energycentral.com/c/ec/ev-news-%E2%80%93-mid-summer

11.3. Charging Ahead

It started out with an interesting article from Energy Central. It seemed to point towards a major EV Charger Project in the closest large city (Oakland, CA) to my hometown, Livermore. However, as I read this article, it described a much broader vision, and a consortium consisting of several major energy. real estate and mobility companies. It also promised to solve a major problem associated with EV Ownership. What if a potential owner cannot host an EV charger at his/her residence?

The solution is obvious: more public fast-chargers. A Level 3 DC fast charger can fully replenish your EV in twenty to thirty minutes. Although this is more time than it takes to fill up an IC-powered car at a gas station, it's in the ballpark.

https://energycentral.com/c/ec/charging-ahead

11.4. How China Makes EVs at a Fraction of US. Prices

The answer to the above question is not a simple one, and there is not a single answer, but many. But as a starting point, this has happened before over a hundred years ago, in the automobile industry, and it had nothing to do with the country of origin.

A tiny, low-priced electric car called the Seagull has American automakers and politicians trembling.

The car, launched last year by automaker BYD, sells for around $12,000 in China, but drives well and is put together with craftsmanship that rivals U.S.-made electric vehicles that cost three times as much. A shorter-range version costs under $10,000.

https://energycentral.com/c/ec/how-china-makes-evs-fraction-us-prices

11.5. Rivian Targets Tesla, Ford

I have at least one nearby neighbor in Livermore that has a Rivian Pickup. Ditto a Ford Mach E, and probably several that have Teslas, mostly Model Ys and/or 3s, but a few Model S and Xs. Keep in mind that Livermore is very high-tech (two National Labs, and the Livermore Valley is sort of a northeastern annex to Silicon Valley).

Rivian's first two consumer models, the R1T pickup and R1S SUV, are priced in the premium range, averaging about $80,000. The company sold about 44,000 combined last year and Scaringe said they were the best-selling vehicles in the U.S. at that price range. But that's not mass market, and mass market is the goal.

This post will cover two related subjects: Rivian's next steps, and the next major domestic source of Lithium.

https://energycentral.com/c/ec/rivian-targets-tesla-ford

11.6. Really Big Electric Trucks

There will be two subjects in this paper. Both of them are flavors of the title, but one I've written about before, and the other, not so much. The first is definitely a clean-sheet design, and the latter looks (and mostly is) derivative of earlier generations. Both need to ramp production very quickly to help my home state (California) make the transition to non-diesel big rigs.

Starting in 2036, no new fossil-fueled medium-duty and heavy-duty trucks will be sold in the state. Large trucking companies also must convert to electric or hydrogen models by 2042. The California Air Resources Board (CARB) decided to review progress and obstacles in meeting the deadlines two and a half years from now.

https://energycentral.com/c/ec/really-big-electric-trucks

11.7. Is the EV-Revolution Slowing Down?

When Elon tells us something about EVs, we had better listen. But in this case, it isn't just Elon. Many pundits have been saying that the rapid growth of light electric vehicles has started to slow down. Is the revolution over? Are the front-line soldiers in this revolution laying down their charging adapters and heading back to their filling stations in (gasp!) gasoline-fueled-cars?

This post will examine the news, opinions and the natural drivers of this slowdown. Also, we will touch on the possible revolution-number-two that might be coming shortly.

https://energycentral.com/c/ec/ev-revolution-slowing-down

11.8. Efficient Hydrogen Storage for Big Rigs

One class of likely mobile users of hydrogen are large road vehicles, ESPECIALLY IF the space required for storage of the hydrogen could fit into current big rig tractor designs and provide a non-stop range comparable to existing diesel-fueled tractors. Although there are quite a few details to work out, this goal appears to be much closer to reality.

https://energycentral.com/c/ec/efficient-hydrogen-storage-big-rigs

11.9. EVs, Late Fall 2023

This EV Post contains the following content:

Technology:

- Fast-Charging vs. Battery-Lifetime
- BMW Believes its Next-gen EVs will Beat Tesla's range
- Tesla 4680 battery cell production breakthrough
- Business:

Volvo Group Acquires Proterra For $210 Million

- EVs Transform the Auto Industry
- Future EVs
- Caddy's Next EV will be a Compact SUV

https://energycentral.com/c/ec/evs-late-fall-2023

11.10. EVs Early Fall 2023

This EV Paper has the following content:

Technology:

- Trade-offs: Price vs. Range vs. Performance
- Are Chargers Keeping Pace with EV Expansion?

Business:

- Record Global EV Sales, Growth expected through 2023
- A $3 Billion Truck Venture
- EVs Switch gets $12 billion in loans & grants from DOE
- EX30, the Smallest, Least Expensive Volvo

https://energycentral.com/c/ec/evs-early-fall-2023

11.11. EVs - Late Summer 2023

This paper covers the following subjects:

Technology

What's next for Batteries?

GM Bets Big on Iron

Business

Tesla:

- Tesla's Native Lands Partnerships
- Why Elon is Glad
- 2024 Model 3

LG Energy / Honda Venture

Subaru's New EV Strategy

New Nissan Vehicles

Nikola, Still Struggling and Focused on Hydrogen

https://energycentral.com/c/ec/evs-late-summer-2023

11.12. EVs Mid-Summer 2023

This paper covers the following subjects:

Technology:

The 2030 National Charging Network

New Battery Chemistry (or Chemistries?)

Hot and Cold Weather Impacts on EVs

How Long Do Electric Car Batteries Last?

Business:

Tesla:

- Tesla Q2 2023 earnings: Expectations beat amid record quarter
- Tesla Model 3 Gets another Price Cut

First Chevy Blazer EV en route to the US

Stellantis Second Battery Factory

Nikola California Hydrogen Refueling Stations

Bipartisan Infrastructure Law Funding to Boost Buses

Big Busses also get boosted

https://energycentral.com/c/ec/evs-mid-summer-2023

11.13. Charging Big Rigs

I've written incessantly about how California intends move to net-zero greenhouse gasses (GHGs) by 2045. One of the most challenging sources of the GHGs are class-8 Semis (a.k.a. big rigs).

This post is about a program and firm that is providing drayage big rigs with electric battery charging infrastructure along their most heavily travelled routes. "Drayage" refers to a form of trucking service that connects the different modes of shipping products.

The California Air Resources Board recently approved rules requiring all of California's in-state drayage fleet – approximately 33,000 trucks – to be zero-emission by 2035.

Also CARB just formed an alliance with major big rig and big rig engine manufacturers: The Clean Truck Partnership. This is covered in this post.

https://energycentral.com/c/ec/charging-big-rigs

11.14. EVs, Early Summer, 2023

This post will cover the following subjects:

Technology:

The Long Road

2023 battery rollouts

NHTSA proposes Auto Emergency Braking Mandate

Business:

Ford

- More Details on New Truck and SUV
- Ford's New Platform, Supply Chain and EV targets
- Ford & Tesla Make Nice (again)

- Ford F-150 Lighting production boost to 150,000/year by year-end

The U.S. Version of the VW ID. Buzz Debut

Hyundai and LG announce battery plant in Georgia

Tesla announces second quarter deliveries

https://energycentral.com/c/ec/evs-early-summer-2023

11.15. EVs Mid-Spring, 2023

This post will cover the following subjects:

Technology:

- Toyota hydrogen fuel cell conversion for Semi-Trucks approved in California
- High-Silicon Anode Batteries Solve Many Problems
- Another Major Battery Material Advance
- A Modest Proposal from the Author

Business;

- Calculating the Fastest Road to an Electric Car Future
- Are EVs Already a Better Deal for Buyers?
- Tesla
    - Musk Bets the House of Tesla on Low Prices and Thin Margins
    - Tesla's “Volume” EV
    - Distant Future Plans
- Ford
- Chevy
- Toyota

https://energycentral.com/c/ec/evs-mid-spring-2023

11.16. Get Your Motor Runnin', Part 2

Part 2 is mainly about traction motors. I covered smaller applications in Part 1. These were important to get Infinitum Electric’s (now just “Infinitum”) motors runnin’, and put some capital plus experience into their company to prep then for the big opportunity (EVs).

In researching this article, I identified two new firms that are also developing high-output motors using new designs, specifically targeting mobility application. One is in the U.S. and one in the EU. I will cover these briefly in the last section of this paper

However, if you are interested in this subject, I would start with part 1, as I will only provide the new information in this (probably very short) post. There is a link to part 1 in the Introduction of this paper.

https://energycentral.com/c/ec/get-your-motor-runnin-part-2

11.17. EVs Early Spring 2023

This post will cover the following subjects:

Supply Chain:

- Tesla borrows a strategy from Ford

New emerging business model for EV charging networks:

- Groceries and a Quick-Charge
- 7-Eleven

Green Truckin' – Mr. Farley: what is required to make a really green truck?

EV Hosting Futures:

- PNNL report: the impact of EVs on the grid in the future
- Tesla V4 Supercharger – More Power & CCS

Upcoming EVs:

- VW's Scout and ID Buzz

EV's in Alaska?

Highest Performance EV Batteries

Tesla's Q1 Results

https://energycentral.com/c/ec/evs-early-spring-2023

11.18. Participants in the Last Clean-Vehicle Segments Emerge

I have written enough papers on hydrogen-fueled vehicles to know their potential advantages verses battery-electric vehicles (BEV):

- Fast refueling
- Very long run-time without refueling

There are two segments of vehicles that appear to be unable to easily transition to designs with no greenhouse gas (GHG) emissions:

- Construction vehicles (bulldozers, front loaders, dump trucks, backhoes, etc.)
- Long-range/duration road vehicles (interstate transports, heavy tow trucks, etc.)

There seems to be a match between the above "advantages" and "vehicles" that might suggest the emergence of some hydrogen-fueled vehicles to meet the needs of the two vehicle segments.

https://energycentral.com/c/ec/participants-last-clean-vehicle-segments-emerge

11.19. E85

If you live in an agricultural area, you probably already know what E85 is. I don't, but every week or two I drive from my primary residence (Livermore, CA) to my mountain home in Arnold, CA. About half way there via my normal route, I pass a gas station that

is right in the middle of California's Central Valley, one of the largest food-stuff producers in the U.S. I have in the past noted that (1) they sell E85 (fuel that is roughly 85% bio-ethanol) because they have a large sign out front that advertises this, and (2) E85 is a lot less expensive than gasoline.

Of course during the peak gasoline prices recently, I wondered if either of the vehicles that I drive to Arnold could use this. When I'm curious about something, particularly when it is related to the Energy Industry, it usually ends up as a paper / post on Energy Central, and thus this post.

https://energycentral.com/c/ec/e85

11.20. Hydro-Honda Gets Help from Trains

I frequently write about transportation. However, it is rarely that I see one flavor of the mobility-industry interact with a completely different flavor. Like, for instance, light road-going electric vehicles interacting with rail-vehicles. This is one of those times.

In the past Honda has been enamored with hydrogen fuel-cell cars. Although they still are to a degree, they seem to be shifting some of their affection to other products in their corporate network.

