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REWIRING THE U.S. FOR ECONOMIC RECOVERY

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The results of the *2035 Report: Plummeting Solar, Wind, and Battery Costs Can Accelerate our Clean Energy Future* (The 2035 Report) are dramatic. Given the plummeting costs of clean energy technologies, the United States could reach 90 percent zero-carbon electricity by 2035, maintain reliability, while *lowering* customer electricity bills from today's levels, on the path to 100 percent zero-carbon by 2045. To reach 90 percent, this infrastructure build-out would productively put about $1.7 trillion dollars in investment to use over the next 15 years, supporting about 530,000 more jobs each year and avoiding at least $1.2 trillion in cumulative health and environmental damages. And it would reduce economy-wide greenhouse gas emissions (GHGs) by 27 percent by 2035.

Building a reliable 90 percent zero carbon electricity system[2] is a huge opportunity for economic recovery—a fantastic way to invest in a healthier economy and support new jobs, without raising electricity bills. But America's current electricity policy framework is not on track to deliver this economic opportunity.

To realize the promise of this affordable, reliable, clean power system, the U.S. would need to double solar and wind annual deployments through the 2020s, and then triple historical maximums in the 2030s.[3] We have done this before, with natural gas power plant deployment rates in 2002.[4] Storage deployment would need to grow 25 percent each year, from 523 megawatts (MW) in 2019 to 20,000 MW in 2035. We would need some new transmission lines

[1] The authors would like to thank Mark Ahlstrom (Energy Systems Integration Group); Allison Clements (Energy Foundation); Eric Gimon, Silvio Marcacci, Bruce Nilles, and Robbie Orvis (Energy Innovation); Bracken Hendricks (Evergreen and Roosevelt Institute); Sam Ricketts (Evergreen and Center for American Progress); Betony Jones (Inclusive Economics); Taylor McNair (GridLab); Courtney St. John and Phoebe Sweet (Climate Nexus); and David Wooley (University of California, Berkeley) for their helpful feedback on this report. Any remaining errors are the responsibility of the authors.

[2] Modeling allowed for all known zero-carbon electricity options, including wind, solar, biomass, geothermal, large hydro, nuclear, and fossil generation with carbon capture and sequestration (CCS). Least cost optimizations eschewed new nuclear or CCS in the final mix, due to cost. All generation sources are supported by transmission, storage, demand response, and flexible grid operations.

[3] 15.1 GW of solar was installed in 2016 and 13.1 GW of wind was installed in 2012. See Bolinger, Mark and Seel, Joachim et al. "Utility-Scale Solar: Empirical Trends in Project Technology, Cost, Performance, and PPA Pricing in the United States - 2019 Edition." *Lawrence Berkeley National Laboratory* 2019. URL: https://emp.lbl.gov/utility-scale-solar; "Wiser, Ryan and Bolinger, Mark. "2018 Wind Technologies Market Report." *Office of Energy Efficiency and Renewable Energy*, *Department of Energy* August 2019. URL: https://emp.lbl.gov/sites/default/files/wtmr_final_for_posting_8-9-19.pdf.

[4] 65 GW of new gas power plants were built in 2002. See "Electric Power Annual 2002." *Office of Coal, Nuclear, Electric and Alternate Fuels*, *Energy Information Administration* December 2003. URL: www.eia.gov/electricity/annual/archive/03482002.pdf.

to interconnect new generation, but relatively few interregional lines. All coal plants could retire, and we would need no new gas plants. Most of the existing gas fleet would be maintained but run infrequently, providing 70 percent less energy than today, and helping to balance the system.[5]

Without the addition of new policies, we are not on track to deliver the most cost-effective electricity system explored in the *2035 Report*, nor will we maximize societal benefits like public health and climate impacts. Policies, utility regulation, and power market structures will need an upgrade. Luckily, policymakers and regulators can take promising actions to remedy this. The technology-neutral policies laid out in this paper are no-regrets actions to get us to 90 percent zero carbon electricity while reducing wholesale electricity costs 10 percent. These policies enable all technologies to compete to achieve a clean, affordable, reliable grid.

We emphasize that the list below represents an optimal set of policies to first get the U.S. to a 90 percent, and ultimately 100 percent zero-emission electric power system. Success, however, does not depend on all adopting all of these policies at once, and most progress can be made with a federal clean energy standard that builds on and complements state policy leadership. Importantly, either Congress or the U.S. Environmental Protection Agency under its existing Clean Air Act authority could put the CES building blocks in place.

In brief, top policy actions include:

- Adopt a federal clean electricity standard reaching 55 percent clean (carbon free) by 2025, 75 percent by 2030, 90 percent by 2035, and 100 percent by 2045. Increased ambition on state clean energy standards is an important complement to this action.
- Extend federal clean energy investment and production tax credits and conversion to more liquid incentives, and extend these incentives to battery storage. These are more important in the absence of a clean energy standard.
- Support coal-dependent communities by shoring up underfunded pension and healthcare benefits, providing stopgap funding for local services, and providing pathways for employment in the clean energy economy through local investment and training programs.
- Use utility- and government-backed refinancing of retired coal equity and debt to lessen the customer and utility burden of the coal-to-clean transition.
- Support a national effort to streamline renewable energy and transmission siting to accelerate responsible clean energy deployment.
- Strengthen federal authority to improve regional transmission planning, allocate transmission costs, and reduce unfair interconnection costs.

[5] The 90% Clean case saw a maximum gas dispatch of 361 GW in 2035, with an additional 90 GW of gas capacity in reserves to meet reliability standards. This is about 80% of the 540 GW of gas capacity currently operating in the U.S. Because little to no new gas capacity is needed to meet this need, this strategy creates significant cost-savings in moving to a clean energy future. The remaining natural gas fleet provides an important role meeting demand in low solar and wind periods, but it experiences annual capacity factors under 10 percent.

- Invest in R&D to develop the technologies needed to get to 100 percent clean electricity by 2045.
- Reform wholesale markets to reward flexibility, be compatible with federal and state clean energy targets, and support investment in a least-cost, technology-neutral portfolio of supply and demand-side resources.
- Reform utility business models to incent demand-side management and create fair rules for utility investment decisions.

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A CLEAN ENERGY STANDARD WOULD DRIVE SUCCESS

A clean energy standard sets a clear goal for the share of total electricity that will come from zero-carbon sources in a future year. A technology-neutral clean energy standard for the electricity sector should include all sources of zero-carbon electricity (solar, wind, biomass, hydro, geothermal, nuclear, carbon capture and storage, and any other proven source of zero-carbon electricity). It should require retail utilities to hit interim targets at least every five years (ideally every three), building up from the existing share of clean energy in the nation's electricity mix (approximately 40 percent today).

Setting a national clean energy standard of 55 percent by 2025, 75 percent by 2030, 90 percent by 2035, and 100 percent by 2045 would be ambitious and achievable, giving America the clean energy backbone it needs to decarbonize other sectors on the path to net zero economy-wide emissions by 2050.[6] Getting underway now to build the clean energy needed to reach 90 percent by 2035 gives engineers and developers time to evaluate the best technologies and pathways to get us to 100 percent carbon-free electricity at least cost by 2045.

Congress or the U.S. EPA could require states to submit plans laying out their path to meet the clean electricity standard, and to update those plans every three years. Legislation should require retail utilities to develop scenarios complying with this pathway as part of utility resource planning, and demonstrate compliance by procuring clean electricity certificates. The federal government could direct funds to the U.S. Department of Energy (DOE) and national labs to track and report state-by-state progress while providing customized technical assistance for state policymakers on how to reach the goal.

States will start from different clean electricity baselines. But given dramatic cost declines for key electricity generation technologies the cleanest electricity available today is usually the cheapest electricity, and the *2035 Report* makes it clear that 90 percent zero carbon electricity is achievable while lowering customer electricity bills.[7] The availability of low-cost zero carbon electricity generation options puts us in a fundamentally different situation than even just a few years ago. Moreover, a just and equitable transition to clean energy sources will spur substantial economic development.

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[6] According to the Intergovernmental Panel on Climate Change, global emissions must reach net zero by 2050 for a reasonable chance of keeping global temperature rise less than 1.5 degrees Celsius. See "Summary for Policymakers of IPCC Special Report on Global Warming of 1.5° C." *The Intergovernmental Panel on Climate Change* October 2018. URL: https://www.ipcc.ch/2018/10/08/summary-for-policymakers-of-ipcc-special-report-on-global-warming-of-1-5c-approved-by-governments/; Energy Innovation's "Net Zero Scenario," reaches economy-wide net-zero emissions while employing a 100 percent clean electricity standard by 2050. See "Net Zero Scenario" *Energy Innovation: Policy and Technology, LLC.* November 2019. URL: https://us.energypolicy.solutions/scenarios/home.

[7] Gimon, Eric and O'Boyle, Mike. "The Coal Cost Crossover: Economic Viability of Existing Coal Compared to New Local Wind and Solar Resources." *Energy Innovation: Policy and Technology, LLC.* March 2019. URL: https://energyinnovation.org/publication/the-coal-cost-crossover/; Teplin, Charles and Dyson, Mark et al. "The Growing Market for Clean Energy Portfolios." *Rocky Mountain Institute* 2019. URL: https://rmi.org/insight/clean-energy-portfolios-pipelines-and-plants/; Dyson, Mark and Glazer, Grant et al. "Prospects for Gas Pipelines in the Era of Clean Energy." *Rocky Mountain Institute* 2019. URL: https://rmi.org/insight/clean-energy-portfolios-pipelines-and-plants/.

