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Needed Electricity Market Reform: "A Bridge To Far" for the EU Or North America?

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I. Introduction

Policy makers now seek electric market reform to respond to climate change, decouple from fossil fuels, optimize systems, and capture cost reductions in renewables and distributed power. [2] This paper rejects an European Union (EU) study that claims we should retain the "well-working" EU electricity markets[3] or North American (NA) electricity markets. Others support a more critical review of these markets,[4] such as to accommodate more renewables.[5] New challenges to reform electric market design in the EU and NA are daunting for technical and political reasons. Wholesale market incentives in current short-term markets are proving problematic as renewables and hydro have zero marginal cost[6], fossil generation is volatile and expensive in comparison, renewable power growth is very rapid, and market manipulation has

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2 A European Parliament study explains several *structural shortcomings of the current European electricity market design… Firstly, insufficiently strong investment signals for renewables meant that the European electricity system was vulnerable to a supply shock in a critical fuel, natural gas. Secondly, consumers were poorly protected against price spikes, with some facing huge and unaffordable increases in their final bills. Thirdly, a lack of demand response meant that scarce gas continued to be consumed, instead of a reduction in demand leading to lower prices.* European Parliament, The design of the European electricity market Current proposals and ways ahead, G. Zachmann, et al. Policy Department for Economic, Scientific and Quality of Life Policies, September 2023, pg. 25. (Hereafter, G. Zackmann, et al.)

3 Ibid, pg. 95.

4 S. Honkapuro, J. Jaanto, S. Annala, A Systematic Review of European Electricity Market Design Options, Energies, April 2023.

5 J. Winkler, M. Altmann, Market Designs for a Completely Renewable Power Sector. *Z. für Energiewirtschaft* **2012**, *36*, 77–92. [

6 D. Mallapragada, *et al., Electricity pricing challenges in future renewables-dominant power systems*, Energy Economics, V. 126, Oct. 2023. The California wholesale circumstance, as it marches to 100% renewables dispatched by CAISO, suggests market failure can be predicted, and may be occurring at present, which would indicate that Locational Market Prices (LMPs) based on security-constrained economic dispatch may be considered obsolete.

been pernicious.[7] Regional incentives exist to reduce market competition and invite gaming, particularly with fossil at the margin. Regulation to discipline market behavior remains challenging both in the EU and NA. Aims are to control prices and meet ambitious climate change targets. The competitive EU and NA markets are based on “merit order,” the incremental price of fossil generation.[8] Increased shares of renewable generation face spikes from fossil cost (especially gas generation) causing steep increases in “competitive” market prices.[9] Compared to NA, the EUs high gas costs make these spikes even more dramatic. The EU proposes market rules to make electricity prices less dependent on fossil costs to buffer markets and customer bills.[10] New NA market rules appear to change little except in states like California and Minnesota. Less discussed are challenges to price ramping capacity to integrate renewables, though some like California’s Independent System Operator (CAISO) have initiated the Extended Day-Ahead Market (EDAM)[11] to add capacity value for ramping.

Increasingly market analytics from Artificial Intelligence (AI) and Machine Learning (ML) are in play. These are double-edged swords that can enhance market efficiency at best[12] but directly enable price manipulation as well. *While AI/ML trading is expected to deliver several efficiency gains for capital markets, it also brings unprecedented risks for their safety and integrity due to some of its technical specificities and related additional uncertainties.*[13] Even with previous analytics the repeating nature of electricity markets allows

7 Northern Europe’s electricity market Nord Pool has been a longstanding model with low cost, financial liquidity, and acceptable market behavior, but is now also challenged to sustain its prominence.
8 *When high prices hit consumers in summer 2022, EU countries acted immediately to ease the burden on citizens with measures such as grants and the suspension of VAT.* D. Mallagragada, op sit.
9 European Council, https://www.consilium.europa.eu/en/policies/electricity-market-reform/#:~:text=in%20the%20future.-,What%20will%20change%20with%20the%20electricity%20market%20reform%3F,electricity%20bills%20paid%20by%20consumers.
10 Ibid.
11 Resource adequacy is differentiated (ramping, local, and system) and new time-based ramping is included, but these separate bollixed services fail to include the large amount of required generation response for ramping.
12 See, A. Azzutti, AI trading and the limits of EU law enforcement in deterring market manipulation, Computer Law & Security Review,Vol. 45, July 2022, https://www.sciencedirect.com/science/article/abs/pii/S0267364922000371?via%3Dihub.
13 Ibid. The writing cited shows *how ‘deterrence theory’, as a normative framework, can allow us to think of innovative solutions to fix the many shortcomings of the EU legal framework in the fight against AI-driven market manipulation. In concluding, this study suggests improving the existing EU anti-manipulation law and enforcement regime with a number of policy proposals. Namely, (i) an improved, ‘harm-centric’ definition of manipulation; (ii) an improved, ‘multi-layered’ liability regime for AI-driven manipulation; and (iii) a novel, ‘hybrid’ public-private enforcement institutional architecture through the introduction of market manipulation ‘bounty-hunters’.* Ibid.

manipulation to result from "common knowledge."[14] Electric market manipulation (gaming) is prominent in NA and parts of the EU, but is little discussed as is difficult to resolve and all sides are embarrassed by it.

This paper explains drivers of change in electric market design, reviews two proposals, and is organized as follows. First is a focus on problems with climate change for fossil dominated market clearing prices, which have challenges with zero marginal cost renewables and with battery storage pricing. Second, California's proposed distributed energy market for Distributed Energy Resources (DERs) is explained in light of customer incentives for clean energy. In ways it mirrors elements of the EU's recent proposal. Noted, traditional competitive market pricing of *energy* becomes less important with extensive zero marginal cost renewables while ramping *capacity* becomes more critical at locations for reliability (largely to maintain voltage). Locational capacity, aligned with customer outage cost, is what customers want and need. Briefly compared are wholesale market initiatives to integrate ramping capacity, a partial fix that holds traditional fossil clearing prices as a dominant feature. Third, the need for locational capacity pricing for customers is explained to go beyond wholesale "energy-only markets." Distribution-level locational capacity pricing is explained[15], as are possible benefits in the EU proposed two-part market with contracts for differences. Also discussed is market manipulation, which remains a challenge where competitive markets are "thin" -- few buyers or sellers -- and at locations where wholesale or distribution circuits are constrained. More market research is needed to remedy thin market conditions.

II. Major Challenges to Use of Customer DERs

While "the Soft Energy Path" is now very old news,[16] the new version is DERs – tailored customer level energy efficiency, demand response, renewable generation, and battery storage – which are more cost effective if connected to distribution through dynamic locational pricing.[17]

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14 See, E. Woychik, B. Carlsson, How Enron *et al* Gamed The Electricity Market: An Empirical Analysis of Trader Knowledge, 8th Global Conference on Business & Economics, 18-19 October 2008, ISBN: 978-0-9742114-5-9.