I live in Livermore, CA. A few years ago, the City of Livermore (in Alameda County), the county to the east (San Joaquin) and other governmental agencies started a short commuter rail project (26 miles long) called Valley Link. This rail link will connect the Altamont Corridor Express to the Bay Area Rapid Transit System.

A major part of Valley Link is a solar powered green-hydrogen production facility in Tracy (Just east of the Altamont Pass in San Joaquin County). This will fuel the Valley Link trains, local hydrogen-fueled busses, and other hydrogen fueling facilities, perhaps including those that fuel light vehicles.

California currently has only 63 operating light duty vehicle (LDV) hydrogen refueling stations, and 29 additional planned LDV hydrogen refueling stations. None of these are in the Livermore or San Joaquin Valleys.

https://energycentral.com/c/ec/hydro-honda-gets-help-trains

11.21. EVs Late Winter, 2023

I started to work on the latest paper in this series in early February and will post it on March 14th, before the Vernal Equinox (March 20 for the Continental U.S., in the afternoon), while it's technically still winter. This covers the following subjects:

Supply Chain:

- GM and Ford are starting to make major commitments to assure their Lithium-Ion Battery materials supply.
- Redwood Materials, the battery recycling and components maker created by Tesla cofounder JB Straubel, has won a major US Federal Grant to expand its production of EV Battery Components.

Rental EVs and New EVs:

- EVs from major rental car firms

- We will review a future EV (2024) from Honda that is below $50k
- There is an upcoming commercial vehicle from Mercedes.
- Five Reasons Having an Electric Vehicle Saves You Money

Manufacturer's Strategy:

- Toyota EV Strategy evolves.
- VW's sub-$25K EV

Tesla:

- Additional information on the Ramp and Technical details on the Tesla Semi.
- Major Lithium Move?
- They're ba-a-ack.
- Investor Day announcements.
- Price Reductions for Model S and Model X

https://energycentral.com/c/ec/evs-late-winter-2023

11.22. EVs Mid-Winter, 2023

I seem to be settling in to around monthly "EV…" posts. One excuse for this post was a good article from Forbes on new EVs from next year and later. Although I'm staying with my focus on medium- and low-priced EVs (less than $50K before rebates and tax credits), I've noted from the Forbes article that GM (and other manufacturers) generally seem to be leading with their more expensive variants of new models.

This post will cover the following subjects:

- Four new EVs coming in 2023
- New EVs coming after 2023
- Three new EVs coming after 2023
- An increasing synergy between EVs and Photovoltaics (PVs)
- Tesla price reductions and other news

https://energycentral.com/c/ec/evs-mid-winter-2023

11.23. EVs' Tough Road Ahead

As I started considering the IEEE Spectrum article used as a source for a future article, I found a lot to like. First of all, it described in detail the changes we (our societies) must make to implement Electric Vehicles, but also explored the risk of over-simplifying the challenges in implementing those changes.

Many parts of the Spectrum article that is referenced above that I do strongly agree with is that the whole life-cycle of EVs, including fuels, electricity, assembly, recycling and supply-chains matters mightily.

https://energycentral.com/c/ec/evs%E2%80%99-tough-road-ahead

11.24. EVs Early Winter 2023

It's a busy time in the electric vehicle (EV) Market. My last post on this was under a month ago, but new, and significant information has been coming in at a rapid pace, and I'm expecting more before the posting date.

In EVs Early Winter we will cover the following subjects:

- A major new award for Ford's Lightning
- The Next EV-SUV rollout for Ford?
- Latest USPS EV commitment
- New workers' skills and new needs as EV factories ramp production
- Tesla's Entry into Mexico
- As Tesla's Semi ramps, PepsiCo reports its early volume and experience.
- Tesla's Giga TX Ramp
- Fickled EV customers.
- Latest USPS EV commitment
- Kia goes boxy & big (see main image).
- California leads and others follow

https://energycentral.com/c/ec/evs-early-winter-2023

11.25. Solid State Battery Breakthrough

Lithium-ion designs that are currently used in EVs use a lithium compound for the cathode, graphite for the anode and a liquid electrolyte. About ten years ago several companies started working on an anode that was made from metallic lithium (rather than a lithium compound as is used in the cathode) and also used a solid-state separator (rather than a liquid electrolyte).

For the last five years these have been the wave of the future. However, there is a problem with these batteries that, to date, no one has been able to solve: dendrites (metal whiskers). The dendrites formed on the metallic lithium anode and eventually pierced through the separator to the cathode, shorting the battery.

Researchers at MIT recently discovered the cause and a potential cure for the dendrite-formation via a major research project. This paper is about the project and possible dendrite problem cure.

https://energycentral.com/c/ec/solid-state-battery-breakthrough

11.26. EVs, Late Fall, 2022

My last post similar to this one was in late-October, and I'm starting this one in time to post in mid-December.

In this paper we will deal with manufacturing commitments, market position, significant awards, new deliveries and needed changes among six EV manufacturers. In the Technology section (3) are an explanation of EV reliability issues, and a major advance in vehicle-to-grid (V2G) technology.

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

11.27. Personal Vehicle Driver Assistance, Engagement & Privacy

When I write about vehicles, I mostly write about electric vehicles (EVs), mainly because these are closely tied to the future of the electric utility sector, and the future of driving. The latter assumption is because EVs only emit greenhouse gasses (GHG) through any of these gases that are produced while generating the electricity used to charge them.

However, although this article about vehicles is not specific to EVs, electric vehicles (mostly Teslas) pioneered connected, data-intensive vehicles. The main feature this technology adds to vehicles is that most upgrades and many repairs can be done over-the-air, and thus not require a dealer visit.

However the connected, data-centric vehicle does have its down-sides. I will cover these in this paper.

https://energycentral.com/c/ec/personal-vehicle-driver-assistance-engagement-privacy

11.28. EVs-Mid Fall, 2022

My last EV post was a little over a month ago. In this Post we will continue to look at various future mainstream EVs plus go up-market (to the heavies) and down-market (to the tiny, hyper-efficient EVs). Also, we will look at some early payoff from the Inflation Reduction Act of 2022 (IRA), as EV manufacturers start expanding their U.S. facilities to take advantage of the IRA's tax credits to boost their volumes. Finally we will look at Tesla's Third Quarter Results and Earnings Call.

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

11.29. Future EV Batteries

This paper started with a very good article in one of my favorite sources (Science), about how consumers are likely to demand EV batteries in the near-term future that can fast-charge at record rates. And further, if manufacturers could not supply these, this would put California's goal of mandating that all light vehicles be mostly electric starting in 2035 at risk.

Contrary to the above argument is the fact that most EV owners in my home state (California) charge in the evenings at home. Experts noted most EV charging is done in off-peak hours, mostly because of time-of-use rates set by utilities that push drivers to power up overnight. Industry experts said efficient charging technology is just getting started.

To reinforce this fact, my electric utility (PG&E) and, I assume, other investor-owned utilities in our state, offer special rates for EVs. These rates are three-tiered time-of-use rate, with a very-low off-peak rate (from 11:00 PM until 7:00 AM).

https://energycentral.com/c/ec/future-ev-batteries

11.30. 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

11.31. 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

11.32. 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

11.33. 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

11.34. 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

11.35. 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

11.36. 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

11.37. 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

11.38. 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

11.39. 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

11.40. 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

11.41. 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

11.42. 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

11.43. 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

11.44. 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

11.45. 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

11.46. 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

11.47. 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

11.48. 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

11.49. 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

11.50. 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

11.51. 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

11.52. 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

11.53. 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

11.54. 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

11.55. 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

11.56. 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

11.57. 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

11.58. 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

11.59. Toyota, Tesla & Schumer

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

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

11.60. 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

11.61. 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

11.62. 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

11.63. 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

11.64. 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

11.65. 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

11.66. 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

11.67. 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. Small Steps to Mitigate Climate Change – Biomass – Pt 2

This is my second post in this series. In the first post, in late July, I focused on woody biomass mainly because of a personal connection. With this post I am focusing on biomass energy in general.

The “rich vein” that I’m using, U.S. Energy Information Administration (EIA), “Biomass explained,” has a good description of biomass energy in general, so we will start with this in section 2 below.

https://energycentral.com/c/cp/small-steps-mitigate-climate-change-%E2%80%93-biomass-%E2%80%93-part-2

12.2. Small Steps to Mitigate Climate Change – Biomass

I started thinking about another future post on Bioenergy, in general, and started researching this. I discovered a very rich vein of information about all of activity currently in progress about this renewable energy source. Now I have way too much material for just one paper, so this will probably be a series.

“Bioenergy Technology” actually covers many technologies. Thus what I will do in this first volume of this series is to start with a description of the value of these technologies, and then cover this technology.

https://energycentral.com/c/cp/small-steps-mitigate-climate-change-%E2%80%93-biomass

12.3. Biofuels Reboot

As I wrote a recent post, “Blueprint for Transportation Decarbonization,” I discovered that U.S. Government currently intends to use many “Sustainable Liquid Fuels,” especially in the Maritime and Aviation subsectors (see the main image of this post). A few days later I was reading my latest issue of Scientific American, and came across an excellent article on these fuels, and you can probably guess the rest of the story.

https://energycentral.com/c/ec/biofuels-reboot

12.4. 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

12.5. 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. Developments in Hydrogen Production

Many have advocated a major role for green hydrogen in reducing greenhouse gas (GHG) emissions, and thus mitigating climate change. I posted the paper summarized and linked in this post a couple of months ago. In this paper I looked at the economics of green hydrogen vs. many applications that could reduce their GHG emissions by using this gas.

In this post we examine electrolyzer technologies, and major manufacturers of hydrogen electrolyzers, mostly those that are based in the U.S.

https://energycentral.com/c/ec/developments-hydrogen-production

13.2. On the Road to H2 in California

Sometimes, when looking at your past work, you feel that you have spending an inordinate amount of time on a given task, or in my case a subject for my posts. However, whether I'm really squandering my time would depend on (1) how important this subject is, (2) how timely it is, and (3) what are the net results. You can probably figure out what the subject of the above feeling is by looking at the title of this post.

I'm assuming most know how important it is for us to greatly reduce the amount of GHG we are emitting ASAP. What about timeliness? The key question: is hydrogen energy production in our distant future, or are imminent breakthroughs on the horizon? After going through recent posts, I now feel very strongly that we are getting really close to making some significant steps in the next year or two.

This paper will present the findings of recent posts and other related information. These should provide a summary of net results.

https://energycentral.com/c/ec/road-h2-california

13.3. A Solution for the Rest of Our Economy

The most important two major projects we can undertake to fight climate are (1) move all electric generation to renewable technologies, and (2) electrify all energy usage by our (the world's) economies, starting with non-electric segments that are easiest to electrify.

However, the above linked projects bring up an important question: what about those segments that are very difficult to electrify, "…the Rest of Our Economy."

https://energycentral.com/c/cp/solution-rest-our-economy

13.4. Molecular Sponges for Hydrogen Storage

Metal-organic frameworks (MOFs) are fairly recent inventions, but I have written about them before, just not in this context. These materials are composites of molecules that are very good at absorbing gases, and my previous post involved carbon dioxide.