States (generally via their public utilities commissions) should require regulated utilities to procure these resources in a technology-neutral way (i.e., via all-source procurement[8]), allowing all zero-carbon resources (including energy efficiency, storage, demand response, and other distributed energy resources) to participate. Second, the all-source procurement should be competitive, meaning the utility or other buyer would have to structure the solicitation as an open request for offers that adheres to a set of standards to accommodate wide participation. Third, it would treat uneconomic assets and the remaining balances on them as sunk costs, while providing for some combination of ratepayer and U.S.-backed securitization of those balances. These actions could make the clean electricity transition very affordable in states that are starting from a lower share of renewables.

A federal clean energy standard enacted by Congress, or an EPA successor to the Clean Power Plan should ensure no state lags too far behind. EPA has significant authority to regulate GHGs from new and existing power plants under Clean Air Act Section 111. Given the rapid decline in technology costs demonstrated by the 2035 report and real-world contract prices, EPA should consider requiring states to create implementation plans for rapid decarbonization of their electricity systems under a similar but more ambitious structure than the Clean Power Plan. Such plans could require reductions GHGs from coal and gas plants given available, lower-cost alternatives that avoid pollution, or plans could take a fleet-wide approach to meet the standard. This includes carbon pollution limits for new gas plants. In the absence of a legislative clean energy standard, an administrative standard becomes essential to a cost-effective, rapid decarbonization of the U.S. electricity system.

Who Can Get It Done

Decision-maker	Policy
U.S. Congress	**Pass a federal Clean Energy Standard** with the following schedule: 55 percent by 2025, 75 percent by 2030, 90 percent by 2035, 100 percent by 2045
Governors, state legislatures, public utilities commissions	**Pass Clean Energy Standards** of 90 percent by 2035 (or earlier), 100 percent by 2045 (or earlier)
U.S. Environmental Protection Agency	Under Clean Air Act authority, **require states to create implementation plans for rapid decarbonization of their electricity systems** given the availability of lower-cost and lower-pollution alternatives, and limit carbon pollution from new gas-fired power plants.

[8] Wilson, John D. and O'Boyle, Mike et al. "Making the Most of the Power Plant Market: Best Practices for All-Source Electric Generation Procurement. *Energy Innovation: Policy and Technology, LLC.* and *Southern Alliance for Clean Energy* April 2020. URL: https://energyinnovation.org/wp-content/uploads/2020/04/All-Source-Utility-Electricity-Generation-Procurement-Best-Practices.pdf.

SUPPORTING CLEAN ENERGY DEPLOYMENT AT SPEED AND SCALE

Beyond a clean energy standard, a suite of complementary policies can help clear the way for building low-cost new clean energy at speed and scale.

TAX CREDITS

Right now, wind and solar projects equivalent to about half of the entire U.S. electric grid capacity are waiting for approval from grid operators.[9] But like many industries, the renewable energy industry has been affected by the current COVID-19 pandemic and related economic crisis. Some projects that were underway before widespread stay-at-home orders are experiencing significant delays. In the first two months of COVID-19 hitting the U.S., more than 600,000 workers in the clean energy industry filed for unemployment.[10] This is a critical time to support these industries that can provide good jobs for Americans across the country, once it is safe to return to development sites.

Thus, it will be important to extend[11] the lifetime of the production tax credit for wind, and the investment tax credit for solar and solar-paired storage, following the Internal Revenue Service's rationale for increasing construction and safe harbor deadlines of these credits from four to five years to accommodate the slowdowns in wind and solar projects due to COVID-19.[12] This policy is much more important in the absence of a federal clean energy standard – the *2035 Report* demonstrates a 90 percent clean energy standard could drive rapid decarbonization and cost declines without extending federal tax incentives.

It will also help to convert those tax credits to direct payments: Today, because of illiquidity, the government only provides about 60 cents worth of incentive for every dollar it spends.[13] Section 1603 of the American Recovery and Reinvestment Act (ARRA) converted tax credits to direct payments, and Congress could adopt this provision again. An alternative accomplishing the same goal is a refundable tax credit, wherein developers can receive the full value of the tax credit, regardless of their tax liability[14]. Lawrence Berkeley National Lab found that Section 1603

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[9] 544 GW Interconnection queues in the United States currently include 544 GW of wind, solar, and stand-alone battery storage, roughly half of the 1,100 GW required. See Bolinger, Mark and Seel, Joachim et al. "Utility-Scale Solar: Empirical Trends in Project Technology, Cost, Performance, and PPA Pricing in the United States - 2019 Edition Slides." *Lawrence Berkeley National Laboratory* 2019. URL: https://emp.lbl.gov/sites/default/files/lbnl_utility-scale_solar_2019_edition_slides_final.pdf.

[10] "Clean Energy Unemployment Claims in COVID-19 Aftermath, April 2020." *E2* May 13, 2020. URL: https://e2.org/reports/clean-jobs-covid-economic-crisis-april-2020/.

[11] Extend the "start of construction" and "placed in service" deadlines, as well as the program end-dates.

[12] "COVID 19 Impacts on American Wind Industry and Mitigation Proposals." *American Wind Energy Association* March 18, 2020. URL: https://www.awea.org/Awea/media/Resources/COVID-19ImpactsonWindIndustryandMitigationProposalsforHill.pdf.

[13] Varadarajan, Uday and Pierpoint, Brende, et al. "Supporting Renewables while Saving Taxpayers Money." *Climate Policy Initiative* September 2012. URL: https://climatepolicyinitiative.org/wp-content/uploads/2012/09/Supporting-Renewables-while-Saving-Taxpayers-Money.pdf.

[14] Bhattacharyya, Bidisha. "Renewable Energy Tax Credits: The Case for Refundability." *Center for American Progress* May 28, 2020. URL: https://www.americanprogress.org/issues/green/reports/2020/05/28/485411/renewable-energy-tax-credits-case-refundability/.

produced more than 51,000 short-term jobs last time, so this adjustment to program structure is good for workers and good for the clean energy industry.[15]

Who Can Get It Done

Decision-maker	Policy
U.S. Congress	**Extend existing tax credits** for all zero-carbon electricity sources, as well as electricity storage projects. Convert them to direct payments, or make them refundable.

BOLSTERING U.S. MANUFACTURING OF CLEAN ENERGY

Reaching 90 percent clean electricity by 2035 would require deploying an average of about 35 gigawatts (GW) of new solar each year, 36 GW of new wind each year, and 10 GW of new four-hour batteries each year.[16] America's current annual manufacturing capacity for solar is 7 GW[17], and wind is 9 GW.[18] Manufacturing capacity for lithium ion batteries (the dominant grid-scale storage technology solution today) will scale with demand for a much larger electric vehicle market. A federal clean energy standard would provide a strong domestic demand for these technologies, and could be designed to provide a guaranteed market for a substantially expanded American manufacturing base for these technologies.

Direct financial support is a tried-and-true way to scale up American manufacturing. The ARRA authorized a 30 percent tax credit for investments in advanced energy manufacturing projects, which ended up totaling more than $2 billion in support. In the power generation business, for example, this funding helped increase the share of domestically-produced wind turbine components from 25 percent in 2006-2007 to 72 percent in 2012.[19] The program was oversubscribed and capped at $2.3 billion – future use of this tax credit should greatly increase or remove caps in order to truly scale American clean energy manufacturing.

In the transport sector, the Advanced Technology Vehicles Manufacturing loan program helped the American auto industry retool with $8 billion in loans and commitments to projects that supported the production of more than four million fuel-efficient cars. The program saved

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[15] Bolinger, Mark and Wiser, Ryan et al. "Preliminary Evaluation of the Impact of the Section 1603 Treasury Grant Program on Renewable Energy Deployment." *Lawrence Berkeley National Laboratory* April 2010. URL: https://eta-publications.lbl.gov/sites/default/files/report-lbnl-3188e.pdf.

[16] In total, 518 GW of new solar by 2035, 540 GW of new wind, and 147 GW of total batteries. In particular, since the battery industry is quite nascent, the real deployment schedule would likely start quite a bit lower than 10 GW in the early years, and ramp up more in the later years.

[17] Pickerel, Kelly. "The Largest Solar Panel Manufacturers in the United States by Capacity." *Solar Power World* November 25, 2019. URL: https://www.solarpowerworldonline.com/2019/11/the-largest-solar-panel-manufacturers-in-the-united-states-by-capacity/.

[18] "Wiser, Ryan and Bolinger, Mark. "2018 Wind Technologies Market Report." *Office of Energy Efficiency and Renewable Energy, Department of Energy* August 9, 2019. URL: https://emp.lbl.gov/sites/default/files/wtmr_final_for_posting_8-9-19.pdf.