16 See, E. Lovins, Soft Energy Paths: Toward a Durable Peace, 1977 (Ballinger), forty-six years ago.
17 See, for example, E. Woychik, M. Martinez, K. Skinner, R. Stevie, and E. Ackerman, Transactive Energy Pricing with Distribution Automation: Enabling Mass Market Distributed Energy Resources, Advanced Workshop in Regulation and Competition: 40th Annual Eastern Conference Sheraton Atlantic City, New Jersey, June 1-3, 2022.

DERs are declining in costs, offer flexible load response, and market power mitigation at regional levels, but require time-based locational pricing to lower distribution and transmission costs, i.e., maximize benefits. Battery storage costs are rapidly declining with booming electric vehicle (EV) growth that will enable use of vehicle-to-grid (V2G) storage. Electric markets in NA and EU have been slow to embrace large-scale integration of DERs. Not surprisingly, large fossil generators dominate governance of grid markets and DERs have successfully lowered wholesale market prices only in some instances. While wholesale electric markets have been initiated in many regions worldwide, DER markets at scale have not.

The International Energy Agency contends *[w]hile such market interventions can help mitigate the impacts of the energy crisis, the potential creation of uncertainty in the investment landscape needs to be minimised to ensure that responses to the crisis do not come at the expense of much-needed investment*.[18] This implies we bar transition to new distributed market structures. A "don't rock the boat" tack though seems risky given current geopolitics coupled to rapid economic and smart grid growth. IEA's concern to hold markets static because of uncertainty is an argument that stasis is better than progress to bring DERs forward rapidly. Absent major market changes, regulation of wholesale markets is likely to intensify, limit real competition, and be more balkanized. New regulation may solve some wholesale market problems but seems unable to keep pace with the onset of rapid changes in technology such as battery storage and electric vehicles (EVs) with vehicle-2-grid (V2G) capabilities.[19] Related is the failure to effectively integrate DERs into wholesale markets.

With new DER technologies, scale, and scope economies, the question is why not initiate new market formation at the local consumer level, especially as DER costs continue to decline which enables the number of DERs to accelerate? Customers can choose the DERs they want, at many levels, without significant regulation.[20] California's initiative to tackle DER integration is unique as it is "bottom-up" from the consumer level at distribution. The focus is on flexible customer load response with dynamic locational pricing. While meritorious by most

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18 https://www.iea.org/reports/electricity-market-report-2023/executive-summary.

19 See, J. McDonald, P. Durand, C, Newton, E. Woychik, *Refining a Holistic View of Grid Modernization*, Smart Grids: Infrastructure, Technology, and Solutions, 2nd Addition, Stuart Borlase, Editor, CRC Press, 2018, pp 725-779.

20 See, for example, M. Martinez, E. Woychik, R. Stevie, and K. Skinner, Distributed Energy Optimization: Steps and Results for Customer Value Capture in Layers, CRRI-Rutgers Monterey, 32nd Annual Markets & Competition Conference, 26-28 June 2019.

appearances[21], dynamic pricing of DERs seems to largely to be rejected by distribution utilities that seek capital growth to net greater earnings, at least in California.[22]

Large scale wind and solar projects have faced rising interest rates, supply-chain issues, and protectionist government responses.[23] This has shattered profitability for large-scale renewable providers. Current debates about what clean resources are most cost-effective – utility-scale or distributed (customer-level) – are technical[24] and have not been productive. Most should acknowledge that needed are "all" clean resources at wholesale and retail levels -- to combat rapid onset of climate change. What seems clear is that integrated and optimized DERs with dynamic locational pricing can dramatically lower customer costs but cut into utility expansion plans and profitability.[25]

III. EU Directions – Blueprint for Market Reform with Climate Change?

A. Promises for EU Electricity Market Reform

The EU promises a set of energy market reforms, largely aimed to address green-house gas (GHG) emissions, and electricity price risks for retail customers. A summary is as follows:

- Better protection for consumers.
- More options for customers to sign electricity contracts:
    - Increased availability of fixed price and fixed term contracts;
    - Flexibility to choose dynamic pricing, with multiple or combined contracts;
    - Clearer information before signing.
- Access to renewable energy locally, which allows solar energy to be sold to neighbors.
- Protections for vulnerable consumers with government assurance of sufficient suppliers of last resort so no consumers remain without electricity and better retail price regulation for households and SMEs.

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21 E. Woychik, M. Martinez, K. Skinner, R. Stevie, and E. Ackerman, Transactive Energy Pricing with Distribution Automation: Enabling Mass Market Distributed Energy Resources, Advanced Workshop in Regulation and Competition: 40th Annual Eastern Conference, Sheraton Atlantic City, New Jersey, June 1-3, 2022

22 See, Prepared Direct Testimony of Dr. Eric Charles Woychik, On Behalf of the Utility Consumers Action Network, California Public Utilities Commission Docket No.: A.22-05-015, Exhibit No. UCAN-01, 27 March 2023 (hereafter, "Woychik Testimony").

23 "Unsustainable Developments," Economist, Dec. 5-9, 2023, pp 57-59.

24 E. Woychik, H. Chen, D. Erickson, *The Dynamics of Wholesale and Distributed Energy Markets*, Smart Grids: Infrastructure, Technology, and Solutions, 2nd Addition, Stuart Borlase, Editor, CRC Press, 2018.

25 Woychik Testimony.

- More stability and competitiveness for companies using and providing energy.

The EU plan promises businesses will have more stable prices with long-term contracts, including power purchase agreements whereby power generators agree to sell energy directly to energy consumers at a certain price. This is considered "retail access" in the U.S. and has met with limited success. Bilateral contracts at the retail level are "standard-form" agreements with provisions that favor sellers (given the information asymmetry of customers). With renegotiation over time customers fail to see the benefits. As Texas and California have shown, DERs are not offered at scale to lower customer exposure to wholesale and utility electricity costs.[26]

The EU proposal also promises more stable revenues for power producers. New non-fossil power-generation investments are planned based on two-way contracts for difference (CFDs). On the one hand the aim is to secure a minimum return on such investments and on the other to prevent excessive costs in the event of further crises. Bilateral contracts for differences are generally complicated by the "weave" of market prices. For all but the largest customers, the data and knowledge to enable such "deals" (negotiations) involves significant if not unacceptable transaction costs.