As you can tell from the title, this paper is about hydrogen storage. Although MOFs weight generally precludes them from being used in hydrogen fuel-cell electric vehicles, there are many hydrogen storage applications for which they are a perfect fit.

https://energycentral.com/c/cp/molecular-sponges-hydrogen-storage

13.5. The Clean-Fuel Debate

Although I've written about this subject recently I've come across several new pieces of information that indicated my prior posts on this might need some clarification.

The perfect should never be the enemy of the good. Or more specifically: For any transition to a cleaner method of operation, perfection is rarely achievable. However, correction of imperfections are relatively easy, so "good" is good enough.

This post will be about hydrogen-fueled internal combustion engines (hydrogen-ICE) and hydrogen-fueled continuous-flow internal combustion engines (hydrogen CF-ICE, mainly gas turbines, a.k.a. combustion turbines, including turbo-fans).

https://energycentral.com/c/ec/clean-fuel-debate

13.6. New Colors of Hydrogen from the Depths

The title of this paper actually describes its content very well, although I'm sure it will leave most readers confused. That is, most readers that are not members of the American Association for the Advancement of Science, and don't regularly read their weekly issue of Science. But now at least you know where my main lead came from.

Would you believe there are vast amounts of relatively pure hydrogen underground, and we can drill wells to extract this? Read on.

https://energycentral.com/c/ec/new-colors-hydrogen-depths

13.7. 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

13.8. 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

13.9. 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

13.10. 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

13.11. 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

13.12. 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.

13.13. 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

13.14. 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

13.15. 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

13.16. 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. Strengthening the Grid's Edge Using Diversity

OK, I get it. Most of the US is one big grid. There are natural boundaries (large lakes, mountain ranges, large national or state parks, etc.) that interrupt the US grid, but only states that have these features, or are the most sparsely populated have "grid edges." I live in the former, and somewhat in the latter for my home state, California.

Isn't California the most populous state? Yes, at almost 40 million people, but it's also a very large state (Texas and Alaska are larger). Also, the population is concentrated in 4 very high-density metro areas (, and 10 to 15 cities that range from just over 500,000 to over 150,000. None of the above heavily populated areas are north of The Sacramento Metro Area nor East of the Central Valley. That leaves many areas with little or no grid, and plenty of grid-edges.

This paper is about methods used to harden the grid at these grid-edges.

https://energycentral.com/c/gr/strengthening-grid%E2%80%99s-edge-using-diversity

14.2. Microgrids for Critical Infrastructure

I have been remiss. It has been almost two years since I have written about Microgrids. However, in my defense, I have been writing about subjects that seem timelier, given recent effects of climate change and the need to remedy this problem.

Although there are probably many applications that small microgrids fulfill, there are at least two where resiliency is the primary driver:

- Isolated remote communities with tenuous utility connections and/or related outage issues (like in forested areas where falling trees and limbs cause service interruptions.
- Urban and suburban critical-infrastructure (like fire-stations, police stations, hospitals, utility switching stations, etc.) with occasional but potentially extended outages.

In this post we will consider the second bullet above, as there are probably many more of these applications. Also the critical infrastructure described above might already have emergency back-up generation, but during extended outages refueling may become an issue.

https://energycentral.com/c/gr/microgrids-critical-infrastructure

14.3. 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

14.4. 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

14.5. 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

14.6. 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

14.7. 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

14.8. 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

14.9. 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. Battery Energy Storage, The Key to Renewables

My home state, California, has enacted several rules and incentives to strongly encourage the use of battery energy storage on the grid at every level. We already have a very diverse energy supply on our grid, but we also have very aggressive goals regarding our transition to a 100% zero-carbon energy supply.

Governor Newsom announced the “Building the Electricity Grid of the Future: California’s Clean Energy Transition Plan” today, showing how California will reach our goal of 100% clean electricity by 2045, while keeping costs affordable and maximizing our energy supply through this transition.

California has an ambitious clean energy agenda, and we’ve exceeded many of our targets, years ahead of schedule. But to reach our ultimate climate goals, we need to build more clean energy faster. In the past, distributed renewable energy resources have played a major role in meeting and exceeding our targets, and in the future that will play an even stronger role, as described in this post.

https://energycentral.com/c/cp/battery-energy-storage-key-renewables-%E2%80%93-derms-special-issue

15.2. Geothermal Energy Overcomes Major Obstacle

Geothermal energy, as I’ve written in a 2021 post excerpt below, may be the perfect renewable, as it is fully dispatchable and uses proven technologies.

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.

Geothermal power has a strong technology base in the petroleum industry. Drilling holes in the ground to extract geothermal steam uses the same tech as drilling holes to extract oil & natural gas. The bad news is that it’s damned expensive, and depending on the specifics of a given (petroleum or geothermal) project may not be justified based on the return on investment. Also, geothermal production requires two wells – one to extract the steam and another to reinject the condensate.

https://energycentral.com/c/cp/geothermal-energy-overcomes-major-obstacle

15.3. Hot Rocks Part 4, 2024 Update & Next Generation

The first three “Hot Rocks…” papers were in 2021 & 2022. I just went back and reread these. They are all quite good and taken together a good course in geothermal energy. There are summaries and links to these in the Introduction of this post. In part 1, I indicated that geothermal generation is the perfect renewable. Why? Because it is fully dispatchable and can be used as base-load, without the need to burn dinosaur fumes and drippings (or anything else), thus no emissions.

Although the earlier three posts are a rather long-read, I would recommend that readers that are really interested in geothermal power take the time to do this. Although geothermal power is nearly perfect, it is not an easy technology to deploy or understand. What is changes since part 3 is that (1) our fearless leaders have determined that we need all developed sources of renewable energy to pull us out of the climate change predicament, and (2) because of the unique characteristics of geothermal power, it will play a leading role. Thus, they are pushing development of geothermal as hard as they can.

https://energycentral.com/c/cp/hot-rocks-part-4-2024-update-next-generation

15.4. Recent Books about Climate & Renewables

I set out assembling this list with a final target of reasonable books on renewable energy, and these are below. But it occurred to me, that without understanding Climate Change, one really cannot understand renewable energy. Ask yourself: why is the world transitioning from petroleum- and coal- based energy to renewables? It is to avoid the worst effects of climate change, so I started with three good books on climate change.

https://energycentral.com/c/cp/recent-books-about-climate-renewables

15.5. Renewable Tipping-Point

I have been privileged to witness the emergence of photovoltaics (PV) and wind-power as major energy generation technologies. Lately it has seemed to be inevitable that these technologies would be able to meet the major challenge of doing most of the heavy lifting as we transition to greenhouse gas (GHG) free electricity. Others agree.

Renewables have historically been considered expensive, their deployment requiring high subsidies or carbon taxes. However, following a fruitful history of innovation and past climate policy, renewables now increasingly compete with fossil fuels. Whether renewables become the new normal increasingly hinges upon industry and trade development rather than a pure normative necessity to meet carbon budgets. Policymakers urgently need to know not only whether a renewables future is possible, but whether it is materializing.

Between 2010 and 2020, the cost of solar PV fell by 15% each year, representing a technological learning rate of around 20% per doubling of installed capacity. At the same time, the installed capacity has risen by 25% per year, causing and partly caused by these cost reductions. Meanwhile, onshore wind capacity grew by 12% a year, with a learning rate of 10% per doubling of capacity. If these rates of rapid co-evolution are maintained, solar PV and wind power appear ready to irreversibly become the dominant electricity technologies within 1-2 decades, as their costs and rate of growth far undercut all alternatives…

https://energycentral.com/c/cp/renewable-tipping-point

15.6. Expanding Hydroelectric Generation, the Easy Way

More renewable electric generation along with less fossil-fueled generation is needed in order to reach net-zero greenhouse gas (GHG) electricity. My home state (California) does not consider nuclear generation or medium to large hydroelectric generation “renewable,” although I do. California defines the two excluded “non-renewable” electricity sources as “zero-carbon resources.”

Hydro power is also a bit strange in other respects, whether it's small medium or large. First of all, it serves several masters. In addition to needs by the electric grid it responds to needs for water.

This post is mostly about medium to large hydro generation, specifically those that have dams, and thus reservoirs.

https://energycentral.com/c/cp/expanding-hydroelectric-generation-easy-way

15.7. 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

15.8. 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

15.9. 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

15.10. 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

15.11. Hydro – Management

Although hydropower is used nation-wide, 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

15.12. 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

15.13. 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

15.14. 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

15.15. 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. Wind & Solar Generation = Big Health Benefits

I tend to focus on the benefits of zero-carbon generation in mitigating climate change by reducing greenhouse gasses. However, there is another major benefit: air quality. Zero-carbon generation includes nuclear, large hydroelectric generation and renewables. The alternative is generation that emits greenhouse gasses like carbon dioxide (CO2), carbon monoxide (CO), nitrous oxides (NOx) and sulfuric oxides (SOx). I don't believe that CO2 in the volumes emitted by electric utility generation is detrimental to human health, the other gasses definitely are.

Lawrence Berkeley National Labs (LBNL) recently published a report that estimated both the air quality and climate benefits of wind and solar energy. This paper is a summary of that report.

https://energycentral.com/c/cp/wind-solar-generation-big-health-benefits

16.2. 5 Stages of Energy Production Viability

We are in the midst of a badly-needed transition from greenhouse-gas-emitting generation technologies to renewable technologies. The speed at which we make this transition will determine the severity of climate-change environmental impacts for the

next few decades. So far, we have done a pretty good job of developing additional renewable technologies and driving down their cost and (especially) the cost of the (mostly electric) energy they produce.

But what does the title have to do with the title of this paper. There are a wide range of renewable technologies, and some of those are very mature, some are immature, and all continue to mature at varying rates. In order to better understand how we (our economy) should allocate our resources I believe that need to do a bit of parsing of these technologies and their maturity. Let's start with the latter.

https://energycentral.com/c/cp/5-stages-energy-production-viability

16.3. Long-Duration Energy Storage to Firm Windpower

It's not a screaming panic, but nevertheless, every ton of CO_2 and other greenhouse gasses (GHG) that we do not pump into the air now will be one less we need to deal with in the future. Also as more catastrophic effects of climate change emerge, we are likely to feel an urgency similar to a screaming panic.

So the subject of this post is important. The primary issue is, Large Battery Energy Storage Systems (BESS) based on Lithium-Ion (LiIon) technology like Tesla's Megapack are ideal for a 4-hour run-time and thus mitigating most of the variability of photovoltaic (PV) generation. PV emits very little GHG, and when paired with LiIon BESS can cover most of the daily energy demand (at least where I live in Northern California), but not the much lower night-time demand after 9:00 PM.

In this paper we will look at candidates for the role of mitigating wind-power and examples of other long-term power deficits needing a long-term storage solution.

https://energycentral.com/c/cp/long-duration-energy-storage-firm-windpower

16.4. Aftermath

I'm an optimist, and I believe we will chart a path in the next decade that will take us to net-zero greenhouse gas emitted by humans at some point thereafter. However, there are probably hundreds to thousands of potential paths. Shouldn't we take path(s) that make life better for humans, and also make our economies more efficient? I believe we should, and so do others.