[19] "The Recovery Act Made the Largest Single Investment in Clean Energy in History, Driving the Deployment of Clean Energy, Promoting Energy Efficiency, and Supporting Manufacturing." *Office of the Press Secretary, The White House* February 25, 2016. URL: https://obamawhitehouse.archives.gov/the-press-office/2016/02/25/fact-sheet-recovery-act-made-largest-single-investment-clean-energy.

33,000 jobs and boosted Tesla, which now employs more than 10,000 people at its Fremont, California factory.[20] Support for advanced manufacturing would come at a critical time as other major manufacturing nations in Europe and Asia are providing such transition support as part of their recovery packages.

Direct loans and loan guarantees leverage side-by-side funding from the private sector. They lower the cost of advanced technologies as new business ventures always face higher interest rates when seeking financing. DOE's Loan Programs Office estimated $39 billion loan and loan guarantee authority could leverage as much as $100 billion of private investments in innovative approaches to modernizing energy infrastructures across all energy sectors. Congress should accelerate access to this lending authority by allowing state and local governments to access federal financing, and empowering state and local actors to deliver project finance. These loan programs are very cost effective for government; the Loan Programs Office had yielded the Treasury net receipts of more than $2 billion by 2015.[21]

Who Can Get It Done

Decision-maker	Policy
U.S. Congress	**Reinstate the manufacturing tax credit** used during the American Recovery and Reinvestment Act to support domestic manufacturing of clean energy technologies.
U.S. Congress; DOE	**Fund a large increase in DOE's capacity to provide low-cost capital** to companies with proven experience willing to expand manufacturing capacity of solar, grid-scale storage, and wind in the U.S.

DEALING WITH STRANDED ASSETS

Retiring coal has demonstrably positive economic and environmental impacts, but retiring power plants can cause financial disruption for utilities[22], due to the fact that utilities have continued to invest in aging power plants and such capital costs are paid off over decades, usually at least 30 years. Under conventional state regulation, monopoly utilities have the right to charge

[20] "Project Summary." *Department of Energy*. Accessed June 5, 2020. URL: https://www.energy.gov/lpo/ford#:~:text=ECONOMIC%20IMPACT,2009%20through%20Model%20Year%202013; Project Summary." *Department of Energy* Accessed June 5, 2020. URL: https://www.energy.gov/lpo/tesla; "Tesla Factory." *Tesla* Accessed June 5, 2020. URL: https://www.tesla.com/factory.

[21] A report from the Government Accountability Office found program costs of $2.2 billion. The report notes "LPO-supported companies have made approximately $4.4 billion in principal and interest payments to the US Treasury," implying the program provided net cash flow benefits of $2.2 billion through 2020. See "DOE Loan Programs Current Estimated Net Costs Include $2.2 Billion in Credit Subsidy, Plus Administrative Expenses." *Government Accountability Office* April 2015. URL: https://www.gao.gov/assets/670/669847.pdf.

[22] Note this should not be considered a problem for power plants in restructured competitive power markets, because private companies entered those markets to sell power, taking on the risk of resource changes over time. This is different than the regulated utility situation, because captive customers are left with the bill for undepreciated balances unless policymakers or regulators step in to alleviate this.

customers the full cost of paying off the remaining power plant balance, including risk-adjusted returns for shareholders and creditors. Rural cooperatives and municipalities face similar credit risks when unpaid coal debt remains long after the plant retires. The result: When new, cheap renewables replace expensive, dirty generation, customers can get stuck with the bill for old power plants, even when they're no longer in use – unless policymakers step in to address this.

The 90 Percent Clean case in the *2035 Report* retires the remainder of the U.S. coal fleet and replaces it with clean power that is cheaper to build and operate than continuing to run the existing coal plants. Coal capacity drops from over 200 GW in 2018 to zero by the end of 2035. According to Carbon Tracker, over $200 billion is "owed" just to monopoly utilities (who own more than half the existing fleet) on these power plants.[23]

Some of these costs will be repaid while coal plants operate less and less over the next 15 years, while significant undepreciated capital costs could remain after retirement absent action by regulators. In cases where capital owed on retired assets is significant, customers could realize even greater savings from the clean energy transition by using cheap capital. Very low-interest government-backed and rate-payer backed bonds can be used to pay the undepreciated book value of early-retired coal plants. For government-backed bonds, the federal government could consider buying retired coal assets for their remaining book value, socializing the costs that would otherwise be borne by customers of the monopoly utility. Using ratepayer-backed bonds to buy down utility-owned retired coal plants would achieve similar savings on financing, but the remaining lower costs would be socialized only by those specific utility customers (at a much lower interest rate).

In reality, the end of the coal fleet could be much faster; the marginal economics of coal get exponentially worse as these plants run less and less.[24] The COVID-19 crisis, for example, has laid bare the vulnerability of coal-fired power plants to market forces: Collapsing demand has mostly resulted in running existing coal plants fewer hours, hastening the trend of renewables generating more power on average than coal-fired generation.[25] As the *2035 Report* shows, we don't need these plants around for reliability, and as renewables and storage currently and increasingly are the more cost-effective source of energy and other grid services, the justification for keeping these plants around evaporates.

Government-backed or ratepayer-backed bonds can be important tools to reduce the cost of retiring uneconomic coal-fired plants. Selling the undepreciated balances to bond-holders is commonly referred to as "securitization." Whether state legislation is needed for securitization varies – about half of states already have authorizing legislation on the books, as the tool was

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[23] Gray, Matt and Watson, Laurence. "No Country for Coal Gen – Below 2°C and Regulatory Risk for U.S. Coal Power Owners." *Carbon Tracker* September 2017. URL: https://carbontracker.org/reports/no-country-for-coal-gen-below-2c-and-regulatory-risk-for-us-coal-power-owners/.

[24] "The Coal Cost Crossover: Economic Viability of Existing Coal Compared to New Local Wind and Solar Resources." *Energy Innovation* March 2019.

[25] Plumer, Brad. "In a First Renewable Energy is Poised to Eclipse Coal in the U.S." *New York Times* May 13, 2020. URL: https://www.nytimes.com/2020/05/13/climate/coronavirus-coal-electricity-renewables.html

used during utility restructuring in the late 1990s, and to pay for large unforeseen capital investments like storm recovery. Legislators can consider Colorado's legislation authorizing coal debt securitization as a model in achieving a balance between ratepayer, public, impacted community, and utility interests.[26]

Our modeling also shows we don't need to build any new natural gas-fired power plants to meet a 90 percent clean energy standard. Current utility plans to spend over $100 billion to build at least 88 GW of natural gas[27] capacity would exacerbate stranded asset risk for both generation and supporting pipeline infrastructure, conflicting with many of the same utilities' plans (and climate plans on their host states) to reach net-zero emissions by 2050.[28] In general, the economics of these projects are inferior to portfolios of clean energy resources explored in the *2035 Report*, and described in further detail by the Rocky Mountain Institute (RMI).[29]

Who Can Get It Done

Decision-maker	Policy
U.S. Congress	**Offer federal debt financing** for utilities where compliance with clean energy standards leads to coal and gas closures, and regulated utilities have reasonable outstanding unpaid balances on those plants.
State Public Utility Commissions	**Prohibit regulated utility investment in new natural gas, unless there is a clear, demonstrated need with no reasonable clean alternative**; require explanation of how such investments would benefit customers, coexist with rapid clean energy deployment, and remain useful over the lifetime of the asset.
State Legislatures	**Authorize public utility commissions to create ratepayer-backed bonds** that securitize uneconomic coal and gas units, relieving utility customers of the obligation to pay high costs of capital, while making utilities whole for their reasonable investments. Include funding for supporting workers and communities in these financial plans.

[26] "Colorado Energy Impact Assistance Act." HB19-1037. *2019 Regular Session*. URL: https://leg.colorado.gov/bills/hb19-1037#:~:text=The%20bill%2C%20known%20as%20the,the%20cost%20to%20electric%20utility.

[27] "A Bridge Backward? The Financial Risks of the 'Rush to Gas' in the U.S. Power Sector" *Rocky Mountain Institute* URL: https://rmi.org/wp-content/uploads/2019/09/clean-energy-portfolio-two-pager.pdf.

[28] Holzman, Lila and O'Boyle, Mike. "Natural Gas: A Bridge to Climate Breakdown" *As You Sow* and *Energy Innovation, LLC.* March 2020. URL: https://energyinnovation.org/wp-content/uploads/2020/03/Natural-Gas_A-Bridge-to-Climate-Breakdown.pdf.

[29] "The Growing Market for Clean Energy Portfolios." *Rocky Mountain Institute* 2019 and "Prospects for Gas Pipelines in the Era of Clean Energy." *Rocky Mountain Institute* 2019.