The EU response to the perceived climate change imperative is impressive in tone. Performance awaits. Germany's new goal is to decarbonize its electricity by 2035 and last year announced it aims to end coal power by 2030.[27] It said that electric climate neutrality is essential to maintain a 1.5 C temperature rise, "an ambitious target that we will meet."[28] Canada, the UK, and the U.S have also committed to have emissions-free electricity by 2035.[29] Austria, Sweden and Denmark have targets for renewables-based electricity systems in the 2030s.[30]

26 E. Woychik, *"Capacity" for the Energy Only Market: Demand Response to Educate Customers, Hedge Market Power, and Ensure Resource Adequacy*, White Paper, Electric Reliability Council of Texas and the Public Utilities Commission of Texas, 28 November 2006;
E. Woychik, *Maximum Market Value and Maximum Customer Choice: Nar the Twain May Meet?* AESP'S Fall Conference and Expo: Customer Behavior and the Smart Grid, Association of Energy Service Professionals, Dallas, TX, 4 October 2011; E. Woychik, *Coupling Demand-Side and ISO/RTO Services -- Not With This Market…* Presentation to Harvard Electric Policy Group, Los Angeles, 25 February 2011.
27 "Germany leads Europe with target to reach 100% clean power by 2035," Euractiv, 13 December 2023, .
28 Ibid.
29 https://www.euractiv.com/section/energy/opinion/germany-leads-europe-with-target-to-reach-100-clean-power-by-2035/
30 Ibid.

The EU Ten-Year Network Development Plans (TYNDPs) of network electric and gas transmission operators, however, shows that its transmission system operators do not plan on timely removal of fossil units of to comply with national GHG goals.[31] Experts show that all scenarios in its draft transmission report indicate the EU will miss the critical milestone of carbon-free electricity by 2035.[32] Changing politics, as they can be, will influence ultimate commitments to fund clean energy, to displace fossil and stay near the 1.5 degree (Celsius) level.

B. From Promises to Fruition – Large Hurdles to Clear?

The IEA rightly contends that major disparities exist between energy endowments in EU countries which influence the types of market response. Measures differ widely to apply subsidies and influence retail prices.[33] These very different relief measures create pricing discrepancies and harm broader competition.[34] In turn these differences limit agreements on recommended EU market reforms.[35] These differences are inevitable and seem largely without cure for wholesale markets among member countries and states. Major differences among NA regions breed disagreement and limit accord, particularly on how competitive markets should be used. Northern Europe has been different with its leadership on wholesale market reform. But as noted experts contend, *a shift from primary reliance on dispatchable thermal generators to primary reliance on [variable renewable] generators with a greater role for storage decouples the determination of [*marginal values of energy*] in efficient systems from the classical economic dispatch curve and the underlying marginal generating costs.*[36] Scarcity pricing as an alternative, however, seems certain to invite market gaming and more volatile high prices.

Some experts recommend more localized distribution markets to manage variable customer loads with dynamic pricing. One aim of this is to rapidly harness customer-level DERs at scale and lower overall rates. Decentralized regional distribution-based markets can also reduce cross-border trading inefficiencies. More complete optimization of locational distribution

31 TYNDP 2024 Scenarios Storyline Report, https://2024.entsos-tyndp-scenarios.eu/wp-content/uploads/2023/07/ENTSOs_TYNDP_2024_Scenarios_Storyline_Report_2023-07.pdf.
32 C. Rosslowe, The EU persuaded the world on renewables, can it now persuade its own Member States? Ember, 15 Dec. 2023; https://ember-climate.org/insights/commentary/the-eu-persuaded-the-world-on-renewables-can-it-now-persuade-its-own-member-states/
33 https://iea.blob.core.windows.net/assets/255e9cba-da84-4681-8c1f-458ca1a3d9ca/ElectricityMarketReport2023.pdf, pg. 81.
34 Ibid.
35 Ibid.
36 Op cit, D. Mallaoragada, et al.

markets can also further reduce the challenges with optimization of wholesale transmission interties, a troubling challenge to be addressed with increased use of variable renewable and battery storage systems.[37]

1. Toxic Fossil and Geopolitics – DERs Offer Personal and Regional Independence

In practice, price protections for consumers require market stability, a level of workable competition, and hedging options. Russia's war with Ukraine and the recent Gaza conflict, however, act to destabilize energy markets and disrupt supply chains. In NA, electric utilities have used extreme politics to contest climate change and promote fossil fuel use.[38] In both settings these conditions cause energy prices to rise. This is the desired effect among fossil petrostates such as Russia. It is notable that half of the countries in the world are now oil, or oil and gas, producers.[39] This then is a large difficult block of nation states to motivate to act against their economic interests.

In response to large fossil asset owners, further destabilization should be expected of energy pipelines, shipping routes, and government support for decarbonization policies. Claims that customers need low-cost fossil fuels will persist, though renewable electricity and electric vehicles will be lower cost and be cleaner. Increasingly, customers and firms must be fully committed to decarbonize fossil footprints as a matter of choice. Still toxic politics in this minefield of mega-market and fossil issues seems likely to remain for some time.

The promise to protect consumers from volatile electric rates and pollution can be met only if vastly more customers are offered DERs to lower their costs and decarbonize. Customer ownership of DERs enables independence in production and flexible load management to integrate large-scale renewables. Dependence can be dramatically reduced both in wholesale markets and in volatile fossil fuel markets to enable effective hedging against volatility and market manipulation, which then offer real customer protections. Scale economies will enable greater use of DERs at lower costs. Australia, Germany, and parts of the U.S. have achieved substantial energy independence with solar electricity at both wholesale and local levels. Energy

37 J. Pfeifenberger, et al., The Need for Intertie Optimization: Reducing Customer Costs, Improving Grid Resilience, and Encouraging Interregional Transmission, Brattle Group, 14 Dec. 2023.
38 See Woychik Testimony.
39 There are approximately 97 oil producers and 99 gas producers now on the planet.

efficiency has also been an effective hedge. In response to dynamic pricing, DERs in combination, customized to specific retail needs, can be even more cost-effective.

Integrated-optimized DERs offer new levels of energy independence and enable personalized customer hedging. "Zero-net-energy" (ZNE) has been a policy goal for California's DER deployment but this approach has withered in the face of extraordinary utility resistance.[40] California policymakers expect a "high DER scenario" with extraordinary growth of solar PVs, battery storage, EVs, V2G, energy efficiency, and demand response.[41] A conservative five-year view in California is that with expected DER cost declines by 2028, 4 million smart inverters, 8.5 million solar rooftop PVs, 14 Gigawatts of storage batteries, 10 million EVs, and 350 thousand EV chargers will be in place.[42] If just 15 percent of this is flexible stationary battery and EV (V2G) capacity is provided to the grid, this amounts to over 68 gigawatts of flexible capacity, which is more than the total peak demand forecast for California, and likely the EU, in 2028.[43] With large amounts of flexible DER capacity and dynamic pricing, utility-scale renewable curtailments can also be reduced in both NA and the EU.

Energy utilities seek revenue stability, resist DERs and ZNE, are laggards on use of market-based Distribution System Operators (DSOs), promote utility capital (rate-base) growth, and support growing fossil fuel use.[44] These drivers suggest strong utility support only for wholesale markets and large-scale renewables. The level of political pressure on DERs is extreme in California and many other parts of NA. Likewise in the EU, with so much "money on the table," politics seems likely to favor the hegemon utilities and fossil producers to preclude customer-based DER solutions that harness dynamic pricing.