Imagine this hopeful, and not impossible, energy scenario for the year 2040. Many countries have met their climate goals and are on track to be completely carbon neutral. Wind and solar parks produce a large portion of their energy. Then, as now, wind farms are operating off the world's coasts—but not all of these offshore sites are connected to the mainland via underwater power cables.

Some of the wind farms instead sit in clusters more than 100 kilometers out at sea. They are highly automated production islands that directly convert wind energy to hydrogen, with a few of them processing the gas into fuels and other goods. Chemical plants on dedicated platforms then process part of the hydrogen, combining it with nitrogen to make ammonia, or with carbon dioxide to produce substitutes for fossil fuels…

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

16.5. US Funds Renewable Technology Development

We are in a war against human-caused (Anthropogenic) climate-change. Like with many past wars, the U.S. Federal government will play critical roles in our mitigation of and recovery from the effects of climate change. Also, like many of our most powerful enemies in the past, climate-change has had and will have many surprises for us.

Occasionally we think that we are masters of our fate. And that our supercomputer suites can predict future climate change with unwavering accuracy. Ha!

Given our limitations, our best strategy is "all of the above," including pushing all renewables (very low carbon energy), mobility and other CO2 generating applications' replacements as hard as we can.

This post is about the current status of our U.S. Government's push to accelerate renewable energy.

https://energycentral.com/c/gn/us-funds-renewable-technology-development

16.6. Linear Thinking

I believe that most of my readers understand that energy storage will play a leading role in mitigating climate change. There are many types of energy storage systems. A five-post series I wrote a bit over a year ago was a review of an NREL Series called "Storage Future Study". This series is referenced at the end of this paragraph. In the Vol 1 post I presented the following table from NREL that summarized the types of storage:

https://energycentral.com/c/gn/linear-thinking

16.7. Renewable Energy Expansion Exceeding all Estimates

I have noted the rapid acceleration in the development of renewable energy at every level: state, U.S. and North American, but since I rarely focus on the international market, I wasn't aware of the global trends that this article covers.

Global decarbonization will require a massive build-out of wind and solar farms. But can developers find enough land, secure the supply chain, and recruit workers while maintaining profitability?

This paper presents evidence that the developers can meet these challenges.

https://energycentral.com/c/cp/renewable-energy-expansion-exceeding-all-estimates

16.8. The Edge of Electric Generation

Forbes has many specialized news-letters. I subscribe to a weekly post called Forbes Current Climate.

Occasionally my cup runneth over, and I have too many good leads for articles. Then something else comes in. Although I have various methods for capturing this content for later digestion, the simplest (for emailed content) is to just leave it in my in-box. I did that with an issue of Current Climate in early January (after capturing a few leads), and then came back to it in early-February (as I'm writing this). I found two really good leads about crazy-edge generation technologies. These quickly developed into this paper.

https://energycentral.com/c/gn/edge-electric-generation

16.9. 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

16.10. 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

16.11. 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

16.12. 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

16.13. 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. Federal Reforms and The Interconnection Problem

Although fossil fuel–generated electricity production has historically vastly outweighed production from wind and solar, that is changing. However, in many countries, there is a substantial and growing waiting list for connecting new generation projects to the electrical grid. In the United States, for example, the number of applications has increased rapidly since 2010 to more than 3000 projects in the various interconnection queues as of 2021 (see this post's main image). The median time from interconnection request to interconnection agreement was 35 months in 2022, with wait times even longer for wind and solar. In response to this growing bottleneck, the US Federal Energy Regulatory Commission (FERC) issued two recent orders aimed at improving the generation interconnection process and long-term transmission grid planning.

https://energycentral.com/c/cp/federal-reforms-and-interconnection-problem

17.2. California Future Renewables

California is my home state, and I am proud to say that they generally lead the pack in battling climate change. Last month our state's Public Utilities Commission approved a plan for deploying additional renewable energy in the next few years, and that is the subject of this post. I also drilled through the press release on the approval to the proposal and will add the core-order from the proposal. Both are referenced and linked below.

https://energycentral.com/c/cp/california-future-renewables

17.3. Interconnection Graveyards – Where Renewable Projects go to Die, Pt 2

In Part 1 of this series, we covered the organizations responsible for approving new renewable (and other generation) projects' access to the transmission grid. In part 2 we will look at the basic process for approving projects' access to the transmission grid and elaborate (to some extent) on the differences among different ISOs' and RTOs' processes.

https://energycentral.com/c/cp/interconnection-graveyards-%E2%80%93-where-renewable-projects-go-die-pt-2

17.4. Interconnection Graveyards – Where Renewable Projects go to Die, Part 1

The problem starts with a one-word characteristic of the most popular and cost-effective renewable generation technologies: variability. These technologies are wind and solar generation. Since they use "natural sources of energy, the fuel is free, and that is one reason why they are so cost effective. However the fuel is also variable, that is it isn't always available.

The good news is that there are many fixes to this variability. That is also the bad news as the fixes come from different agents, and are promoted differently in different regions.

In this post we will attempt to take a top-down approach. I have collected many good recent articles on this subject, and have found a really good source that I will use for Part 2 of this series. In part 1 we will look at the underlying structure of organizations where we must attempt to resolve the title issue.

https://energycentral.com/c/gn/interconnection-graveyards-%E2%80%93-where-renewable-projects-go-die-part-1

17.5. Rooftop Solar Energy Tug of War, Part 4, Final Resolution

Even as I was writing parts 1 and 2 of this series, and thus reviewing the original ruling (issued about a year ago), there was no doubt in my mind that the chances of this ruling standing intact were slim to none. This perception was mainly because the solar industry felt that this ruling was highly unfair to them and was likely to seriously hurt future rooftop solar energy deployments. Also, the solar industry is strongly viewed as a positive environmental influence in our state, is financially very powerful, and thus strongly influences many political leaders. Thus, this decision was set aside last summer, and the CPUC (on Nov 10) issued a new proposed decision.

On December 15, the CPUC approved the proposed decision that the above review is based on, but with mark-ups. I downloaded the decision, and skimmed through it, and although nothing looks like a major change, there are significant changes. This paper is a detailed review of the approved decision.

https://energycentral.com/c/cp/rooftop-solar-energy-tug-war-part-4-final-resolution

17.6. Rooftop Solar Energy Tug of War, Part 3, Proposed Resolution?

Even as I was writing parts 1 and 2 of this series, and thus reviewing the original ruling (issued about a year ago, ditto parts 1 & 2), there was no doubt in my mind that the chances of this ruling standing intact were slim to none. This perception was mainly because the solar industry felt that this ruling was highly unfair to them and was likely to seriously hurt future rooftop solar energy deployments. Also, the solar industry is strongly viewed as a positive environmental influence in our state, is financially very powerful, and thus strongly influences many political leaders. Thus, this decision was set aside last summer, and the CPUC (on Nov 10) issued a new proposed decision.

I don't intend to revisit the new decision in detail, because it builds on and modifies the original decision. What I will do with this post is to outline significant differences between the prior decision, the current draft decision, and reference my papers describing the original decision to expedite this process.

https://energycentral.com/c/cp/rooftop-solar-energy-tug-war-part-3-proposed-resolution

17.7. 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

17.8. 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

17.9. 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

17.10. 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

17.11. 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

17.12. 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

17.13. 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. California Residential Solar Firms

This is a curious post for your author. I recently completed my own Solar + Storage Project and posted a three-part series. However, my project was unusual due to the we needed a solar-roof design. In other words, no separate PV Panels allowed, and the PV needed to be attractively integrated into the roof. Thus, a new solar roof was required. “Solar roof” greatly limited the number of bidders. Our project went well and we are both very pleased with the results, but our project is atypical. Going forward my solar project will be typical (for California) in that I specified a battery energy storage system, and most systems in California are evolving to include these due to a recent PUC Ruling.

I felt that my readers might be better served if I expanded my criteria for this paper to include designs that did use conventional PV Panels, So I started to research the viability of doing this paper. I included the firm(s) that implemented my project, but I also included other large firms that do business in much of California (and in a few cases, beyond), and have broad offerings, that at least include PV and battery energy storage systems (BESS), and most also offer reroofing (solar or conventional).

https://energycentral.com/c/cp/california-residential-solar-firms

18.2. The Next-Generation Solar Technology?

I occasionally write about a technology called perovskite-silicon tandem solar cells. These have been the wave of the future for about ten-years. But the real question is will they always be in the future, or will solar modules using these products enter production soon, and if so, what compromises will they have?

This post should answer those questions.

https://energycentral.com/c/cp/next-generation-solar-technology

18.3. Residential Solar Energy Consumer Protection

A few months ago, I completed my own rooftop solar energy project. Since I worked as an application engineer for a number of large electric-utility vendors (most notably Siemens and Landis & Gyr), I was familiar with the proposal process, including the stage where the buyer (me) prequalifies the potential bidders. Because of this I ended up with a reputable vendor for my project, and all went as planned.

Recently, I found three other resources for potential residential solar energy clients in an article from PV Magazine. I drilled though Reference 1 to the three federal agencies mentioned therein, and found some useful information. Below I will devote a section to each agency, with a summary and a link to their resources. At the end of this article, I added a fourth section on a California Agency, since I'm from this state. And suspect some readers will also call California home.

https://energycentral.com/c/cp/residential-solar-energy-consumer-protection

18.4. PV & Storage, Early Summer, 2024

This series seems to require two posts per season to keep up with all of the information that is flowing across my desk. This paper will cover the following subjects:

Technology: IEA Fact Sheet on bifacial PV modules and tracker design

Business: the Treasury Department rolled out guidelines for a voluntary carbon market aimed at ensuring credits purchased are tied to actual climate-enhancing actions.

Major Projects: I found seven major projects, mostly in the West. I believe all of these are all above 150 MW.

https://energycentral.com/c/cp/pv-storage-early-summer-2024

18.5. PV & Storage, Mid Spring, 2024

I've decided to broaden my focus a bit with this post. I'm still staying within the U.S., but focus a bit more on other states, rather than just on my home-state (California).

https://energycentral.com/c/cp/pv-storage-mid-spring-2024

18.6. Rooftop Solar Energy Tug of War, Part 7, implementation and results

This paper, as planned, is the final episode in this very long series on residential solar energy projects in California, and this part, the prior parts 5 and 6 are specifically about my project. The prior part of this paper is linked in the Intro of this paper, and part 5 is linked in the Intro of part 6.

https://energycentral.com/c/cp/rooftop-solar-energy-tug-war-part-7-implementation-and-results

18.7. PV & Storage, Early Spring, 2024

This is the year that "PV and Storage" became real for your author. I am nearing completion for a project to install a new Salar Roof and a Battery Energy Storage System on my primary residence in Livermore, California. See section 3.1.1 in this paper

for the series of papers I am writing on my project. The third of this series will be completed in a few weeks.