PERMITTING AND SITING

Wind and solar plants require significant but manageable land area. In the 90 Percent Clean case in the *2035 Report*, we anticipate that 515 GW of ground-mounted solar generation[30] would occupy 13,200 square kilometers (km^2) of land.[31] The additional 596 GW of wind capacity would require 149,000 km^2 of land, though only 10 percent of this space would be unusable, with the other 90 percent continuing to allow farming and grazing between the turbines. Thus, 596 GW of wind would occupy about 15,000 km^2 of land, sited on 149,000 km^2 of farmland. This combined amount of occupied land for new wind and solar installations, 28,200 km^2, is about triple the land currently devoted to golf courses, and equivalent to about half the land owned by the Department of Defense.[32]

Reducing permitting and siting conflicts by pre-screening federal and state lands for suitability is crucial to enable this rapid buildout of new renewable resources and associated transmission. This is already ongoing in the Western U.S., through the federal West-wide Energy Corridors[33] planning process. The planning process identifies continuous strips of federal land across jurisdictional boundaries suitable for transmission development. Federal agencies have also prescreened areas of ideal development for solar energy in six Western states (Solar Energy Zones)[34] and offshore wind energy off the Atlantic Coast (Wind Energy Zones).[35] Texas also provides a model with a history of pre-approving and building out transmission to "Competitive Renewable Energy Zones" where clean energy resources are abundant.

Robust stakeholder engagement minimizes environmental, cultural and other stakeholder conflicts. Eventually, these processes streamline federal siting, review, and permitting processes for developers. Each site receives streamlined approval because it undergoes National Environmental Policy Act review and responds to local stakeholder concerns before it is leased to developers. Efforts to engage with private landowners are crucial to completing many of the corridors will increase the likelihood of success.

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[30] About 60 GW of solar is on rooftops in the 90 percent Clean case.

[31] Ong, Sean and Campbell, Clinton et al. "Land-Use Requirements for Solar Power Plants in the United States." *National Renewable Energy Laboratory*. June 2013. URL: https://www.nrel.gov/docs/fy13osti/56290.pdf.

[32] 654 million acres are dedicated to grazing. See Merrill, Dave and Leatherby, Lauren. "Here's How America Uses Its Land." *Bloomberg* July 31, 2018. URL: https://www.bloomberg.com/graphics/2018-us-land-use/.

[33] "West-wide Energy Corridor Information Center." *Bureau of Land Management, National Forest Service, and Department of Energy.* Accessed June 5, 2020. URL: http://corridoreis.anl.gov/.

[34] "Approved Resource Manage Plan Amendments/Record of Decision (ROD) for Solar Energy Development in Six Southwestern States" *Bureau of Land Management* October 2012. URL: http://blmsolar.anl.gov/documents/docs/peis/Solar_PEIS_ROD.pdf.

[35] "Wind Planning Areas." *Bureau of Ocean Management*. Accessed June 5, 2020. URL: https://www.boem.gov/sites/default/files/renewable-energy-program/Mapping-and-Data/BOEM_Wind_Planning_Areas_12_15_2016_metadata.pdf.

Data is also key to pre-screening renewable resource and transmission areas. The Western Electricity Coordination Council has developed the Environment Data Viewer,[36] a tool that should be expanded for the rest of the U.S. to enable smart infrastructure development. The tool uses Geographic Information Systems data for different land conflicts, enabling users to create maps of low-conflict land. For example, existing rights of way are the lowest conflict (green), while low-conflict undeveloped land is yellow, and land with explicit environmental, infrastructure, or cultural conflicts ranges from orange to red. The tool uses professional judgment of transmission planners, Bureau of Land Management and U.S. Forest Service, environmental leaders and even archaeologists to build the classifications in the tool.

Who Can Get It Done

Decision-maker	Policy
U.S. Congress	Require the Department of Energy and Department of Interior to **develop and update national energy corridors and renewable energy zones**, and publish a national database of land conflicts to facilitate development and responsible siting.

INTERCONNECTION AND TRANSMISSION PLANNING REFORM

Today's grid operator and state regulatory approaches to transmission planning and generation interconnection are not up to the task of delivering a low-carbon grid at speed and scale. While 544 GW of renewable generation lies in wait to interconnect to high-voltage transmission systems[37] – nearly half of the capacity needed to meet a 90 percent clean energy standard – these projects face unreasonably high barriers due to conventional interconnection rules. Rather than investing in transmission planning that would more efficiently serve society's economic and policy goals, today's rules typically require every new generation resource to separately pay grid upgrade costs to interconnect their power plant the system, when there would be far greater societal benefit to view transmission planning and upgrades with a more holistic regional perspective. The Federal Energy Regulatory Commission (FERC) should exercise its authority and expand its capacity to require regional transmission expansion and simplified interconnection rules that support the realities of society's policy goals and a 90 percent by 2035 clean energy standard.

Transmission networks can be planned in advance to accommodate a sensible mix of very low-cost renewable resources, creating net benefits for customers, and Congress should reform FERC's electric transmission authority to support the changing electricity system in a cost-effective manner. To begin, cost-allocation should be driven by analysis of the benefits[38] and

[36] "Environmental Data Viewer." *Western Electricity Coordinating Council*. Accessed June 5, 2020. https://ecosystems.azurewebsites.net/WECC/Environmental/.

[37] These include both RTO and non-RTO transmission systems. See "Utility-Scale Solar: Empirical Trends in Project Technology, Cost, Performance, and PPA Pricing in the United States - 2019 Edition." *Lawrence Berkeley National Laboratory* 2019.

[38] Benefits should include quantifiable environmental, resilience, and public policy benefits, in addition to direct economic benefits. The basic idea is to codify the lax suggestions of FERC Order 1000. The Midcontinent Independent System Operator

balanced by a consideration of the negative factors beyond direct cost (e.g., land-use impact, landscape degradation, habitat disruption). Congress could give FERC a clearer mandate to enforce and expand Order 1000 (FERC's regional transmission planning order), by requiring timely plans, accounting for public policy in planning, and allocating regional costs to beneficiaries where regions fall short.[39]

The Midcontinent Independent System Operator (MISO) Multi-Value Project (MVP) transmission expansion plan (submitted to FERC for approval in 2011) provides an example of regional cost allocation that benefits all electricity customers. The MVP portfolio proactively identified regional transmission solutions, or MVPs, that meet one or more of three goals. These lines:

- Reliably and economically enable regional public policy needs,
- Provide multiple types of regional economic value, and/or
- Provide a combination of regional reliability and economic value.

The costs of this MVP portfolio were allocated across the region, rather than only to specific developers, utilities, states or market participants. The results from the most recent review of the program speak for themselves:

- Benefits in excess of its costs, with a benefit-to-cost ratio ranging from 2.2 to 3.4;
- $12.1 to $52.6 billion in net benefits over the next 20 to 40 years;
- Enabling 52.8 million megawatt-hours of wind energy to meet renewable energy mandates and goals through year 2031[40].

Duplicating MISO's cost allocation and adopting a more comprehensive, proactive regional planning approach in the rest of the country could reduce interconnection queue waiting times and improve the risk for developers, while benefiting all electricity customers throughout a region. Such planning processes could build on the intent of Order 1000 but strengthen its requirements to account for public policies, allocate costs, and submit meaningful regional plans. This should also apply to FERC-jurisdictional transmission outside the nation's independent system operators (ISOs) and regional transmission organizations (RTOs).

Congress could also push FERC to act on cost-allocation for new multi-state transmission lines. Though these lines do not feature prominently in the *2035 Report*, their benefits are clear from other modeling exercises.[41] For example, FERC should encourage high voltage inter-regional

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(MISO) Multi-Value Projects methodology is a model to consider building upon. See "Multi-Value Projects (MVPs)." *Midcontinent Independent System Operator, Inc.* URL: https://www.misoenergy.org/planning/planning/multi-value-projects-mvps.

[39] See Holden, Emily. "State Regulators, Clean Energy Advocates Square Off on Bill Pre-empting Power Line Siting Authority." *E&E News* April 22, 2015. URL: https://governorswindenergycoalition.org/state-regulators-clean-energy-advocates-square-off-on-bill-pre-empting-power-line-siting-authority/.

[40] "A 2017 Review of the Public Policy Economic, and Qualitative Benefits of the Multi-Value Project Portfolio." *Midcontinent Independent System Operator, Inc*. September 2017. URL: https://cdn.misoenergy.org/MTEP17%20MVP%20Triennial%20Review%20Report117065.pdf.

[41] Bloom, Aaron. "Interconnections Seam Study." *National Renewable Energy Lab* 2018. URL: https://www.terrawatts.com/seams-transgridx-2018.pdf.; MacDonald, Alexander E. and Clack, Christopher T.M. et al. "Future Cost-Competitive Electricity Systems and Their Impact on U.S. CO_2 Emissions." *Nature Climate Change* January 2016. URL: https://research.noaa.gov/article/ArtMID/587/ArticleID/542/Rapid-affordable-energy-transformation-possible.

transmission to access least-cost (and clean) resources, by requiring regional Order 1000 Planning Authorities to develop compatible models (incorporating state energy resource plans) and pursue interregional transmission where benefits exceed costs. Alternatively, Congress could vest DOE with authority to plan large interregional lines, reducing complexity of coordinating planning between regions. A more holistic cost benefit analysis of this nature can also help address the most common reason many important transmission lines have failed: disagreements between states over how to fairly allocate costs. For multistate lines, FERC could require states denying a regionally beneficial line to demonstrate certain criteria are met to justify denial, similar to the rate design structure used in the Public Utility Regulatory Policy Act.