2. Retail (Customer) Access to Competitive Electricity

The EU proposes to expand options for customers to sign electricity contracts, but information asymmetry seems likely to prevail. It appears that customers simply do not have the resources or time to be more fully informed about retail market prices. Success for customers

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40 See, Woychik Testimony, op cit..
41 Ibid, pp. 64-68.
42 Ibid, pp. 64-65.
43 Ibid. EU electricity demand appears to be approximately the same as California ISO's electricity demand, between 50 GW and 55 GW at peak. Of course, winter peak demands are much higher, and summer peaks less, in the EU.
44 Ibid, pp. 330-333.

with Retail Access in the U.S. has at best been mixed. Issues with “competitive” wholesale markets have further reduced the benefits. With increased availability of fixed price and fixed term contracts the price premium (adder) to capture uncertainty is difficult to estimate. AI can be expected to arm the seller, but how can customers or regulators be equally positioned? AI requires intense data processing and is expensive. But persistant information asymmetry favors the seller (with greater resources).

The EU recommends customer flexibility to choose dynamic pricing, with the possible use of multiple or combined contracts. Dynamic pricing can be implemented at different levels, and usually includes fixed cost recovery for distribution services, though this is complicated. Wholesale competitive market components can be added to distribution pricing elements, both of which should include locational delivery terms.

Smart Energy Europe (SEE) shows huge scale potential from customer DERs with major benefits at the wholesale distribution levels.[45] Upward and downward flexibility is estimated to lead to \$4.5 billion in lower generation costs and 37.5 Mt savings in GHG emissions.[46] Enabling 60 GW of capacity during highest demand peaks is estimated to save \$2.5 billion annually.[47] EU distribution grid benefits are estimated at \$10 billion to \$27 billion in reduced investment between 2023 and 2030, between one quarter and three quarters of the current forecast investment needs to integrate new loads and renewables.[48] Consumers may see \$67 billion in cost reductions while indirect benefits could reach over \$270 billion in lower prices, capacity costs, grid investment, system balancing costs and carbon emissions.[49] SEE Executive Director Michael Villa commented, *the active role of consumers makes enormous sense both now, for this emergency situation, and in 2030, to help integrate renewable electricity and achieve our 55% greenhouse gas reduction in a cost-effective way*.”[50]

Customers that take utility distribution service may be required to absorb lost distribution revenues, which include fixed costs, as grid-level demands decrease with greater use of DERs. While use of EVs and electrification (of end uses) will increase to meet GHG goals,

45 https://www.smart-energy.com/industry-sectors/energy-grid-management/demand-side-flexibility-in-europe-130-164gw-by-2030/
46 Ibid.
47 Ibid.
48 Ibid.
49 Ibid.
50 Ibid.

pricing for related services gets more complex. What elements are competitive and what elements allow certainty in cost recovery? Utilities have requested more certain revenue flows with greater use of DERs. Fights over use of DERs in the U.S. have become infamous. If the customer goal of ZNE is achieved, use of utility and wholesale grids diminishes. This expected eventuality – increased customer use of DERs and decreased wholesale grid use -- creates further political tension in regulatory arenas, financial circles, and between governments. As consumers seek to be more independent and adopt DERs to achieve ZNE, grid capacity at wholesale and distribution will be substantially reduced. Distribution utilities contend they are fighting for their very existence. Over time this seems to be the case; DERs will allow customers to be "off-grid."

The use of DERs and dynamic pricing can enable most EU aims, to provide access to renewable energy locally, allow solar energy sales among neighbors, and have clearer information about energy purchase and trading decisions. As DERs achieve greater scale consumers will be less vulnerable, providers of last resort are less pivotal, more consumers will have electricity service, and regulation as well as DER services can focus more on household needs for energy.

C. COP28 – Transition to Phase-Out Fossil

Climate diplomacy has enabled all parties to agree to move away from fossil fuels in energy systems, an important breakthrough. The bulk of planetary emissions results from the vast fossil wealth. A red flag was "raised" by the leader of the COP28 climate summit before the UN-backed talks claiming "that there is 'no science' that says phasing out fossil fuels is necessary to keep global warming under a critical threshold."[51] Debate on policy continues to be in flux, however, over fossil's impact on climate change. Petro economies and "big money" companies choose to say jobs are at stake and the science is unclear. COP28 also engaged 103 countries to sign the Global Methane Pledge to reduce methane emissions 30% below 2020 levels by 2030. Methane's global warming potential over a 20-year period is 86 times that of

51 CNN, https://www.google.com/search?q=controversy+with+COP+28+PRESIDENT&rlz=1C1CHBF_enUS994US994&oq=controversy+with+COP+28+PRESIDENT&gs_lcrp=EgZjaHJvbWUyBggAEEUYOdIBCTEzNTg2ajBqN6gCALACAA&sourceid=chrome&ie=UTF-8.

carbon dioxide.[52] For fossil generation methane leaks are more an issue.[53] The U.S. Environmental Protection Agency claims 23.5 percent of total methane emissions come from natural gas systems, while 8 percent of methane emissions are from coal mining.[54]

The U.S. Energy Information Administration (EIA) states that U.S. CO2 emissions are expected to decrease by 3% for all of 2023. *The largest reduction in CO2 emissions is from decreased use of coal, down 18% from 2022. Emissions from petroleum remain unchanged as falling gasoline consumption is offset by rising consumption of jet fuel and diesel, and emissions from natural gas increase slightly. In our forecast, total energy-related U.S. CO2 emissions fall by 1% in 2024.*[55] Its Canadian neighbor Alberta, however, is fully against limiting fossil fuels.[56] China and the U.S. promise to triple renewable energy by 2030, and a cross-cutting coalition of countries push for fossil fuel use to be reduced. A general goal reached at COP28 is to transition away from fossil use by 2050, albeit this seems far too late and out of time.[57] Many countries and regions are well off track with progress to cut emissions. The COP28 agreement says, relative to 2019 levels, GHG must be cut 43 percent by 2030 and 60 percent by 2035 to limit global warming to 1.5 degrees C by century's end.