This paper covers the following subjects:

Technology:

Steady Gains on Many Fronts

Business

Hawaii & California Follow the Same Path

The Residential Specialists

US Major Milestone

Projects

https://energycentral.com/c/cp/pv-storage-early-spring-2024

18.8. PV & Storage Early 2024

Several factors can encourage a new industry to grow rapidly. These include:

- Growing demand for the industries new products.
- Customer-industries that require an increasing volume of the new industries new products.
- A supportive environment that encourages the new industry's growth, including parallel markets.
- Technological breakthroughs that increase performance and/or improves the new products' price/performance metrics.

When several of the above factors appear simultaneously, the new industry's growth can be explosive. This appears to be happening in the Battery Energy Storage System (BESS) Industry currently. This paper will cover this subject.

https://energycentral.com/c/cp/pv-storage-early-2024

18.9. Next Generation Battery Emerges

Frequently a new product in the energy industry takes off like a rocket, finding many new applications in a few years, selling in huge volumes and spawning many new companies. That is the up-side. The down-side is they frequently also spawn their competition. In this case the former is the lithium-ion battery, and the latter is an emerging competitor: the sodium-ion battery.

This was inevitable. lithium and sodium are both Alkali Metals, column 1 of the Periodic Table of Elements, and they are only one row apart, so they share many characteristics. Lithium is actually very common, but current demand for lithium-ion batteries is stretching the supply to the limit and driving up pricing. Sodium is much more common than lithium, so it is unlikely that any surge in demand for these would ever significantly elevate pricing. That is only where advantages of sodium-ion batteries start.

https://energycentral.com/c/ec/next-generation-battery-emerges

18.10. Next Generation PV Draws Near

I found an excellent paper on the title subject in Science. Thus, a large majority of the text below will be from that (reference 1) and not from me. Note that I eliminated secondary references from ref 1 for clarity. However, since PV cell and module technology has their own languages, and since the text below takes a deep dive into this technology / language. I am referencing an earlier post in this paper's introduction to prep readers for PV-Speak.

https://energycentral.com/c/cp/next-generation-pv-draws-near

18.11. Rooftop Solar Energy Tug of War, Part 6, Selection, Survey & Design

This paper will focus on the project phases between and including the contractor selection, the site survey and the creation and approval of the design.

https://energycentral.com/c/cp/rooftop-solar-energy-tug-war-part-6-selection-survey-design

18.12. PV & Storage Late-Fall 2023

This paper contains:

Technology:

- The Next Generation of Photovoltaic Modules

Business:

- New Rules, Incentives Shaping Solar-Plus-Storage Market
- U.S. Photovoltaic System and Energy Storage System Cost Benchmarks
- Update
- Projects

https://energycentral.com/c/cp/pv-storage-late-fall-2023

18.13. Rooftop Solar Energy Tug of War, Part 5, Real World Project

This paper contains:

- Brief explanation of likely California solar (plus storage) tariff going forward.
- Sample Specification with clarifications
- Brief comments on bidding process
- Management issues to focus on during proposal cycle:
  - Fairness

- Few bidders
- Prequalification

https://energycentral.com/c/cp/rooftop-solar-energy-tug-war-part-5-real-world-project

18.14. PV & Storage Mid-Fall 2023

This Post will contain the following content:

Technology:

- Recent Developments in Solar Energy

Business:

- Solar Module Prices Crash (in the EU)
- U.S. expands solar tariffs
- Projects

https://energycentral.com/c/cp/pv-storage-mid-fall-2023

18.15. PV & Storage Late-Summer 2023

This post will contain the following content:

Technology

- New Liquid Metal Battery System
- Solar Cell Technology, into the Future
- US Made Solar Cells with High Efficiency

Business

- Over 150 GW of Solar Manufacturing Announced
- US solar installations expected to be a record 32 GW in 2023
- Projects

https://energycentral.com/c/cp/pv-storage-late-summer-2023

18.16. PV & Storage Mid-Summer 2023

This post will cover the following subjects.

Technology:

Solar Forecasting Brings Reliability and Economic Savings

American-Made Solar Prize Winners: Where Are They Now?

Putting Solar Energy Installation on Autopilot

Business:

US-India joint venture will spend $1.5B to build US solar factories

Canadian Solar Announces U.S. Module Manufacturing Plant

Solar4america Technology New HJT Solar Cell Factory in the US

Storage Projects

PV Projects and PV + Storage Projects

https://energycentral.com/c/cp/pv-storage-mid-summer-2023

18.17. PV & Storage Early Summer 2023

This post will cover the following subjects:

Technology:

- Major Advance in Flow Battery Architecture
- Ultra-Thin Film Photovoltaics Everywhere
- Rolling Hills PV
- Bifacial PV Panels on Tracking Systems?
- PVEL 2023 PV Module Reliability Scorecard

Business:

- CAISO plan supports 17GW of solar within a decade
- Enel New 3 GW Solar Panel and Cell Factory in the U.S.
- Tesla Battery Energy Storage Business
- Battery maker wins $850M DOE loan to build US factory

Projects:

- Strata Clean Energy 1 GWh Scatter Wash BESS Project
- rPlus Energies to build solar project in Idaho Power system
- Apex adds 195 MW of solar and 400 MWh BESS in Texas
- 400 MW BESS for Portland General Electric
- 162 MWac Pachwáywit Fields solar for Portland GE Online
- Tesla project breaks ground, Arizona's largest project

https://energycentral.com/c/cp/pv-storage-early-summer-2023

18.18. Rapidly Accelerating PV Deployment

This post came together in an amazing way. First an article in “Science” really got my attention. This article was really a plea for the title of this paper. But then other information came in within a few days on developments that might facilitate these rapid deployments. Thus, I was hooked: this paper was authored, and quickly, within in two weeks.

https://energycentral.com/c/cp/rapidly-accelerating-pv-deployment

18.19. PV & Storage, Spring 2023

This post will cover the following subjects:

- On-shoring Energy Storage Technology
- Limits to Projects for California
- Clean Electricity a Large Majority by 2030
- Expanding Tesla Megapack Business
- Recent project summaries

https://energycentral.com/c/cp/pv-storage-spring-2023

18.20. Gen 3 Concentrating Solar Power

Many years ago, I felt the technology war for generating power had been won by photovoltaics (PVs). I was right, but I might have missed a few words in this conclusion: “…the technology war for generating **electric** power… photovoltaics (PVs) **plus battery energy storage (BESS)**.”

Although electrification is a major pillar in reducing the amount of GHG major industries emit, many still needs large amount of thermal energy (heat). Yes, you can generate heat with electricity, but this is generally inefficient, especially for high-temperature heat.

The current U.S. Department of Energy understands this. Thus, they have continued to plug away, reinventing concentrating solar power (CSP) and associated technologies. This paper will review their efforts, including a major CSP test facility that they just broke ground on in New Mexico.

https://energycentral.com/c/cp/gen-3-concentrating-solar-power

18.21. PV & Storage, Early 2023

This has been a challenging paper. First of all I, and my colleagues at Energy Central decided to use a part of this paper in a publication by Energy Central that will predate this post (next post in this list, immediately below), but I needed to delay this paper so that the excerpt would post first. Second, the section in question (last section of this paper) also required a difficult and time-consuming analysis using my Major PV & Storage Project Database. Third, the results of this analysis were extremely strange, requiring additional research and analyses to understand why. And now (late January), as I’m finally start to write this (having already written the last chapter), I have much work to do.

I do have enough content to follow my preferred format (below).

- PV and Storage Technology News
- PV and Storage Business News
- Major PV and Storage Projects

https://energycentral.com/c/cp/pv-storage-early-2023

18.22. Major PV & Storage Projects – 2021 vs. 2022

In an earlier post, described and linked in this post, I extracted the large PV and / or Battery Energy Storage projects that were completed in 2021 from a U.S. Energy Information Administration database. At that time, I indicated that I would repeat this process for large 2022 projects in early 2023. The tables in this post are a repeat of the primary table from the earlier post followed by the 2022 table. These are followed by an analysis.

https://energycentral.com/c/em/major-pv-storage-projects-%E2%80%93-2021-vs-2022

18.23. The Future of Solar Energy: 2nd Post… Plastics

Roughly a year ago I posted the paper named “State-of-the Art PV Panels: “One word… plastics.” That post explored various options for solar modules that overcame several disadvantages of existing module designs.

Organic photovoltaics (OPVs) are currently poised to assume this role. Although these currently have some issues with efficiency, they are improving this metric over time, and they have cost advantages, are more easily recycled than existing silicon-based designs, are light, and flexible.

In this post I will review OPVs and their advantages over other PV designs.

https://energycentral.com/c/cp/future-solar-energy-2nd-post%E2%80%A6-plastics

18.24. PV and Storage, Fall 2022

I have tried to understand how many of the title projects are being developed over time, and probably have made some reasonable estimates of this via a database I created. The problem is, this is one strange market, with many different types of entities participating in it, a majority with different business methods. In the last section of this post, I describe some improvements in my methods, and the first outputs from my database after implementing these.

Earlier parts of this post will cover various business issues, mainly for PV and some good news from the U.S. Energy Information Administration (EIA).

https://energycentral.com/c/gn/pv-and-storage-fall-2022

18.25. Renewables and Natural Disasters

For any electric generation source. It is reasonable to ask how resilient it will be in the face of expected natural disasters. The answers for these questions are complicated by the impact of these disasters becoming worse over time. Unfortunately, this has recently been the case due to climate change creating more, and much worse weather-related catastrophes.

The most recent disasters worsened by climate change in the U.S. include wildfires (in the west), hurricanes (mainly on the Gulf and East Coasts) and non-coastal flooding (widespread).

This post will cover two subjects. The first and primary subject is hardening photovoltaic (PV) projects to withstand storms. The second subject is a case study for a small community's recovery efforts after extensive river flooding.

https://energycentral.com/c/cp/renewables-and-natural-disasters

18.26. 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

18.27. 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

18.28. 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

18.29. 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

18.30. 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

18.31. 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

18.32. 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

18.33. 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

18.34. 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

18.35. 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

18.36. 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

18.37. 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

18.38. 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

18.39. 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

18.40. 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

18.41. 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

18.42. 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

18.43. 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

18.44. 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

18.45. 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

18.46. 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. Tomorrow's Energy Storage

My home state (California) has very ambitious climate change mitigation policies. We are really further down this path than any other U.S. state, and most other nations. Before we started this process, we already had a very diverse generation mix, that had substantial renewable and zero-carbon generation. As we evolved this further away from fossil-fuels, we discovered a very powerful tool, battery energy storage systems (BESS). We now have the largest BESS fleet of any economy except China.