Who Can Get It Done

Decision-maker	Policy
U.S. Congress	**Affirm FERC's authority for transmission cost allocation and planning for public policy impacts to the grid**, including regions outside of ISOs/RTOs. Give particular attention to the federal clean energy standard, or in its absence state and utility clean electricity goals. Make clear the intention to reduce interconnection queue times and require beneficiary customers to pay their fair share.
U.S. Congress	**Provide states with matching funds to pay for interstate transmission lines** with demonstrable reliability, cost, and renewable integration benefits. Consider vesting DOE with authority to plan for and site interregional transmission lines to streamline development of the nation's most crucial and beneficial long-distance transmission projects.
FERC	Exercise authority to **require regional transmission expansion and simplified interconnection rules** that support the realities of society's policy goals and a 90% by 2035 clean energy standard.
FERC	**Require regional Planning Authorities to develop compatible models** (incorporating state energy resource plans) and pursue transmission where benefits exceed costs. Require states denying a regionally beneficial line to demonstrate certain criteria are met to justify denial.
FERC	**Require regional transmission planning bodies created under FERC Order 1000 to propose to FERC multi-value transmission projects**, accounting for state and federal clean energy policies, with Federal authority to promulgate a cost allocation methodology where regions fail to act.

SUPPORT FOR AN EQUITABLE AND FAIR TRANSITION

The 90 Percent Clean case in the *2035 Report* results in a net increase of 8.5 million job-years by 2035, or approximately 530,000 total jobs annually, as employment from expanding renewable energy and battery storage more than replaces jobs previously supported by the extraction, transport, and burning of coal and gas. Americans as a whole will have more jobs, but jobs lost in coal will be particularly acute, approaching zero in 2035 and geographically concentrated around plants and mines. Coal-fired electric power generation employed a total of 86,000 U.S. workers in 2018, alongside 75,000 workers in coal fuels.[42] Policy must ensure these communities are not left behind, but rather strengthened by a federal clean energy standard.

Coal's decline is already impacting communities and the need for supporting these communities is abundantly clear. Three kinds of policies can help overcome these negative community impacts: transition assistance to assure basic services and community income do not collapse, reinvestment in clean energy and environmental restoration in these communities, and job retraining to provide new economic opportunity for anyone who wants to join the clean energy transition workforce.

Communities currently involved in fossil fuel extraction often rely heavily on current tax revenue to sustain municipal services; pensions also provide economic security to workers who have in many cases endangered themselves to earn a decent living and provide energy powering America's prosperity. With the coal industry's collapse, federal programs must shore up both, ensuring these communities and workers can transition to a sustainable economic future.

The first step is providing stopgap funding to supplement the tax base provided by retired coal infrastructure. Colorado provides one model for this – new legislation created a "Just Transition Office," empowering it to submit a plan to the legislature to establish benefits including supplementing tax revenue and healthcare benefits to coal transition communities.[43] The next step is to shore up federal programs that sustain pensions owed to coal workers: The Black Lung Disability Trust Fund is currently $6 billion in debt,[44] while the Pension Benefits Corporation faced a $53.9 billion deficit in 2018 and is on a path to insolvency by 2025.[45]

Policy can also create new employment opportunities in these communities and ensure the new jobs are family-supporting careers. The first is environmental remediation, as coal plant retirements leave ash ponds and mine reclamation as major public works to restore the land and ensure community health. This fund could build on and expand the 2019 RECLAIM Act, which

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[42] "2019 U.S. Energy & Employment Report." *Energy Futures Initiative* and *National Association of State Energy Officials* URL: https://static1.squarespace.com/static/5a98cf80ec4eb7c5cd928c61/t/5c7f3708fa0d6036d7120d8f/1551849054549/USEER+2019+US+Energy+Employment+Report.pdf.

[43] "Just Transition from Coal-Based Electrical Energy Economy." Colorado HB19-1314. *2019 Regular Session* URL: https://leg.colorado.gov/bills/hb19-1314.

[44] "Black Lung Benefits Program: Options for Improving Trust Fund Finances." *Government Accountability Office* May 2018. URL: https://www.gao.gov/assets/700/692103.pdf.

[45] Manganaro, John. "PBGC Fiscal Year 2018 Report Highlights." *Plan Sponsor* November 16, 2018. URL: https://www.plansponsor.com/pbgc-fiscal-year-2018-report-highlights/.

had more than a dozen Republican co-sponsors, and proposed appropriating $1 billion for the Abandoned Mine Reclamation Fund to revitalize communities hardest hit by the downturn of the coal industry. The Center for American Progress estimates that a $2 billion investment in orphan oil and gas well clean-up has the potential to create 14,000 to 24,000 jobs in energy producing states.[46] Providing universal broadband access is another force multiplier for economic opportunity in rural coal communities.

Thankfully, more than two thirds of coal power used in America has high-quality renewable resources and suitable land within 35 miles, such that wind or solar can replace these plants at immediate savings to customers;[47] that share grows to 86 percent by 2025. New wind and solar built near these old plants could put people in the same community to work, and would also take advantage of transmission freed up by retiring coal, obviating the need for new and costly lines. However, while clean energy workers earn higher and more equitable wages when compared to all workers nationally,[48] coal plant operators tend to earn substantially more on average than clean energy production workers.[49]

Congress should increase tax incentives (or more liquid cash grants) for wind and solar developers if projects are sited near coal communities. To support job quality, access to the incentives can be conditioned on offering training programs for workers from these communities to work on construction and maintenance of new facilities, as well as meeting certain labor standards such as ensuring high-quality benefits, living wages, rights to organize, and apprenticeship opportunities.[50] Coal workers are not going to be enough to fill the national need for a renewable workforce however, federal funds must address the need for job training to support the rapid growth of these industries under a 90 percent clean energy standard.

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[46] Kelly, Kate and Rowland-Shea, Jenny. "How Congress Can Help Energy States Weather the Oil Bust During the Coronavirus Pandemic." *Center for American Progress* April 29, 2020. URL: https://www.americanprogress.org/issues/green/reports/2020/04/29/484158/congress-can-help-energy-states-weather-oil-bust-coronavirus-pandemic/

[47] "The Coal Cost Crossover: Economic Viability of Existing Coal Compared to New Local Wind and Solar Resources." *Energy Innovation* March 2019.

[48] Muro, Mark and Tomer, Adie et al. "Advancing Inclusion Through Clean Energy Jobs." *Brookings Metropolitan Policy Program* April 2019. https://www.brookings.edu/wp-content/uploads/2019/04/2019.04_metro_Clean-Energy-Jobs_Report_Muro-Tomer-Shivaran-Kane.pdf.

[49] Coal power plant workers earn $36/26/hour on average, while clean energy production workers earn $28.41. See "2019 U.S. Energy & Employment Report." *Energy Futures Initiative* and *National Association of State Energy Officials* URL: https://static1.squarespace.com/static/5a98cf80ec4eb7c5cd928c61/t/5c7f3708fa0d6036d7120d8f/1551849054549/USEER+2019+US+Energy+Employment+Report.pdf; For clean wage see "Advancing Inclusion Through Clean Energy Jobs." *Brookings Metropolitan Policy Program* April 2019.

[50] "Good Jobs for 21st Century Energy Act." S.2185. *116th Congress* URL: https://www.merkley.senate.gov/news/press-releases/merkley-trumka-senate-democrats-announce-major-new-legislation-to-create-good-paying-jobs-in-the-transition-to-clean-energy-2019.

Who Can Get It Done

Decision-maker	Policy
U.S. Congress; State Legislatures	Provide stopgap funding to supplement the tax base provided by retired coal infrastructure. Consider setting up a national Just Transition Office with state satellite offices.
U.S. Congress	Shore up federal programs that sustain pensions for coal workers: including the Black Lung Disability Trust Fund and Pension Benefits Corporation.
U.S. Congress	Build on and expand the 2019 RECLAIM Act, which proposed appropriating $1 billion for the Abandoned Mine Reclamation Fund to revitalize communities hardest hit by the downturn of the coal industry.
U.S. Congress	Increase tax incentives (or more liquid cash grants) for wind and solar developers if sited near coal communities. Condition incentives on training and employing workers from these communities to work on construction and maintenance of new facilities, as well as increased labor standards.
U.S. Congress; Dept. of Labor	Address the need for job training to support the rapid growth of these industries under a 90 percent clean energy standard.

ADDRESSING MARKET FAILURES IN WHOLESALE MARKETS

In the *2035 Report*, variable renewables dominate new additions to the power supply with complementary gas, storage, and hydro resources providing needed flexibility. But even though the resulting resource mix is lower cost than today's system, current market structures are not likely to support the required investment to deliver this resource mix – existing market structures are more likely to stand in the way by skewing investment toward uneconomic fossil resources.

When they were first created, competitive markets for electricity, or RTOs/ISOs, were designed around the technical elements of the grid at the time. Grid operators dispatched large central station power plants to follow inflexible load, with power flowing in one direction from these central generators out to customers. RTOs/ISOs managed the scheduling and dispatch of these power plants, ensuring they had enough to meet relatively predictable demand. While this system and its concomitant rules, procedures, and definitions seemed reasonable when it was designed 20 years ago, it is increasingly strained as the grid modernizes and zero-carbon electricity makes up a greater share of the total. These markets need an upgrade to ensure they are finding the least-cost, reliable solution for customers as new technologies become available and the resource mix changes.