At odds, for example, SoCal Gas and San Diego Gas & Electric refuse to recognize the massive climate risk from its transport and sale of natural gas.[58] California's regulators have ambitious aims for GHG reduction by 2025, 2030, and to be net-zero by 2040. But its energy utilities, to date, are not required to provide concrete plans to achieve these goals.[59] The phase-

52 https://www.bloomberg.com/news/articles/2023-12-04/chevron-exxon-opt-out-of-funding-cop28-methane-reduction-fund?leadSource=uverify%20wall. Notably, Chevron and Exon have opted out of the methane reduction fund agreed to by 50 other oil and gas producers.
53 Direct connections between electric generation and methane, however, with its gas and oil production components, have been all but ignored.
54 See, https://www.epa.gov/cmop/about-coal-mine-methane.
55 EIA Outlook
https://www.eia.gov/outlooks/steo/report/total.php#:~:text=In%20our%20forecast%2C%20total%20energy,fall%20by%201%25%20in%202024.&text=In%20our%20forecast%2C%20we%20assume,more%20HDDs%20than%20in%201Q23.
56 Alberta's Premier says Canada's rules to enable a 75% cut in fossil emissions by 2030, will cost tens of billions in infrastructure upgrades, which is "costly, dangerous and unconstitutional" placing lives at risk and forcing thousands of job losses. In a joint statement with Alberta's environment minister, the province pledged to "use every tool at our disposal to ensure these absurd federal regulations are never implemented in our province." Bloomberg, https://www.bloomberg.com/news/articles/2023-12-04/trudeau-government-cracks-down-on-methane-leaks-from-oil-gas?leadSource=uverify%20wall.
57 UN Climate, COP28 Agreement Signals "Beginning of the End" of the Fossil Fuel Era, 13 December 2023, https://unfccc.int/news/cop28-agreement-signals-beginning-of-the-end-of-the-fossil-fuel-era.
58 Woychik Testimony, op cit.
59 Ibid.

out of fossil fuel use will no doubt present excruciating big-money politics, possibly more so for NA (with its oil and gas production) than the EU.

D. Pernicious Market Manipulation in North America and Europe

Electricity market design can be refined to reduce market manipulation. Still, a large incentive exists to allow nation-states to have lax regulations, especially to arbitrage cross-border exchanges that net artificial gains-from-trade. U.S. legislators targeted energy market manipulation in a May 2023 bill,[60] but have failed to progress since. Known as the Energy Consumer Protection Act, it enables the federal regulator to ban companies from trading in energy markets if found to manipulate markets for electricity or natural gas.[61]

Similarly, the European Council and the Parliament have reached a provisional agreement on regulation to improve the EU's protection against market manipulation in the wholesale energy market (REMIT).[62] REMIT aims to enable open and fair competition as well as greater transparency and integrity.[63] The EU Agency for Cooperation of Energy Regulators (ACER) can inspect, request information, limit use of trading platforms, and member states can impose fines.[64]

Ongoing electricity market manipulation has occurred since the late 1990's. [65] The U.S. Federal Energy Regulatory Commission's (FERC) has defined market manipulation broadly to include fraud or untrue statements, and acts or practices to deceive.[66] The EU (REMIT) defines market manipulation more specifically as false or misleading transactions; price positioning, fictitious or deception transactions, and use of false or misleading information.[67] Numerous case studies of market gaming have been performed.[68] Far less than California's electric market

60 https://www.naturalgasintel.com/u-s-legislators-target-energy-market-manipulation-with-new-bill/.
61 Ibid.
62 https://www.consilium.europa.eu/en/press/press-releases/2023/11/16/protection-against-market-manipulation-in-the-wholesale-energy-market-council-and-parliament-reach-deal/.
63 Ibid.
64 Ibid.
65 G. Kaiser, Ed. Guide to Energy Market Manipulation, Global Competition Review, 2018.
66 Ibid. pg. 180.
67 Ibid. This may include "wash trades", "marking the close," cross-market manipulation, market cornering or "spoofing," "pump and dump," circular trading, or pre-arranged trading. Ibid.
68 Example case studies explored capacity withholding, market foreclosure, generation market power, reduced market liquidity, contracts to reduce competitive response, cross-market manipulation, and beneficial trading in related markets. Ibid, pp 182-189. See also, E. Woychik, How Enron et al Gamed the Electricity Market: Qualitative Assessment and Quantitative Analysis, Doctoral Thesis, Weatherhead School of Management, Case Western Reserve University, 18 May 2006.

manipulation from 1999 to 2001 (at least $70 billion)[69], settlements on electric market manipulation cases in the U.S. during 2023 amounted to $1.54 billion.[70] Noted as well are a number of EU market manipulation cases last summer.[71]

In the U.S., storage batteries do not face market participation rules like traditional generators, which then creates the potential for manipulative gaming. As a California report explains, *Batteries may also take actions to prevent charging or discharging in earlier intervals to restrict state-of-charge in later intervals in a manner that leads to undeliverable day-ahead schedules. These scenarios can contribute to inefficient market outcomes … and may be susceptible to gaming.*[72] Control of these manipulative tendencies is likely to be difficult when the integration of EV batteries (vehicle-2-grid) and stationary batteries occurs in the millions.

Intentional use of AI and ML for gaming are expected to be difficult to regulate. AI is particularly suspect to enjoin manipulation even if the intentions of market designers are otherwise. *As AI systems mediate more of our digital interactions, it is important to understand the degree to which AI systems might manipulate humans without the intent of the system designers*.[73] As the stakes increase in repeating market interactions, which are prone to gaming[74], market manipulation will involve major resources from firms that can afford such efforts, though there may be political and financial consequences. The challenges to reduce electric market gaming seem likely to increase in traditional wholesale electric markets.

E. Barriers to the Use of Traditional Market Clearing Prices

Not unlike previous "well performing" wholesale electricity markets in Northern Europe, NA and the EU now face major challenges with integration of renewables. First, what happens when zero-marginal-cost (ZMC) resources dominate, which is expected with use of renewables to attain GHG goals? Related, how to determine market clearing price (MCP) for distributed

69 Ibid.
70 2023 Report on Enforcement, Docket # AD07-15-017, U.S. Federal Energy Regulatory Commission, 16 November 2023, pp. 19-18.
71 S. Henley, European Energy Market Enforcement Cases – A Summer of Tough Love…, Cube Logic, 8 August 2023. file:///C:/Users/konoc/Documents/3_Strikes_Research/European%20Energy%20Market%20Enforcement%20Cases%20-%20A%20Summer%20of%20Tough%20Love...%20-%20CubeLogic.html.
72 California Independent System Operator, Special Report on Battery Storage, June 2023, pg. 20.
73 M. Carroll, A. Chan, H. Ashton, and D Krueger, *Characterizing Manipulation from AI Systems*, EAAMO, arXiv:2303.09387v3 [cs.CY], 30 Oct 2023.
74 R. Aumann, *Markets With A Continuum Of Traders*, Econometrica, Vol. 32, No. 1-2, January-April, 1964.

energy resources to indicate "right-time, right increment, right-location" at customer sites? In many cases MCP can be zero ($0.00/MWH).

Then how to price flexible load response that uses renewable generation, representing both capacity and energy? California's Independent System Operator seeks to integrate ramping needs (capacity) and energy prices at marginal 5 minute, 10 minute, and 15 minute increments. Before this CAISO used the market clearing price of energy plus an ancillary services (operating reserves) market adder to reflect optimization of these two resources.[75] In any case as we proceed to 100 percent renewables (to further decarbonize) it appears that only grid-scale batteries, with integrated DERS, can provide the capacity needed, particularly to meet fast-ramping needs.