Deep decarbonization of electricity generation together with electrification of many end-use activities are necessary to limit climate change and its damages. Wind and solar generation, which have no operating carbon dioxide emissions, have experienced major cost reductions, and are being deployed at scale globally. These are likely to provide a large share of future total generation. Unlike traditional generators, the output from these variable renewable energy (VRE) resources depends on weather conditions, which sometimes change rapidly. Thus, VRE generators cannot be dispatched to follow variations in electricity demand. Electricity storage, the focus of this paper, can play a critical role in balancing electricity supply and demand and can provide other services needed to keep decarbonized electricity systems reliable and cost-effective.

https://energycentral.com/c/cp/tomorrow%E2%80%99s-energy-storage

19.2. Sodium-Ion Battery Energy Storage Systems

This paper is about a leading technology in the manufacture of electric vehicles (EVs), and the title technology, a rapidly developing competitor. If you know anything about

EVs, you've immediately guessed that the above "…leading technology…" is lithium-ion batteries, and you are correct. However, electric vehicles are not the only market that that uses these batteries, and one of them offers the first step up a ladder that may lead the new-comer to an entry-point into the EV market. Furthermore lithium-ion battery technology has some vulnerabilities, one of them very recent, very large, particularly with respect to sodium-ion batteries.

https://energycentral.com/c/gr/sodium-ion-battery-energy-storage-systems

19.3. NanoElectroFuel Boosts Flow Batteries

I'm sure your first question is: what the heck is nanoelectrofuel (NEF). Since that is the main subject of this paper, we will get to that herein, but first let's talk about the current state of the art for flow batteries. In case you don't really know much about these, I'm partially to blame, because I haven't written about the for a couple of years. The last post was in 2020 and is summarized and linked in the introduction to this paper.

However, below are the basic metrics for the Vanadium Redox flow battery.

- Charge/discharge roundtrip efficiency: 65% to 75%
- Typical charge/discharge cycle life: 10,000 cycles
- Present value of installed cost: $5,800 to $6,600 per kW
- Levelized cost of energy: $260 to $300 per MWh

Although, given the right application, these have a place, their niche is very narrow…

https://energycentral.com/c/ec/nanoelectrofuel-boosts-flow-batteries

19.4. Domestic Lithium

Currently Electric Vehicles (EVs) are ramping up production very rapidly. Ditto Battery Energy Storage Systems (BESS), mostly used in conjunction with renewable energy production from Wind and Solar-Power. The primary chemistries used in conjunction with the batteries in both of the products is Lithium-Ion (Li-Ion) Batteries. Although other non-lithium chemistries have been proposed, Li-Ion is the state-of-the-art presently.

Although there are several viable types of Li-Ion batteries, each requiring different other elements in their cathode chemistries, all of these require lithium. The primary questions about these product's supply chain are: (1) can we ramp up the Lithium supply rapidly enough, and (2) can we source these domestically (from the U.S.)?

https://energycentral.com/c/cp/domestic-lithium

19.5. Li-Ion was good enough for many Breakthroughs

Based on the title you can probably guess that this post is about Li-Ion Batteries. However, rather than looking to the future of these amazing energy storage devices, we are going into the past to see how these played a key role in two technological revolutions. And furthermore, we will look at the people that developed them, especially one individual whose name is in the above title.

https://energycentral.com/c/ec/li-ion-was-good-enough-many-breakthroughs

19.6. Lithium-Ion Battery Breakthroughs

There is certainly room in the lithium-ion battery market for a design that offers substantially higher energy density than standard LiIon batteries, and the first subject of this post, NanoGraf, certainly offers that.

This post will also explore several new battery technologies that will allow the optimization of various lithium-ion (a.k.a. LiIon) battery components. The overall goal is to end up with a family of these batteries that are both safer, less expensive, and have better performance.

https://energycentral.com/c/ec/lithium-ion-battery-breakthroughs

19.7. A New Form of Energy

Has anyone noticed that we use the same type of batteries to power smart-phones, laptops, electric vehicles, C&I facilities and Grids. These are all lithium-ion batteries. Yes there are a number of chemistries, ranging from expensive to very expensive. Lithium-ion batteries have a much higher energy density (watt-hours of energy per kg of mass) than other batteries. This is important in all portable electronics and vehicles, but what about facilities, and especially grids?

There are thousands of potential chemistries and configurations that can store and release electric power, and there must be hundreds of these that are substantially less expensive than lithium-ion batteries. Even if these have much lower energy density than LiIon batteries, they might be good candidates for grid energy storage.

Recently I came across such a candidate. This paper will be a review of their product. The name of the company is Form Energy, and thus the title of this paper.

https://energycentral.com/c/cp/new-form-energy

19.8. Storage as Transmission

Large battery energy storage systems (BESS) are not really generation systems, but they can strongly optimize many generation systems including intermittent renewables like photovoltaic (PV) and wind turbines. It is also not transmission, but can also optimize, and in some cases defer transmission upgrades.

I recently came across the following article regarding my home state (California).

“The California Public Utilities Commission is pushing forward two proposed battery energy storage facilities in Central California instead of upgrading existing nearby transmission lines, citing a lower cost for the battery storage projects...”

I researched the title issue and came across a really good DOE document on this issue, and the main subject of this post is a summary of that document.

https://energycentral.com/c/gr/storage-transmission

19.9. 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

19.10. 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

19.11. 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

19.12. 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

19.13. 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

19.14. 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

19.15. 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

19.16. 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

The last volume is linked below and it has summaries/links for the other volumes.

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

19.17. 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

19.18. 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

19.19. 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

19.20. 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

19.21. 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

19.22. 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

19.23. 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

19.24. 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

19.25. Long-Term Storage

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

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

19.26. 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

19.27. 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

19.28. 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

19.29. 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

19.30. 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

19.31. 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. Off-Shore and On-Shore Wind Comparison

Although I write frequent papers about off-shore wind technology, a couple of years ago, I decided not to focus on on-shore technology. The reason for this decision was that on-shore technology seemed to be maturing, and moving into a business-as-usual state of development. Off-shore on the other hand was in a rapid-deployment phase, and was rapidly expanding and deploying new technology everywhere, especially off my home-state’s shore-line.

I recently thought I would review recent on-shore technology, and see if there were any new developments. When I went through my Bing search engine and asked a few

questions about recent on-shore technology, I mainly got off-shore responses, including one from one of my main sources (first reference in this paper).

https://energycentral.com/c/cp/shore-and-shore-wind-comparison

20.2. California's Plan for Offshore Wind

The format of this post will be unusual for your author. I usually like to use multiple information sources and interject my own analysis. Herein there will be one source, reference 1 in this post. You will note that the source of this in the California Energy Commission (CEC). Since I have worked with the state agency in the past, I know they will bring a degree of rigor and inclusion, that I cannot match, so a large part of this post hereafter will be from the primary reference. My work will be compressing the relevant excerpts from the primary reference to keep the length of this paper within reasonable bounds while retaining the most important content.

Offshore wind energy developed in federal ocean waters off California's coast is poised to play an important role in diversifying the state's portfolio of resources as it complements the generation attributes of other clean energy resources. Offshore wind can support grid reliability and help California achieve its 100 percent renewable and zero-carbon energy goals, as well as the electrification of other sectors, such as transportation.

https://energycentral.com/c/cp/california%E2%80%99s-plan-offshore-wind

20.3. East Coast Offshore Wind Comes to Life

It has been a multi-year slog, but the first sizable wind farm on the east coast has been completed. Your author has followed these projects since 2019. One of the early projects to start planning has now been completed. This project is South Fork Wind, and details on this project, as well as other major East Coast projects that are making progress, are contained in this post.

https://energycentral.com/c/cp/east-coast-offshore-wind-comes-life

20.4. Altamont Pass Wind Farm

This story is deeply personal. I had been stationed in the SF Bay Area in the Army before I went back to Texas to complete my BSEE degree. I graduated from Texas Tech in 1975. After graduation, I accepted a job in Southern California, but after a couple of years, several circumstances pushed me toward the Altamont Pass. My wife had a sister that lived in Livermore, on the western side of the above pass. Then I received an offer from GE Vallecitos Nuclear Center (Just west of Livermore) to be their Facilities Electrical Engineer, and our course was set.

We settled in Livermore, and I enjoyed my job at GE. However, a few years thereafter, the nuclear industry started imploding, so I moved to another (non-nuclear) job in Silicon (Santa Clara) Valley. After a brief move to San Jose to be closer to my work, we decided that we greatly preferred Livermore, and moved back in 1985. We have lived in the same house in Livermore ever since.

https://energycentral.com/c/cp/altamont-pass-wind-farm

20.5. The Loftiest Vessels

I have written about these before, but not under my mobility category. Although these are mobile, and this provides an important asset for their overall capabilities, they are not really ocean-going ships as most think of them. These are renewable energy generators: floating offshore wind turbines.

These currently comprise a tiny fraction of the currently deployed offshore turbines, but they are on the verge of increasing their numbers very quickly.

All of the offshore wind projects being actively developed (installing turbines) or complete in the U.S. are on the East Coast and bottom-mounted, not floating. Although we have three major projects under development off of the West Coast, none of those will be bottom mounted. This is because the ocean off the West Coast quickly plunges to depths beyond the capabilities of bottom-mounted designs, floating wind turbines are the only game in town. Also, there are other large ocean areas world-wide planned for development that have the same “deep-water” issue.

https://energycentral.com/c/cp/loftiest-vessels

20.6. Offshore Wind, Fall 2023

I’ve had this paper queued up to work on since the beginning of fall (mid-September). I was stuck with two articles, and needed more for a post, so I went searching, and found enough content for a reasonable paper. This paper will have three sections: (1) recent developments involving Pacific projects (read: California), (2) recent developments (many) involving Atlantic projects and (3) a major new document from BOEM.

https://energycentral.com/c/cp/offshore-wind-fall-2023

20.7. Offshore Wind Update, Early 2023

This post will cover the following subjects:

Early stage offshore wind projects, including

- The lease sale opening up the Gulf of Mexico for development
- West Coast lease sale results

East Coast wind projects nearing first-power

U.S. DOE efforts to accelerate development of offshore wind

Misinformation Campaign against offshore wind

https://energycentral.com/c/cp/offshore-wind-update-early-2023

20.8. Offshore Wind, Fall 2022

The last post on this subject was almost six months ago. I have collected a reasonable amount of new information on this subject, including a blockbuster, so I guess it’s time to start and schedule my next windy post.

This post will cover a major disruption in the offshore turbine market, major east coast projects that are entering the construction phase, and west coast projects that are approaching lease sales.

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

20.9. 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

20.10. 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

20.11. 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

20.12. 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

20.13. 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

20.14. 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

20.15. 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

20.16. 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

20.17. 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

20.18. 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

20.19. 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

20.20. 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

20.21. 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

20.22. 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

20.23. 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

20.24. 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

20.25. 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. Fire, Utilities' First Technology

I'm reasonably sure that you might find the title interesting, but it is inadequate. What fire really is, is humanity's first invention, tool, weapon, survival & destruction method. Furthermore, it shaped modern humans in a process that ended in Homo sapiens.

Although fire predates humans (Hominids), there is clear evidence of which early human tamed it: Homo erectus (erect man). This ancestor of Homo sapiens (our species) emerged about 2 million years ago, and is generally considered to be the first "modern human." Fire is much older. Remnants of fire storms have been dated to hundreds of million years ago. This is because fire did not need humans as an ignition source, it already had that: mainly lightning but also other sources.