The system no longer generates the majority of its energy from large baseload power plants, and is transitioning to a highly flexible system made up of many smaller, more modular resources. New carbon- and fuel-free resources are available that have different characteristics. Low-cost battery storage is a flexible source of grid services and creates new opportunities to shift supply and demand. New demand-side technologies enable grid operators to send price signals that, for the first time, can allow supply and demand to be truly co-optimized. It is an exciting time of new options for grid managers, but the market structure has not adequately adjusted to these changes.

The keys will be truly allowing all technologies that can provide reliable service to compete on equal footing and exposing the value of grid flexibility.

In particular, the *2035 Report* shows the importance of flexible resources to complement a least-cost, renewables dominant system. While 450 GW of natural gas (down from 537 GW in 2018[51]) operational in the scenario with 90 percent zero-carbon electricity, that gas operates at around a 10 percent capacity factor, providing flexibility and energy when wind and solar are in occasional short supply. But other resources not modeled (e.g. demand-side resources), or not commercialized today (e.g. long-duration storage), could provide similar services. New markets will have to pay for these services – the modeling suggests that keeping natural gas plants around but idle most of the time is a conservative solution against which other new technologies should compete to provide these flexibility and energy services in a technology-neutral market structure.

PRINCIPLES

The set of ten principles below are intended to ensure technology neutrality and achievement of power system goals at least cost in the RTO/ISO construct.[52] Wholesale electricity markets should:

- Accommodate rapid decarbonization, including the elimination of barriers to participation of zero carbon resources.
- Support grid reliability, up to the amount that customers would knowingly be willing to pay.
- Facilitate demand-side participation and grid flexibility.
- Keep costs affordable for customers by promoting short-run economic efficiency through optimized dispatch of the lowest-cost resource mix, and the use of both existing and emerging technologies that can manage reliability and congestion.
- Keep costs affordable for customers by promoting long-run economic efficiency—including efficient, competitive entry to *and* exit from the market—under conditions of significant uncertainty.

[51] "Table 4.3 Existing Capacity by Energy Source, 2018." Electric Power Annual. *Energy Information Administration* October 18, 2019. URL: https://www.eia.gov/electricity/annual/html/epa_04_03.html.

[52] Aggarwal, Sonia and Corneli, Steven et al. "Wholesale Electricity Market Design for Rapid Decarbonization." *Energy Innovation: Policy and Technology, LLC.* June 2019. URL: https://energyinnovation.org/wp-content/uploads/2019/07/Wholesale-Electricity-Market-Design-For-Rapid-Decarbonization.pdf.

- Minimize the exercise of market power and manipulation.
- Minimize the potential for distortions and interventions that would prevent or limit markets' ability to achieve efficient outcomes, consistent with the public interest (including overarching public interest in a sustainable environment and economy).
- Enable adequate financing of resources needed to deliver cost-effective reliability, based on an efficient allocation of risk (i.e., those that can best mitigate risk should bear it). Customers should not be on the hook for poor investment decisions made by private investors.
- Be capable of integrating new technology as electricity needs evolve, and adapting as technology changes.
- Have designs that are readily and realistically implementable.

REQUIRED MARKET REFORMS

Public participation in wholesale market governance

The RTOs/ISOs that run the U.S. regional wholesale electricity markets are, in large part, captured by the incumbent transmission owners and generators they regulate.[53] RTO/ISO governance structures are not prescribed by FERC, so each regional wholesale market's governance structure is unique. But governance ultimately impacts how responsive these entities are to different perspectives, and RTO/ISO governance structures create an outsized role for regulated transmission and generation owners to influence market rule changes and RTO/ISO proposals.

By contrast, consumer, state, clean technology, and environmental stakeholders in many wholesale markets have limited opportunity to participate in market rule changes and proposals and vastly fewer resources to support their participation. As a result, RTO/ISO proposals tend to favor incumbents, stifle innovation, and lack upfront input from state, consumer, and environmental interests that have to then battle bad proposals in FERC-regulated dockets.[54] Court decisions have prevented FERC from fixing flawed governance.

Congress could introduce legislation clarifying FERC's authority to direct or modify RTO/ISO governance, and providing a framework for evaluating stakeholder and state regulator access to decision-making.

Expose the Value of Flexibility

The transformation of the resource mix both benefits from an increasing amount of flexibility and provides the means of providing such flexibility. For example, as solar makes up a higher share of electricity generation in the California Independent System Operator region, grid operators need more ramping capability to allow full use of the solar electricity and other clean energy resources. Flexibility comes in many forms, but is not something market operators have

[53] Simeone, Christina. "PJM Governance: Can Reforms Improve Outcomes?" *Kleinman Center for Energy Policy* May 19, 2017. URL: https://kleinmanenergy.upenn.edu/sites/default/files/proceedingsreports/PJM%20Governance%20Reforms.pdf

[54] Simeone, Christina. "PJM Governance: Can Reforms Improve Outcomes?" *Kleinman Center for Energy Policy* May 19, 2017.

traditionally considered when designing products or procuring new resources. In fact, several RTOs/ISOs rely heavily on markets for capacity, which is typically defined as megawatts of power available year-round. As the grid evolves and more wind and solar come online, capacity becomes too blunt an instrument. A focus on flexibility is more prescient.

The best way to create value for flexibility is to enhance price signals in the energy markets themselves, to ensure they are rewarding flexible resources. Examples include reducing or eliminating dependence on capacity markets; raising or removing the price caps, which would incent resources to be available and have the flexibility to produce during times of system need; adopting reserve shortage adders like operating reserve demand curves, which better reflect the value of resources to the system as it approaches a shortage; and creating specific market products that pay for and obtain the type of flexibility needed by grid operators. RTOs/ISOs should test and demonstrate how demand-side and clean energy resources can participate as aggregated resources, and provide these services reliably through pilots (see also "all-source procurement" recommendations, below).

Require All Generators and Imports to Participate in Economic Dispatch

In wholesale electricity markets, some amount of self-scheduling occurs where power plant operators, for a range of reasons, choose to run their plants regardless of the real-time market price of electricity. Valid reasons sometimes exist for choosing to self-schedule. For example, a hydro plant may not be able to reduce its output if doing so means that it will overflow or violate environmental constraints.

Though valid instances do exist, in practice self-scheduling is often the product of contract terms benefitting the utility while shifting risk to customers, rather than the presence of technical limitations on a resource.[55] When self-scheduling makes up a significant share of the total amount of electricity available to market operators, it can introduce challenges to operating the grid flexibly. The challenge is in the fact that if power plants are price-takers (i.e. they will dispatch at any price) then they are not responsive to changes in the market prices that reflect the constraints of the electric grid at any given time and would otherwise elicit flexibility. Self-scheduling decisions can also squeeze out renewables from providing zero-marginal-cost power and thereby increase customer costs.

All FERC-jurisdictional utilities and generators, including imports and renewables, should be required to participate in economic dispatch. Enforcing this in organized wholesale markets requires only a rule change from FERC or the RTOs/ISOs, but in vertically integrated markets, the shift would be more significant. Even in vertically integrated markets, wholesale power is available from other utilities; utility efforts to dispatch their own generation prejudices independent power producers and excess power from neighboring utilities, resulting in higher customer costs. FERC should explore the relationship between vertical utilities' self-dispatch and the ability for wholesale entities to access new markets with cheaper power, and consider

[55] Daniel, Joseph. "The Billion-Dollar Coal Bailout Nobody is Talking About: Self-Committing in Power Markets." *Union of Concerned Scientists* June 3, 2019. URL: https://blog.ucsusa.org/joseph-daniel/billion-dollar-coal-bailout-nobody-is-talking-about.

limiting uneconomic dispatch within vertically integrated non-RTO/ISO utilities to achieve just and reasonable wholesale rates.

Minimize Restrictions on Resource Participation

As new technologies emerge and request to participate in the market, RTOs/ISOs have often reacted by imposing restrictions on the types of connections and services those technologies can offer. The emphasis should be on approaches that allow any resource, including aggregations or subsystems of smaller demand-side resources, to participate in providing any services that they are technically capable of providing in a performance-based, technology-agnostic way.

For example, wind and solar can also provide flexibility to the grid, but are often restricted from doing so effectively. Under a more open participation model, wind, solar, storage, and demand-side resources could offer many flexibility services currently provided by fossil plants. One analysis found that allowing solar to pre-curtail and provide ramping services in the California market counterintuitively resulted in less involuntary curtailment, less gas burn, and greater flexibility.[56] Inconsistent responses to FERC Order 841, which requires each RTO/ISO to define participation models for energy storage, and FERC's responsive review of proposals prejudicial to storage, exemplify this issue and an appropriate regulatory response.[57]

Varied approaches to aggregating demand-side resources, and limits on their participation also prejudices markets toward conventional solutions. RTOs/ISOs should be required to facilitate means by which demand-side resources can fully participate through aggregation. This includes allowing aggregators or distribution utilities to participate directly in RTO/ISO markets rather than requiring these resources be controlled directly by RTOs/ISOs. Addressing restrictions on resource participation can tap into a significant amount of flexibility that is available today but going unused.