Currently California has achieved a 50 percent renewables level[76] for utility-scale resources. Denmark has achieved at least 67 percent renewables.[77] As these regional wholesale markets absorb more renewables the number of hours at zero market-clearing-price (MCP) will be increasing. Costs for "Resource-Adequacy" (available capacity) in California meanwhile have increased substantially to incorporate the necessary ramping capacity that ensures reliability.

IV. Drivers of Change in Modern Electric Market Design

Jan Moen noted in 2009, that there were growing concerns among policy makers and participants about the ability to effectively foster the completion of the internal electricity market and tackle market power issues.[78] Northern Europe's electric markets -- trading between Norway, Sweden, Denmark, Finland, and Holland --- have benefited from both consistent market design and regulation to enable some consistency in related regulatory tariffs. Electric markets in the U.K., U.S., and rest of Europe have been less successful, with greater dependence on fossil fuels, more market manipulation, and major differences in preferred market structure.

75 This is the new extended Day-Ahead market. https://www.caiso.com/Documents/extended-day-ahead-market-edam-fact-sheet.pdf.
76 Padilla Report, https://www.cpuc.ca.gov/-/media/cpuc-website/industries-and-topics/documents/energy/rps/2023/2023-padilla-report---final.pdf.
77 https://www.trade.gov/country-commercial-guides/denmark-renewable-energy-products#:~:text=Overview,while%20biomass%20contributes%2011.2%20percent).
78 J. Moen, Regional Initiative: Which Appropriate Market Design?, EUE Working Papers, RSCS 2009/60, ISSN 1028-3625.

The EU's October 2023 agreement is ambitious and highlights the major challenges with modern market redesign.[79] Referenced is the *Russian invasion of Ukraine [which] has also caused uncertainty on the supply of other commodities, such as hard coal and crude oil* [resulting] *in substantial additional increases in the volatility of price levels of electricity.*[80] To tackle rising energy prices the EU seeks '"a toolbox for action and support"'[81] The EU's recent energy markets proposal seems to add DERs to the mix. Obviously recognized by some is that record sales of DERs can create prosperity without pollution.

California, New York, and other regions in NA have views largely consistent with the EU, specifically to enable *faster deployment of renewable energy and clean flexible technologies [as] the most sustainable and cost-effective way of structurally reducing the demand for fossil fuels for electricity generation and for direct consumption through electrification and energy system integration. Thanks to their low operational costs, renewable sources can positively impact electricity prices across the Union and reduce direct consumption of fossil fuels.*[82]

CAISO has recently adopted Day-Ahead Market Enhancements (DAME) to enable two new market products, Imbalance Reserves and Reliability Capacity, which are to address increased system variability and uncertainty, with the aim to improve market efficiency.[83] This flexible market requirement approach will extend the day-ahead market to address growing differences in the load forecast net of variable energy resource production (i.e., the net load forecast) to better procure firm dispatchable resources needed in real-time. These imbalances and related market uncertainty have increased with rapid growth in variable energy resources, the extreme weather-related uncertainty, and related extreme weather events. CAISO contends these new market products will capture expected major variability and uncertainty to reduce net load imbalances. Pricing of utility-scale battery storage resources will be enhanced. While the CAISO wholesale plan states all resources and load *will submit an economic bid or self-schedule in the day-ahead market based on their availability and operational circumstances*[84], this does

79 EU_Agreement_ST-14339-2023-INIT_en.pdf.
80 Ibid, pg. 3.
81 Ibid, pg. 4.
82 Ibid, pg. 8.
83 See, 185 FERC ¶ 61,210, U.S. Federal Energy Regulatory Commission, Docket No. ER23-2686-000 Order Accepting In Part, Subject to Condition, and Rejecting In Part Tariff Revisions, 20 December 2023, https://www.caiso.com/Documents/Dec20-2023-OrderAcceptingTariffRevisionsinPart-SubjecttoCondition-RejectinginPart-EDAM-DAME-ER23-2686.pdf.
84 Ibid.

not include discrete demand-side bidding *per se*.[85] As explained further below, wholesale electric markets are one sided (supply) so preclude customer (opportunity cost) bidding.

In these circumstances, a score of new drivers for market design should be recognized:

1. Renewable resource integration with zero marginal cost suggest traditional prices for wholesale grid trading are absent and pricing for local capacity is needed.[86]
2. To achieve major carbon reductions renewable resource integration requires large amounts of rapid response resources for ramping, which are costly.
3. Fossil generation must be eliminated and replaced with storage batteries and renewables which lack reference prices in a traditional "competitive" electricity market.
4. Large numbers of small distributed (customer) energy resources, including renewables and batteries, should be integrated and optimized at distribution level voltage to increase grid flexibility, maximize carbon reduction, and reduce utility bills.
5. Local distributed renewables can exercise market power when the required "deep-liquid" condition (many buyers and sellers) is absent, which will then require mitigation with customer-based bid-caps.
6. Market manipulation should be expected absent the "deep-liquid" market condition or approaches to opportunity cost pricing that mitigate market power.
7. EU proposed two-way contract for differences (CFDs) uses customer willingness to pay (opportunity cost) but lacks remedy for market power or to price local ramping needs.
8. Implicit price caps through CFDs, a blunt hammer if not localized, will create serious distortions, which are difficult to correctly value in terms of lost load.[87]
9. Lacking are large scale DER breakthroughs or related dynamic locational pricing at the distribution (customer) level, including related market power mitigation.
10. Distribution and wholesale grid regulators must ensure flexible locational capacity needs.

V. A Bespoke Two-Part Market for Local Distributed Resources and Large Renewables

85 The Electric Power Supply Association (EPSA) sued the FERC because customer Demand Response (DR) significantly lowered wholesale electricity prices in organized ISO/RTO markets, mainly by reducing peak demand. EPSA did not win this U.s Supreme Court case, rather jurisdiction was clarified to enable DR to be used in wholesale markets. EPSA V. FERC, 136 S. Ct. 760 (2016).

86 Capacity pricing, however, lacks near-term micro-efficiency and fuel cost references.

87 J. Moen, pg. 20.

A. California's Effort to Enable large Scale DERs With Dynamic Pricing

Mass implementation of DERs is expected in California by 2025 and across much of Europe by 2030. In anticipation of a high-DER future, California's DER Action Plan 2.0 will help the CPUC guide its utility infrastructure planning and improve coordination across rate design, grid planning, affordability, load flexibility, market integration, and customer programs.[88] The Plan's 2.0 Update for 2022-2026 shows a future with sustained high growth of DERs, forecasting from 2019 to 2030 as follows:

- 260 percent increase in behind the meter (BTM) solar generation;
- 770 percent increase in BTM energy storage capacity; and
- 370 percent BTM electric transportation demand (including vehicle-to-X).