In fact, early humans probably captured their first fires from lightning-ignited wildfires. They understood how valuable this tool was, thus protected and transported it, and eventually learned how to create fire without the help of lightning storms.

https://energycentral.com/c/gn/fire-utilities%E2%80%99-first-technology

22.2. 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

22.3. 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

22.4. 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

22.5. 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

22.6. 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

22.7. 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

22.8. 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

22.9. 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

22.10. 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. The Air We Breathe, Parts 2 & 3

The impacts of climate change are no longer a distant threat on the horizon—they are right here, right now, with a growing intensity that is adversely affecting our communities and our environment, here in California and across the globe. The science that, decades ago, predicted the impacts we are currently experiencing is even stronger today and unambiguously tells us what we must do to limit irreversible damage: we must act with renewed commitment and focus to do more and do it sooner…

In mid-November I came across a just-released scoping plan by the California Air Resources Control Board (CARB) which was very good and thorough. It also clearly defined how CARB will lead us (California) to Carbon Neutrality by 2045. As I got well into the source document (and this paper) I looked at my word-count and saw I was well over my preferred length, and not near covering all of the plan that I needed to, thus this paper is now parts 2-and 3.

This paper is a summary of CARB's Scoping Plan. Part 2 of this paper describes:

High level goals of California's greenhouse gas (GHG) reduction efforts, and methods we intend to use to achieve these goals

- The severity of climate change impacts
- Innovative steps we intend to take to control GHG

Part 3 of this paper (posted two days after Part 2) describes:

- Scenarios used to develop this plan
- Action Plans for each Sector in the Scoping Plan Scenario

- Carbon Removal and Sequestration Methods and Roles

https://energycentral.com/c/ec/air-we-breathe-part-2

https://energycentral.com/c/ec/air-we-breathe-part-3

24.2. The Air We Breathe

I have said in the past that energy and water are tightly linked. 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 power sector.

But this post is not about water, it is about an even more important resource for energy, as well as every living thing on our planet. The title of this post might help you guess what this resource is.

My home state (California) has an interesting relationship with air. We have more vehicles than any other state, and also drive more miles. Many of these miles are driven in very long daily commutes in some of the largest metropolitan areas in the U.S. Our air quality problems date back to the 1950s. Since then, we have had the most aggressive pollution control measures in the U.S. In fact, in recent years a group of states with similar issues have adopted our solutions. One other thing, the governmental body that defines the rules to remedy our air quality issues is the California Air Resources Control Board (CARB).

This post is about current and future CARB rules, especially as they impact various energy users.

https://energycentral.com/c/cp/air-we-breathe

24.3. 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

24.4. 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

24.5. 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

24.6. 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

24.7. 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

24.8. 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

24.9. 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

24.10. 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. Pacific Fusion: The Third Path

I do write about nuclear fusion occasionally, just not very often. The last paper I wrote on this subject was a late 2022 update of a paper I originally wrote in early 2021.

Earlier papers covered two processes for nuclear fusion (two bullets below).

- Steady-state magnetic confinement fusion reactors (a.k.a. Tokamak or Stellarator)
- Pulsed laser-driven inertial confinement fusion reactors

The subject of this paper is pulsed magnetic inertial confinement fusion.

https://energycentral.com/c/gn/pacific-fusion-third-path

25.2. Twisted Fusion: The Stellarator, Part 2

The short story is that there are basically two popular configurations of potential nuclear fusion reactors: The Tokamak, created by the USSR in in 1968, and an earlier design, the Stellarator, invented by American scientist Lyman Spitzer of Princeton University, which began operating in 1953 and demonstrated plasma confinement in 1951. Both of these designs had "issues." The dynamics of the Stellarator had early success, but its operation was simply too complex for the physicists at that time to understand. The Tokamak also had early success, but had the same issues, and still does.

Fast-forward to modern times. Current computer simulations allow the Stellarator designers to model the operation of their fusion reactor and optimize it. The Tokamak's problems appeared to be simpler on the surface, but the physics were much more complex, thus its issues remain to be simulated and understood.

This paper focus on the evolution of the Stellarator, recent advances and plans for its future.

https://energycentral.com/c/gn/twisted-fusion-stellarator-part-2

25.3. Nuclear Element

There is no element as critical (as in criticality) to the development of nuclear power and nuclear weapons as uranium, and without uranium, neither would exist in their present forms. Also, the world would be a different place. Although it is not widely known, uranium has had many uses outside of nuclear applications, but the nuclear applications are (by far) the most important.

This paper is a review of all of the above, and also a review of a book from which I drew much of this information for this post.

https://energycentral.com/c/cp/nuclear-element

25.4. Nuclear Power Partnerships

I have covered several emerging nuclear power technologies in the past. Since the nuclear industry has a long history (the first fission reactors were built during WWII, in the early 1940s), there have been many flavors of advanced reactors. In this post we will

look at Kairos Power, who is developing a “Pebble Bed” Reactor using an advanced “Flibe” coolant/heat transfer fluid. This ends up being an ideal design for future Artificial Intelligence (AI) server farms. Thus, Kairos Power, a US-based nuclear engineering company, recently inked a long-term deal with Google to develop and bring the company’s first SMR online “quickly and safely by 2030,” with continuing rollouts planned through 2035.

https://energycentral.com/c/gn/nuclear-power-partnerships

25.5. Roadblock to Nuclear Expansion

The title issue is both simple and complex. Current conventional (fission) nuclear reactors use fuel elements, each of which is a cluster of alloy tubes that (generally) contain enriched uranium. These fuel elements each have productive life of 2 to 5 years. When spent fuel elements are removed from the reactor, they are extremely radioactive, and thus they are moved to a spent fuel pool to allow short half-life (extremely radioactive) isotopes to decay, which allows them to literally cool down over five years and be moved to dry storage.

However, the big problem is that there are currently no intermediate or long-term places to store these fuel elements, so they are accumulating at these reactor sites. Some of these reactors are in locations that are geologically unstable, adjacent to oceans, near large populations, or all of the above.

This two-part series will examine this problem, including how we got here, and what moves the U.S. is making to resolve it.

https://energycentral.com/c/cp/roadblock-nuclear-expansion

https://energycentral.com/c/cp/roadblock-nuclear-expansion-part-2

25.6. Nukes Part 8 - Fast Breeders

Many times, I thought I had left my history in the dust, only to have a new team bring it back to me. In case you are wondering about the title of this paper, it is a type of nuclear fission reactor that was in my deep past. I graduated from college (BSEE) in 1975. My first job out of college was with Rockwell Atomics International. The projects I worked on there all involved a type of reactor called a Liquid Metal Fast Breeder Reactor.

The “Liquid Metal” was its heat-transfer fluid: either liquid sodium or a sodium-potassium alloy (NaK). “Fast” refers to the neutrons emitted by the nuclear reaction that are “fast” (high-energy), and remain fast until they undergo additional reactions. In a standard water-cooled fission reactor, the neutrons are moderated (have their energy reduced). Breeder means that the LMFBR breeds its own fuel.

This report is also about Oklo, who wanted to focus on the technology with the most demonstration history, with inherent safety, while having the capability to use waste as fuel. All of these capabilities were demonstrated by LMFBRs well before my history with this technology.

https://energycentral.com/c/cp/nukes-part-8-fast-breeders

25.7. Aneutronic Fusion Energy

The title of this post describes a type of fusion energy that overcomes many of the challenges that come with conventional fusion energy systems that use neutrons to transfer thermal energy from the nuclear fusion reaction to the heat-transfer fluid.

A new breed of maverick fusioneers is aiming to solve the neutron problem. Their approach is to swap D-T fuels for readily available elements that, when fused, release energy that's carried by charged particles, instead of neutrons.

https://energycentral.com/c/cp/aneutronic-fusion-energy

25.8. Not so Distant Nuclear Fusion

It is an interesting time for nuclear power, and this paper will explain why. This post mostly deals with nuclear fusion, but unlike the last post it will cover fusion power plants that may be on-line within the next decade. Also, it will cover some recent news about fission power plants.

https://energycentral.com/c/gn/not-so-distant-nuclear-fusion

25.9. Distant Nuclear Fusion – Update

When we look up at night and view the stars, everything we see is shining because of distant nuclear fusion. - Carl Sagan, Cosmos (1980, p. 238)

Note that this update was prompted by a major achievement by Lawrence Livermore Labs, National Ignition Facility. The original "Distant Nuclear Fusion" paper was posted in January 2021. I am leaving most content below that is unrelated to the recent achievement in place, and not really updating it, except for subsection 4.7. I describe the above-mentioned achievement in this subsection and reference the source.

https://energycentral.com/c/gn/distant-nuclear-fusion-%E2%80%93-update

25.10. Nukes, part 7

I've mentioned before that when I worked for Landis & Gyr Systems (1980 to the late 1990s, when it was gobbled up by Siemens), PacifiCorp was one of our best customers.

Thus when a came across an article about how they are considering converting their coal-fired power plants to nukes, I had to write a short paper on this.

Then after I basically had completed and scheduled the above-described paper's posting, another nuclear revival took a large step forward. PG&E's Diablo Canyon Nuclear Plant was scheduled for closure in 2025, but a sudden change-of-heart by our Governor Newsom, with a recent boost by his friend, President Biden, put this Nuke on the path to redemption.

This post is about the advanced reactors being considered by PacifiCorp for replacing their coal-fired plants, and the latest twist in the Diablo Canyon epic saga.

https://energycentral.com/c/gn/nukes-part-7-0

25.11. Twisted Fusion: The Stellarators

Although I've written several posts on nuclear fission reactors, and even more that mentions them, I have only written a single posts on nuclear fusion reactors. This earlier post described the two current fusion experiments that have a reasonable path forward to the creation of a working fusion power plant.

In addition to the two designs described in the above post, there is a third much older design, the stellarator. Lately this pioneering design has received much more attention. It was abandoned many decades ago, primarily because the mathematics that describe the physics were just too complex to analyze using then-existing methods, Thus, scientists moved on to a greatly simplified reactor, the tokamak.

However, recently more attention has been focused on the stellarator, and there is a major experiment in Germany that may prove to be the most viable path to a commercial nuclear fusion reactor.

https://energycentral.com/c/cp/twisted-fusion-stellarators

25.12. 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

25.13. 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

25.14. 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

25.15. 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

25.16. 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.

25.17. 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

25.18. 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

25.19. 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

25.20. 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

25.21. 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

25.22. 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. Long-Term Security-Constrained Optimum Dispatch

I've visited this topic before, albeit in a 2018 post that is summarized and linked in the Intro to this post. Although the above 2018 post is still basically correct, the electric grid, its generation control methods and consumers have changed massively since then, and the pace of that change is accelerating. Thus, I thought it was time to update this general subject.

The title of this post comes from a new generation of grid-control systems that optimize how power-flow (dispatch) is controlled to improve efficiency, resilience and reliability.

https://energycentral.com/c/um/%E2%80%9Clong-term-optimum-dispatch-digital-transformation-special-issue%E2%80%9D

28.2. Transmission Backbone for Western Renewables

Renewables, mainly wind and solar, are expanding rapidly in my home state (California) and the rest of the Western Grid. Many of these are “Grid-Scale” generation projects – hundreds of MW. Also, many of these projects tend to be concentrated a particular area because of concentration of the renewable resource (mostly wind) or financial consideration (like low-cost long-term land-lease arrangements from the federal government or other landowners).