Pay for Uncompensated Reliability Services

An evolving resource mix on the grid will increase the value of certain grid services while decreasing the value of others. For example, turbine-based generators (including steam and gas turbines) provide inertia and frequency response (through governor response) and this is a useful response after a major transmission or power plant outage. Because turbine-based generators have been ubiquitous in the past, RTOs/ISOs did not see a need to specifically procure frequency response (other than through standards) or indeed to even pay for this service, and grid operating practices have adjusted to the relatively slow frequency response provide by such resources. However, the growth in inverter-based resources (such as wind, solar,

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[56] "Investigating the Economic Value of Flexible Solar Power Plant Operations." *Energy and Environmental Economics, Inc*. October 2018. URL: https://www.ethree.com/wp-content/uploads/2018/10/Investigating-the-Economic-Value-of-Flexible-Solar-Power-Plant-Operation.pdf; Nelson, James H. and Wisland, Laura. "Electricity in California: The Role of Non-Flexibility in a Cleaner Electricity Grid." *Union of Concerned Scientists* August 2015. https://www.ucsusa.org/sites/default/files/attach/2015/08/Achieving-50-Percent-Renewable-Electricity-In-California.pdf.

[57] Gramlich, Rob and Goggin, Michael. "Too Much of a Wrong Thing: The Need for Capacity Market Replacement or Reform." *Grid Strategies, LLC.* November 2019. http://eelp.law.harvard.edu/wp-content/uploads/Ari-and-Jason-Burwen-Transcript-Final.pdf.

batteries and many newer loads) means that less of this traditional frequency response may be available to system operators over time.

However, using the power electronics and software of their modern inverters, wind, solar, and battery resources can provide almost any desired grid behaviors, including frequency response and other grid-support services, and can do so with great speed and accuracy.[58] However, an opportunity cost may exist for these resources to provide these services, and the ideal grid service may be different from the service that conventional generators were capable of providing, so a new product should be defined and market mechanisms should be created to encourage provision of the services from whichever resources can do so with the lowest cost and the greatest benefit to the grid.

As new resources enter the electricity mix and create value for new and different services, RTOs/ISOs should create new products that expose the value of these services and encourage their provision at least cost.

Who Can Get It Done

Decision-maker	Policy
U.S. Congress	**Introduce legislation clarifying FERC's authority to direct or modify the governance of RTOs/ISOs**, and providing a framework for evaluating stakeholder and state regulator access to decision-making.
FERC,RTOs/ISOs	**Enhance price signals in the energy markets themselves**. Reduce or eliminate dependence on capacity markets; raise or remove the cap on scarcity prices; and adopt reserve shortage adders like operating reserve demand curves, which better reflect the value of resources to the system as it approaches a shortage.
FERC, RTOs/ISOs	Keeping in mind a preference for enhancing energy price signals and reducing dependence on capacity-like mechanisms, **expose the value of flexibility through specific products that pay for and obtain the type of flexibility that has system value**.
FERC, RTOs/ISOs	**Require all generators participating in wholesale markets, including imports and renewables, to participate in economic dispatch**. Consider expanding this requirement to non-RTO/ISO, FERC-jurisdictional utilities and generators.
FERC, RTOs/ISOs	**Address restrictions on resource participation** in energy, ancillary services, and capacity markets, particularly wind, solar, storage, efficiency, and demand response. Continue and build on the work of Order 841.

[58] Loutan, Clyde and Klauer, Peter et al. "Demonstration of Essential Reliability Services by a 300-MW Solar Photovoltaic Power Plant." *National Renewable Energy Laboratory* April 2017. URL: https://www.nrel.gov/docs/fy17osti/67799.pdf

DOE/National Labs	Work with FERC and RTOs/ISOs to **develop useful technology pilots, model language to increase resource participation, and model rules to pay for flexibility.**
FERC, RTOs/ISOs	As new resources enter the electricity mix and create value for new and different ancillary services, **RTOs/ISOs should create new products** that expose the value of these services and allow encourage their provision at least cost.

REMAKING UTILITY REGULATION FOR THE MODERN GRID

In the U.S., federal and state jurisdiction over electricity industry is split – the federal government regulates wholesale electricity sales under the authority granted to Congress from the Interstate Commerce Clause of the Constitution, while the rest (typically characterized as retail sales) is left to the states. Due to natural electricity grid monopoly characteristics, monopoly distribution utilities of some kind will always serve as an interface between customers and the bulk grid system. State utility commissions govern monopoly distribution utilities, and play a primary role in ensuring these entities meaningfully contribute to a low-cost, reliable electricity future.

PERFORMANCE-BASED REGULATION AND NEW UTILITY BUSINESS MODELS

If current trends hold, significant portions of power demand will be met with resources that operate on the distribution system, either owned and operated by local utilities or customers themselves. These "distributed energy resources" comprise battery storage, distributed solar PV, energy efficiency, demand response, and electric vehicles, which can all contribute both energy and much-needed flexibility to the system. Each has the opportunity to provide system flexibility and help with zero-carbon energy, but the distribution utility serves as a gatekeeper by determining price signals to electricity customers and managing the operation of the distribution grid. Regulators need new approaches to ensure distribution utilities are properly incented to optimize the system around the value these resources provide.

Performance-based regulation (PBR) is a model for aligning utility incentives with societal goals like affordability, reliability and resilience, and better environmental outcomes.[59] PBR reforms the current method of paying for utility service. Under the current regime, utilities increase earnings by building more stuff, on which they recover costs plus a regulated return for

[59] Littell, David and Kadoch, Camille et al. "Next-Generation Performance-Based Regulation: Emphasizing Utility Performance to Unleash Power Sector Innovation. *Regulatory Assistance Project* September 2017. URL: https://www.raponline.org/knowledge-center/next-generation-performance-based-regulation-emphasizing-utility-performance-unleash-power-sector-innovation/; Gold, Rachel and Myers, Amanda, et al. "Performance Incentive Mechanisms for Strategic Demand Reduction." *American Council for an Energy Efficiency Economy* and *Energy Innovation: Policy and Technology, LLC*. February 2020. URL: https://energyinnovation.org/wp-content/uploads/2020/02/Performance-Incentive-Mechanisms-for-Strategic-Demand-Reduction.pdf; Aggarwal, Sonia and O'Boyle, Mike. "Getting the Most out of Grid Modernization." *Energy Innovation: Policy and Technology, LLC*. URL: https://energyinnovation.org/wp-content/uploads/2017/02/GridModernizationMetricsOutcomes_Feb2017.pdf.

shareholders. PBR breaks this link, instead it explicitly ties utility profits to the outcomes indicative of a clean, resilient, affordable power system. Innovative PBR mechanisms include performance incentive mechanisms for demand-side optimization and decarbonization, multi-year rate plans to incent affordable service, and earnings sharing mechanisms to incent customer-side ("non-wires") solutions in lieu of traditional infrastructure.[60]

State regulators should explore and expand performance-based regulation as a complementary policy to encourage early compliance with clean energy goals, incent cost-effective demand-side management, and control utility costs through the transition. For example, Hawaii's Public Utility Commission (HIPUC) has recognized that current utility regulation is incompatible with the state's 100 percent clean energy standard.[61] The HIPUC has undertaken thorough stakeholder engagement, and identified a range of performance-based regulation approaches as key pillars of reform needed to achieve an affordable clean energy future.

COMPETITIVE ALL-SOURCE PROCUREMENT

Regulated monopoly utilities will be the largest (and in many cases, only) "buyers" of wholesale power. They participate in wholesale electricity markets on behalf of customers, both purchasing from competitive markets and hedging against these markets with long-term bilateral contracts for certain resources. Many others are vertically integrated, owning and operating power plants and the poles and wires that ultimately reach customers.

Monopoly utilities have embedded incentives to insulate themselves from competition or the need to innovate, which often results in them choosing to build and maintain overly risk-averse portfolios of resources and passing the related unnecessary costs

Electrification and Flexible Demand

With rapid U.S. electricity grid decarbonization, transitioning transportation and buildings from oil and gas to electricity can drastically reduce emissions in those sectors. Thankfully, electric cars, heat pumps and air conditioners, and water heaters can also provide significant grid flexibility to complement wind and solar variability, reducing energy transition costs. On the other hand, rapid transportation and building electrification would increase electricity demand, and thus the need for clean energy deployment. The 90 Percent Clean case in the *2035 Report* accounts for very little of this potential flexibility or new load, but the broader modeling literature suggests significant positive impacts of flexible load on cost and reliability.[1]

Even without electric vehicles and buildings driving greater demand, flexible demand management today is already an underused source of grid flexibility. Brattle economists identified nearly 200 GW of cost-effective demand flexibility potential in the U.S. by 2030. This demand flexibility potential, which equates to 20 percent of estimated U.S. peak demand in 2030, would more than triple the existing demand response (DR) capability and would be worth more than $15 billion annually in avoided system costs.[1]

Well-timed charging of electric vehicles and building heating can reduce power system costs significantly by making the most of renewable generation, reducing peak demand to reduce the need for grid upgrades, and reducing the need for storage, gas peaker plants, and other sources of flexibility on the bulk system. Studies of Colorado[1] and Minnesota[1] by Vibrant Clean Energy indicate that deep decarbonization of the vehicle and building sectors is possible at a low cost if vehicles and building components provide grid flexibility, charging or preheating buildings or water heaters when renewables are readily available, and delaying when they are not.