Driving DER growth [are]advancements in technology, social norms, and cost declines. California's transportation electrification (TE) and climate goals are the strongest policy drivers, and are expected to result in millions of electric vehicles (EVs) and electric vehicle service equipment (EVSE) DERs by 2030.[89]

In response, working groups and subject matter experts have designed this retail market to integrate with CAISO. The details of the latest market design changes are largely established. The related retail tariff design has proven most difficult, largely as distribution utilities want very high certainty of revenues to cover fixed costs and profits. California's Public Utilities Commission developed "Advanced Strategies for Demand Flexibility Management and Customer DER Compensation."[90] The aims are to enhance DER coordination, reduce costs, promote customer engagement, and enable rate recovery. It signals distribution constraints and provides financial settlements as a "platform service" for customers access to value, trade, and use DERs. Distribution utilities are promised full cost-of-service recovery. Utilities provide distribution operations and "transport" prices to support DER trading. This aims to be a unified, universal, dynamic, and economic market to enable locational time-differentiated rates, i.e. dynamic locational pricing. Benefits include greater customer load shifting, reduced needs for ramping, reduced renewable curtailment, and these features:

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88 CPUC Press release, April 21, 2022.
89 Ibid, pg. 4.
90 Advanced Strategies for Demand Flexibility Management and Customer DER Compensation, Cal. Pub. Utilities Comm., 22 June 2022.

- Standardized, universal access to locational distribution prices and wholesale energy cost;
- A subscription option (average load shape and energy quantity);
- Transactive energy (TE) features to lock in price in advance;
- TE agents, purveyors of DERs including EV charging;
- Customers connected to grid through a smart meter, internet modem, TE platform, & end use device, through an agent;
- TE market is automated to process buy and sell tenders, as well as transport and customer subscription tenders;
- Agents for customers can 1) respond to observed prices, 2) automate "prices-to-devices," and 3) further optimize DER use and adjust to customer needs over time;
- Platform, and DSO, that then clears transactions and provides settlement (billing).

Expected with this distribution-based TE market is that wholesale markets will then embrace opportunity cost and scarcity pricing to compete, moving away from traditional marginal cost pricing. Large scale zero-marginal-cost renewables can be procured under bilateral contracts. Contracts for differences may also be used for this purpose. Increasingly, locational capacity at the distribution level is expected to be the focus of regional market competition among consumers and producers.

B. Issues and Opportunities with CalFUSE

The CalFUSE market is intended to enable a multi-sided platform to act as intermediary to connect two or more mutually dependent groups of users (e.g., sellers and buyers) with shared economic objectives in trading. To successfully scale and create competitive conditions this market must attract many users, reduce search costs, and reduce total transaction costs. This approach aims to further promote customer engagement and equitable utility ratemaking. In response to dynamic time-of-use prices use of customer DERs are optimized for real time distribution grid management. Opportunity-cost pricing will be coordinated with retail tariff design. These opportunity-cost prices reflect customer value-of-service,[91]and reflect willingness to pay at customer delivery points. The distribution utility offers reliable grid operations consistent with DER facing market prices.

91 Outage costs are one important measure of time-based, customer value for reliability.

1. Cross-Subsidy When Opportunity Costs Pricing is Used

In regulation, the controversy of cross-subsidy between customers –deviation from customer responsibility for "stand-alone costs" – is a tough challenge to ameliorate. "To be subsidy-free, revenues for each possible grouping of services must at least equal the incremental cost of that grouping."[92] Practical difficulties occur for utilities, however, to achieve subsidy-free pricing of electric rates, both to identify the "right" customers in a grouping and to choose the "right" grouping of services."

Absent non-linear self-selection of bids by customers, groupings of customers and of services inevitably drive cross-subsidies. Nonuniformities in customers and in services remain non-trivial problems for utilities that seek certainty in cost recovery. Political tradeoffs often reflect noisy controversies among customers, particularly those that face perceived "unfair treatment." Customer-based opportunity cost pricing is then essential to ensure efficiency and reduce subsidies.

Utility ratemaking has evolved with the aim to gain efficiencies from use of subsidy-free prices where "no one group of customers is paying more than its stand-alone cost and the regulated firm recovers all of its costs."[93] The proposed TE approach provides settlement-level prices for each individual customer. Fixed cost utility recovery is also enabled through tariff components. With this, the need for "right" customer groupings (to reduce subsidy) is reduced as each customer can choose, and trade, based on self-selecting nonuniform prices. "The economic efficiency of nonuniform prices comes from their function of sorting diverse consumer types into tariff packages designed for them."[94] Beyond utility tariffs, TE is used to separately price individual customer transactions which obviates the need for tariff packages.

In this new TE model, economic efficiency is accomplished by the "[s]ubscription transaction tariff, including the development of subscriptions for each [individual] customer."[95] Importantly, opportunity cost pricing curves are used to calculate localized time-based price allocations for base generation, ramp rate, and delivery (distribution) costs. Opportunity cost

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92 S. Brown and D. Sibley, The Theory of Public Utility Pricing, (Oxford UP), 1986, footnote 11, pp. 54-55. In different terms, "the revenue from each subset of goods covers the incremental cost of producing it…" J. Laffont and J. Tirole, A Theory of Incentives in Procurement and Regulation, (MIT Press), 1993, p. 31.
93 Brown and Sibley, p. 3.
94 Ibid, p. 97.
95 Barrager and Cazalet, p. 78.

prices, conditioned by customer opportunity costs, are developed to monetize delivery, generation resource adequacy, and flexible resource need.

2. Market Power at Customer Locations – "Deep-Liquid" Condition is Lacking

This version of opportunity-cost pricing aims to adjust the dynamics between supply and demand without reference to the underlying marginal cost but rather use as reference the customer's willingness to pay or opportunity cost. The price of delivered electricity, a flexible load response, may have a low supply and high demand, so rises, and so on. Acceptance of suitable buy and sell offers determines transaction prices. With highly localized, thin market conditions, there is concern that market participants can create artificial scarcity – bid-up their "opportunity cost" -- to increase demand and thus price. Not unlike wholesale market power mitigation, plant-based bid-caps seem necessary when locational constraints become well known and still must be accommodated.[96] Where customer location can be used to manipulate TE availability and pricing, pre-arranged terms and price levels should be negotiated, not unlike terms used in by CAISO in the Western Energy Crisis.[97]

3. Customer Engagement to Define Willingness to Pay in Two-Sided Markets

A deficiency in competitive wholesale electric markets world-wide has been to enable customers to directly register their willingness to pay. One-sided wholesale market clearing has dominated where suppliers (generators) define willingness to sell but exclude customer willingness to pay or opportunity cost. Demand-side management – the "other side of the market" to include customers at large scale -- has never been used at large scale in wholesale markets.