This paper covers a baseline analysis for the Western Interconnection, including data development, analysis methodology, and discussion of results. The Western Interconnection Baseline Study (baseline study) provides an assessment for how potential investments in transmission and renewable generation projects could contribute to achieving future decarbonization goals across the Western Interconnection. By modeling a high renewable generation scenario for the year 2030, the baseline study provides an initial assessment of how transmission lines in advanced permitting stages, combined with anticipated new renewable resources, align with national decarbonization goals. In doing so, it establishes a comparative baseline for transmission and generation expansion scenario analyses in the forthcoming National Transmission Planning (NTP) Study Report.

https://energycentral.com/c/gr/transmission-backbone-western-renewables

28.3. The Hardest Problems, Part 2

I have been the electric utility branch of the computer industry for most of my career. During that time, I became well aware that, although there were many very large companies in this industry, there was really only one that was dominant: Big Blue. When I saw that they were getting into quantum computing in a big way, I knew that there would be a part 2 “The Hardest Problems” post.

What, you don’t know who Big Blue is? Read on.

Big Blue, a moniker that has resonated in the world of technology and business since the 1980s, is a nickname for the International Business Machines Corporation, better known as IBM. This nickname may have originated from the blue tint of its early computer displays or from the deep blue color of its corporate logo. However, Big Blue stands for more than just a color; it represents a tech giant with a rich history and far-reaching influence...

https://energycentral.com/c/iu/hardest-problems-part-2

28.4. No Scientific Proof

I am not a scientist. I am an electrical engineer. However, I am a member of the American Association for the Advancement of Science (AAAS), and have been for many years. I also faithfully read every weekly AAAS issue of “Science” (although not every article therein – my interests are limited).

The following is a reasonable definition of The Scientific Method:

The principles and empirical processes of discovery and demonstration considered characteristic of or necessary for scientific investigation, generally involving the observation of phenomena, the formulation of a hypothesis concerning the phenomena,

experimentation to test the hypothesis, and development of a conclusion that confirms, rejects, or modifies the hypothesis.

https://energycentral.com/c/pip/no-scientific-proof

28.5. Vegetation Control with a Twin Assist

A utility with any grid, be it distribution-only or distribution, transmission and high-voltage transmission, faces a major battle in managing the vegetation below and in the immediate vicinity of the powerlines. One of the major reasons for this is, even before they (or more likely their contractors) get out the chain saws and bucket trucks, they need to survey the lines and see what is needed.

It would be good if a computer-simulation could make a reasonable estimate of the work required. But the problem is that the simulation needs to cross over two very different domains: the lines and support structures are one, and the vegetation is another. The former is complex enough, especially considering the differing requirement for each physical and electrical variations, but the latter is more likely to be the utility's worst nightmare.

https://energycentral.com/c/gr/vegetation-control-twin-assist

28.6. The Hardest Problems

I need to start this paper by saying that I don't understand Quantum Computers, which is this paper's subject. However, I do understand what they can do.

There are some problems that cannot be solved by classical supercomputers. Even if you project these massive facilities current growth in capabilities out to several decades, they will still fail when confronted with these problems. Probably ditto for several centuries.

However, Quantum Computers appear to be capable of solving these same impossible problems with a few years of scaling. This article is about one project to create the first quantum supercomputer.

https://energycentral.com/c/ec/hardest-problems

28.7. Alternative Desalination Process Better Suited for PV

Relatively pure water is an important ingredient for almost everything. In almost every residence it is used for washing clothes, dishes, residential surfaces and occupants. Although i will not go into the gory details about how commercial and industrial firms use water, there are a huge number of functions it performs for each.

One of the main advantages of water is its price: it's really inexpensive. Where I live in the SF Bay Area, we get most of our water from rainfall on nearby mountains, but since we get little rain from May through September. During drought years some communities are forced to use salty or brackish water and desalinate it, which increases its price. Reverse Osmosis is the most popular process for desalinating water, whether it is brackish water or seawater.

Our last dry-spell (I wouldn't classify it as a drought) was in the rain-years 2020/2021 and 2021/2022. The rain-years 2022/2023 and 2023/2024 have had above normal

precipitation. However, our droughts are frequent (see the chart in the Intro of this paper or the Main Image).

https://energycentral.com/c/cp/alternative-desalination-process-better-suited-pv

28.8. Bright Developments

The bright developments started over a century ago. When it comes to serving the needs of humanity, lighting the darkness is probably right up there with keeping warm when it's cold. Mr. Edison made a major breakthrough in 1879 when he invented the incandescent light bulb. For over a century it met most of our needs for lighting…

Nick Holonyak Jr. was an American engineer and educator. He is noted particularly for his 1962 invention and first demonstration of a semiconductor laser diode that emitted visible light…

So, is the LED Light Bulb the end of this parade of progress? No, it's just the start.

https://energycentral.com/c/ee/bright-developments

28.9. The Godfathers of Energy Efficiency, Part 3, Microwave

believe all of these Godfathers share one attribute, an amazing force of character. However, the inventor of the microwave oven takes the top award in this category.

Percy Spencer was born in Howland, Maine in 1894. Eighteen months later, Spencer's father died, and his mother soon left him in the care of his aunt and uncle. His uncle then died when Spencer was just seven years old. Spencer subsequently left grammar school to earn money to support himself and his aunt.

When Percy was 12, he discovered that a local paper mill was soon to begin using electricity, a concept little known in his rural home region, and he began learning as much as possible about the phenomenon. He applied to the mill, and he was hired to install electricity in the plant, despite never having received any formal training in electrical engineering or even finishing grammar school.

At the age of 18, Spencer joined the U.S. Navy. He had become interested in wireless communications, so he made himself an expert on radio technology: He also subsequently taught himself trigonometry, calculus, chemistry, physics, and metallurgy.

By 1939, Spencer became one of the world's leading experts in radar tube design…

https://energycentral.com/c/ee/godfathers-energy-efficiency-part-3-microwave

28.10. The Godfathers of Energy Efficiency, Part 2, Red

First of all, there is only one person that holds the title of "The Godfather of Energy Efficiency." If you would like to read about him, go to my earlier post (2021) summarized and linked in the Introduction to this paper.

However, there have been many other professionals that have made critical contributions to energy efficiency, and some of these have interesting back-stories. Thus, I decided to add a few parts to the original "Godfather" post and turn this into a series.

https://energycentral.com/c/ee/godfathers-energy-efficiency-part-2-red

28.11. Laying down the Law – In Memory of Gordon Moore

Intel cofounder Gordon E. Moore, the man behind Moore's Law, died on 24 March at the age of 94. This post is about this amazing engineer.

Gordon Moore cofounded Intel, a firm that produced the earliest microprocessors. Microprocessors produce today's super-computers (via massively parallel designs). We can only model the future with these powerful tools. This will enable us to (1) better predict the ravages of Climate Change, (2) rapidly deploy renewables to moderate the effects of Climate Change, and (3) understand and simulate other measures to moderate Climate Change.

https://energycentral.com/c/ec/laying-down-law-%E2%80%93-memory-gordon-moore

28.12. Two Major HVDC Projects

This paper's title describes what it is about. These are two very important projects. The first, briefly described below, is also an important part of a major wind power project. This transmission project is currently planned to be completed by 2026.

The largest renewable energy infrastructure project in U.S. history, an $8 billion wind farm and transmission line-is set to begin construction in 2023. San Francisco-based Pattern Energy took over the projects, called SunZia Wind and SunZia Transmission, from Southwestern Power Group in July 2022. The wind part of the project consists of a total of 3,000 megawatts from wind farms to be built in three counties in New Mexico. An 885-kilometer bidirectional high-voltage direct-current transmission line will run from New Mexico and south-central Arizona. The transmission line will sidestep the growing difficulties of connecting renewable energy sources to the power grid.

The Second Project is currently in the development phase, and has just started, but appears to be well along in planning, and may be completed by 2028.

The North Plains Connector is an approximately 385 mile and up to 600 kilovolt high voltage direct current (HVDC) transmission line connecting the U.S. eastern and western electric grids in, respectively, North Dakota and Montana. The North Plains Connector will be open to all sources of electrical power generation. In response to demand, the project will be able to transport power in either direction along the line.

https://energycentral.com/c/gr/two-major-hvdc-projects

28.13. Metamaterials

The title of this paper is a strange-word for most of my readers, but is also an amazing technology that will facilitate fast and secure communication among tomorrow's energy systems. In case you don't think that communication is that important for energy systems, you haven't had my involvement in the intersection between these two technologies in the last three or four decades. Everything from supervisory control systems for electric transmission, distribution and gas pipelines to advanced metering infrastructure and the Internet of Things touch various energy systems and require ubiquitous communication.

The problem is there are an increasing number of other applications that require fast and secure communication, as well as more and more bandwidth, and we are starting to have a "laws of physics" problem.

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

28.14. How California Beat the Heat

California has not been unique this summer in that we too have been suffering from extreme heat. However we have been unique in three ways:

1. Our extreme heat frequently comes in late summer to early fall, as it did recently.
2. Our recent extreme heat event broke many records.
3. In spite of "2" above, the electric utilities in California managed to mostly keep the grid operating.

This post describes how the California Grid avoided crashing during the record-breaking heat wave that started on September 5.

https://energycentral.com/c/gr/how-california-beat-heat

28.15. 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

28.16. 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

28.17. 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

28.18. 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

28.19. 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

28.20. 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

28.21. 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

28.22. 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

28.23. 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

28.24. 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

28.25. 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

28.26. 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.

28.27. 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

28.28. 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

28.29. 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

28.30. 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

28.31. 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

28.32. 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

28.33. 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

28.34. 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

28.35. 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

28.36. 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

28.37. 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

28.38. 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

28.39. 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

28.40. 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

28.41. 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

28.42. 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

28.43. 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

28.44. 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

28.45. 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

28.46. 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 Pitch Fest 2023 & the Rest of the Story

This is a long and torturous story. The “hottest” part of this story was in the period between 2016 and 2020. I was there then, following this story and posting many papers. This paper will examine the latest stage of this saga.

You might think that this post is about wildfires. It’s not, rather it starts with about the main methods used to avoid having the grid start wildfires and expands from there. It also explores a particular wrinkle that Northern California brings to create the needed technology: innovations.

https://energycentral.com/c/gr/pge-pitch-fest-2023-rest-story

30.2. 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

30.3. 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

30.4. 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

30.5. 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

30.6. 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

32. Special Issues

Note that this category was created is March, 2024

32.1. Trends & Predictions 2024

This paper is a response to the Energy Central call for posts for “Trends & Predictions 2024” under the topic heading “Clean Energy Goals.” I started composing this (in late December) by looking at my recent past posts and upcoming posts by the submission deadline. I post two papers a week so that gave me a good volume of posts to quickly review and parse into a particular topic. I ended up with four posts. Each of these involve a specific goal.

https://energycentral.com/c/cp/trends-predictions-2024