[60] Cross-Call, Dan and Gold, Rachel et al. Navigating Utility Business Model Reform: A Practical Guide to Regulatory Design." *Rocky Mountain Institute* November 2018. URL: https://rmi.org/wp-content/uploads/2018/10/RMI_Navigating_Utility_Business_Model_Reform_2018-1.pdf.

[61] "Performance Based Regulation." *State of Hawaii Public Utilities Commission*. Accessed June 5, 2019. URL: https://puc.hawaii.gov/energy/pbr/.

through to customers. Moreover, those same utilities pass on significant environmental risks to customers through their pollution. Regulation must ensure utilities procure any new resources fairly, allowing all different kinds of technologies – including customer-owned resources and demand management – to compete to provide the least-cost clean energy solution to customers under a 90 percent clean energy standard.

All-source procurement has emerged as a model for obtaining needed energy at very low costs. As noted above, federal funds assisting states in compliance with a 90 percent clean energy standard should come with conditions, including requiring competitive all-source procurement. In particular, regulators and utilities should observe the following principles[62] in procurement:

- Regulators should use an open resource planning process to determine a technology-neutral total procurement need before opening procurement.
- Regulators should require utilities to conduct competitive, all-source bidding processes, including demand-side resources, with robust bid evaluation.
- Regulators should conduct advance review and approval of procurement assumptions and terms.
- Regulators should renew procedures to ensure that utility ownership is not at odds with competitive bidding.
- Regulators should revisit rules for fairness, objectivity and efficiency.

To effectively incorporate demand-side resources into procurement, DOE and the national labs should sponsor new pilots for "clean energy portfolio" development in partnership with distribution utilities. RMI has demonstrated that portfolios of distributed energy resources, storage, wind, and solar, can provide the energy and services of a conventional gas plant at lower cost.[63] Now we need real-world models of this portfolio-based approach, resulting in a scaling up of valuable distributed energy resources in procurement.

Who Can Get It Done

Decision-maker	Policy
Public Utility Commissions	**Explore and expand performance-based regulation** to encourage early compliance with clean energy goals, incent cost-effective demand-side management, and control utility costs through the transition. Use Hawaii's open and thorough stakeholder process as a model.
DOE/National Labs	**Sponsor new pilots for "clean energy portfolio" development** in partnership with distribution utilities.

[62] Wilson, John and O'Boyle Mike et al. "Making the Most of the Power Plant Market." *Energy Innovation: Policy and Technology, LLC.* April 2020. URL: https://energyinnovation.org/wp-content/uploads/2020/04/All-Source-Utility-Electricity-Generation-Procurement-Best-Practices.pdf.

[63] Dyson, Mark and Engel, Alex. "The Economics of Clean Energy Portfolios." *Rocky Mountain Institute* 2018. URL: https://rmi.org/insight/the-economics-of-clean-energy-portfolios/.

Public Utility Commissions	**Require utilities to undertake all-source procurements** when they identify the need for more generation resources, allowing all resources to compete to meet a technology-neutral need, using the principles above.
Congress	**Condition federal funds** assisting utilities with compliance with a 90 percent clean energy standard on competitive all-source procurement, using the principles above.

R&D TO SUPPORT THE PATHWAY TO 100 PERCENT CLEAN ELECTRICITY

Although the *2035 Report* shows we can maintain a dependable, affordable electricity grid while rapidly deploying wind and solar, it makes sense for the federal government to support research now to clarify the path to 100 percent. Increased funding for research, collaboration, and technology transfer efforts can speed along the development and acceptance of needed solutions, with particular focus on system needs like long-duration storage and system stability.

LONG-DURATION STORAGE

The *2035 Report* shows a 90 percent clean electricity system can meet customer demand for every hour of the year over the whole period. To do this, nearly 80 percent of existing gas capacity operates at a low capacity factor, provides energy during sustained but infrequent shortages of wind and solar power. To squeeze the remaining GHGs out of the electricity sector, we will likely need resources that provide dispatchable, long-duration energy, or a way of capturing and sequestering carbon. Some technologies are promising, including flow batteries, new battery chemistries, compressed air energy storage, modular nuclear, and electrolysis-derived hydrogen production, but none have reached commercialization for power provision yet. To prepare for the last 10 percent of decarbonization, Congress should leverage and amplify the incredible capacity of DOE and the national labs for research in developing and commercializing the most promising of these technologies.

NEW RESOURCE ADEQUACY FRAMEWORKS

Resource adequacy (RA) is a key way of assessing the reliability of a given set of resources.[64] The current RA framework focuses on having sufficient conventional generation (or using newer resources only as if they are conventional-like generators), plus a reserve margin, available when the system demand peaks. This is often defined as megawatts of electricity generation capacity available year-round. But the grid is changing, and reliability no longer solely depends on having enough power plants to meet infrequent peak demand. Instead, as renewables become a greater share of the total energy mix, day-to-day grid flexibility will be key to reliability. Many new kinds of resources will be available to help provide the flexibility the system needs – distributed energy resources, storage, and demand response are some of the most important.

[64] Gimon, Eric. "Why Climate Advocates Should be Interested in Resource Adequacy." *Energy Innovation: Policy and Technology, LLC.* April 2020. URL: https://energyinnovation.org/wp-content/uploads/2020/04/Why-Climate-Advocates-Should-Be-Interested-In-Resource-Adequacy.pdf.

System needs will change under a high share of renewable energy – researchers must develop new metrics that can give utilities, regulators, and system operators the confidence they need to invest in a low-cost low-carbon portfolio that moves beyond dispatching power plants to meet peak demand.

INADEQUACY OF DISPATCH AND PLANNING MODELS

Standard models for transmission system planning used by RTOs/ISOs fail to account for the capabilities of new technologies. They treat electricity demand trends as static, and do not properly model capabilities of new, clean resources like energy storage, demand response, solar, and wind. For example, solar-plus-storage together can meet summer peaks in many systems, yet the models do not allow for this option to be considered. Standard models determine which plants generate in real-time, relying on generic "participation models" based on conventional power plant characteristics. New forms of generation (e.g., renewable energy), storage, demand-side resources, and combinations thereof, are forced to fit into existing participation models, unfairly discriminating against these resources while promoting dispatch of fossil fuel generators.

DOE and FERC have roles to play to standardize models and articulate modeling capabilities RTOs/ISOs must possess to qualify as regional planning entities. Federal agencies can empower the national laboratories to improve these models and develop open-source tools that utilities, RTOs/ISOs, and state public utility commissions can use in their planning and operations.

VOLTAGE, FREQUENCY, AND STABILITY CONTROL TECHNOLOGIES

Wind and solar PV generation (and many modern loads) are electrically connected to the electricity system via power electronic converters. This stands in contrast to the synchronous generator that has dominated electrical generation technology from the beginning. Some fundamental issues and opportunities come along with this underlying change in the nature of the electricity system.

As previously noted, using the power electronics and software of modern inverters, wind, solar, and battery resources can provide almost any grid behaviors that are desired, and can do so with great speed and accuracy. In 100 percent clean electricity systems with little or no synchronous generation, some of the other grid resources, including renewable generation and storage, may need to provide additional stability and reliability services. Congress should fund already ongoing research into technologies, such as grid-forming inverters[65], to commercialize technologies needed to support a 100 percent clean energy grid by 2045.

Who Can Get It Done

Decision-maker	Policy
U.S. Congress	Allocate funds to DOE and national labs to **create new models for resource adequacy under high shares of renewables**,

[65] GFI have been tested successfully in microgrids, but not as part of the bulk system. See Ellis, Abraham. "Grid Forming Inverters in Interconnected Systems." *Sandia National Laboratories* 2018. URL: https://der-lab.net/wp-content/uploads/2018/11/Ellis_GFI-Vienna.pdf.

	improve electricity sector resource planning and wholesale market models, and study and commercialize grid-forming inverters and grid stability in high-renewables electricity systems.
National Association of Regulatory Utility Commissioners; PUCs	Support regulated utility research and development to support the transition to 100% clean. Consider pooling resources at the RTO/ISO level, regional level, or multistate utility level to share risk and increase impact.
Department of Energy (DOE)	Allocate funds to **improve electricity sector resource planning and wholesale market models**. Use national laboratory capabilities to improve these models and develop open-source tools that utilities, RTOs/ISOs, and state public utility commissions can use in their planning and operations.
Federal Energy Regulatory Commission (FERC)	Articulate **advanced modeling capabilities RTOs/ISO must possess** and use to qualify as regional planning entities.
DOE; National Labs	**Conduct research in conjunction with utilities and RTOs/ISOs into grid-forming inverters** and other technologies to support system stability and security.

CONCLUSION

America has an opportunity to harness cheap, clean electricity to transform our economy, boosting jobs and cutting pollution while lowering electricity bills for citizens. It would be a crime to waste it. We have the technology, the enterprising businesses to get it done, a solid manufacturing base to build, and we know the policy pathway. Bold action to adopt a clean energy standard can set the nation on the right course, and complementary policies can help support action at every level from federal to state and local communities.