Nobel Laureate Robert Wilson explains incomplete markets may result from absence of complementary goods…insufficient contracts, or strategic behavior."[98] A double auction based on supply and demand with clearing prices set by many buyers and sellers is incentive efficient and therefore a more complete market.[99] The dynamic pricing or TE markets proposed in

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96 E. Woychik, *Western Market Power Mitigation with Plant Bid-Caps,* for California ISO Board, Strategy Integration Inc., 9 February 2001; E. Woychik, *Use of Plant-Based Bid Caps to Fix the Western Electric Wholesale Markets: Summary Discussion,* Strategy Integration Inc., 25, June 2001.
97 See, E. Woychik, et al, *Knowledge to Game the Day-Ahead Electricity Market*, Business Review Cambridge, Vol. 7, No. 1, 2007.
98 R. Wilson, *Exchange*, Allocation, Information, and Markets, Ed. J. Eatwell, M. Millgate, O. Newman, (Macmillian), 1989, pg. 89.
99 Ibid.

California and elsewhere are designed as the equivalent of double auctions. Notably, customer market (price) preferences create a natural buffer against market manipulation and market power.[100]

As large numbers of DERs will be in place in this decade, and markets for DERs would naturally be two-sided (supply and demand) to enable use of customer preferences, this seems like the appropriate direction to take.

C. Adaptations for the EU and NA to Take DERs and Dynamic Pricing to Scale

4. Distribution-Level Competitive Markets for Flexible Capacity

Localized distribution utilities can implement dynamic pricing to enable trade among customers and competitive DER providers. A "recipe" has been published, pilots are ongoing, and numerous workshops convened to demonstrate operational and trading benefits.[101] Proposed rate designs have been very politicized as a result of high rates, prompting legislation to demonstrate how income-based rates can be applied. Momentum has stalled as a result of utilities that seek to control capital growth of distribution and transmission, opposing economic efficiency. Utilities specifically oppose widespread use of customer DERs that lower customer bills and move them closer to ZNE.

A recent regulatory case has brought these issues to the fore and shown that certain consumer groups strongly support utility labor unions, which further encourage the utility view that continued utility capital growth is the preferred path and not DERs.[102] As more battery-based resources are available, most notably from EVs, utility executives fear obsolescence with huge growth in DERs. Customer costs for DERs and EVs are declining, and concurrently customers seek greater independence from utilities with use of DERs.

Distribution utilities, as operators and providers of reliability, prefer dynamic circuit switching options that preserve their role in the business. Independent distributed energy markets would erode traditional utility investments as customers in greater numbers seek sustainability and to use more clean electricity.

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100 E. Woychik, How Enron et al Gamed the Electricity Market: Qualitative Assessment and Quantitative Analysis, Doctoral Thesis, Weatherhead School of Management, Case Western Reserve University, 18 May 2006.
101 See, California Public Utilities Commission, Rulemaking 22-07-005.
102 Woychik Testimony, op cit.

The new smart-inverters, required in Hawaii and California when DERs are installed, enable customers with batteries to have reliable power when distribution utilities have outages. The duration of battery back-up and solar PV supply depend on the smart-inverter, building efficiency and the kinds of back-up, PV, and management available.[103] DER investments can be incremental, adjusted to fit customer needs over time.

Static, independent DER systems are more difficult to monetize, to maximize benefits, compared to DERs that can react to dynamic prices. Distribution-level competitive (dynamic) pricing simply accelerates the use and availability of DERs for all involved customers. It bodes to reduce utility capital needs, and profits, however, as the grid-edge becomes more economically efficient. Electric utilities and most utility labor unions, thus, resist DERs and dynamic pricing.

5. Bilateral Contracts to Integrate Large-Scale Renewables

Competitive procurement has been used to obtain large-scale renewables, which are then managed under bilateral contracts by those with an obligation to serve customers. The largest customers can also "buy-in" to renewable portfolios or directly procure renewables and manage these assets with bilateral contracts. These assets are "must-take," as available resources, in competitive wholesale (price-taker) markets but rarely set price and have zero variable costs.

As wholesale markets world-wide approach 100 percent renewables they will become real-time "accounting systems" to meet ramping capacity needs. With declines in use of fossil fuel resources that previously set price, wholesale markets are increasingly "thin" and have the binary problem; either fossil generation sets the price or the price is zero. Large scale renewables can be "dispatched" as bilateral contracts and face congestion and needs for curtailment. Renewables cause major ramping needs to occur to sustain reliability when solar and wind generation fall-off. Ramping needs will then be largely met with battery storage and flexible customer demand.

103 J. Carvallo, et al, A Guide for Improved Resource Adequacy Assessments in Evolving Power Systems: Institutional and Technical Dimensions, Lawrence Berkeley Laboratories, June 2023, https://emp.lbl.gov/publications/guide-improved-resource-adequacy

With the changing nature of competitive "energy-only" wholesale markets, competitive distribution-level markets will emerge to manage flexible customer loads, likely with dynamic pricing.

VI. CONCLUSION

The world of competitive wholesale electricity markets, largely thermal based, ushered in the security-constrained (reliability) economic dispatch methods we have relied on for the last twenty-five or more years. These one-sided (supply) single-price auctions have been controversial and costly, especially as Enron-style market games gained prominence. Market manipulation has since been tamped down but rises up periodically in new and innovative ways. Now with GHG the constraint, renewables and more broadly DERs show us a new path, using two-sided (supply-demand) auctions, capabilities to lower wholesale and distribution costs, and consumer-based pricing at the retail level. The EU and NA proposed directions summarized above show major agreement in overall direction and suggest much can be learned from each continent as we proceed.

A proverbial tidal-wave of DERs is soon upon us, led by customer-based solar photo-voltaics, storage batteries, and electric vehicles (both for charging and as mobile batteries).[104] Smart inverters for solar photovoltaics and battery storage provide customer resiliency (reliability) at ever lower cost with tailored energy efficiency. Smart meters are widely used. Optimized DERs provide flexible customer loads which are essential to manage large- and small-scale variable energy renewables. CalFUSE is an example of this distribution-based market, which in transition can work with current wholesale electric markets to address climate change, resiliency, cost increases, and control of customer bills. We must with comity integrate the electricity demand- and the supply-side. Hegemon fossil wealth and investor-owned electric utilities will oppose this with great force. Albeit this electricity market transition seems a bridge too far, given the hegemony, politics and substantial challenges. That said, modernization – response to the need for change -- is requisite.

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104 World Energy Outlook, International Energy Agency, October 2023, https://iea.blob.core.windows.net/assets/42b23c45-78bc-4482-b0f9-eb826ae2da3d/WorldEnergyOutlook2023.pdf; P. Gagnon, et al, 2023 Standard Scenarios Report: A U.S. Electricity Sector Outlook, December 2023, NREL/TP-6A40-87724.