TOOLS FOR ENERGY REGULATORS TO MANAGE POWER SECTOR INFLATION

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For decades, renewable energy developers fought to become the dominant source of new power sector generation, and it's worked—for the most part. Renewable energy technology costs have fallen fast over the past decade in the United States, to the point where new clean energy is cheaper than running existing coal plants nationwide. Those significant declines have recently leveled off, and in some cases costs have increased. But this temporary development doesn't mean we should abandon clean energy or decelerate fossil fuel plant retirements. Instead, policymakers and utilities have an opportunity to manage cost fluctuations and continue reducing electricity prices.

Energy Innovation researchers conducted interviews with industry experts and analyzed publicly accessible data to understand recent renewable price data trends. Data from Lawrence Berkeley National Laboratory and LevelTen indicate that changes in wind, solar, and battery prices in 2022 and 2023 have been relatively modest on average. Wind, solar, and hybrid projects continue to find ample market value at or around these prices nationwide. We find that recent price fluctuations result from a combination of short-term and enduring trends. Several factors are driving recent inflation in the power sector and specifically for renewable energy. These include supply chain disruptions, trade issues, and raw material prices. Rising interest rates and labor constraints have also complicated the landscape, affecting clean energy project financing and development. Moreover, interconnection costs, transmission constraints, and project delays have slowed industry growth.

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Ultimately, we find evidence that the forces driving cost increases are already abating and that the overarching trend of economies of scale for renewable energy and storage will continue to lower costs. Furthermore, fossil fuels are not a refuge from rising prices: The same near-term trends driving inflation in the wind and solar industries are largely present in other industries, including fossil fuel extraction and infrastructure construction. Policymakers can deploy several tools to reduce overall costs by ensuring clean energy resources encounter lower risk and lower the future costs of clean electricity resources, such as:

- Link market information to competitive procurement for effective integrated resource planning.
- Reexamine planning practices in light of new government-backed financing options under IRA, and tax credit bonuses for energy communities and low-income communities.
- Update and streamline interconnection processes to reduce costs and development bottlenecks.
- Improve transmission planning to build out capacity on regional and interregional levels to cost-effectively integrate renewable energy onto the grid.
- Encourage federal and state commitments to diversify the clean energy supply, including fostering a low-cost, mature U.S. offshore wind industry.
- Invest in the domestic supply chain through Inflation Reduction Act (IRA) funding, including developing domestic battery manufacturing for stationary storage and electric vehicles.

If policymakers prioritize these cost-reducing measures, we can return to falling clean energy costs and fully leverage federal support to lower electricity bills for all.

Table of Contents

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INTRODUCTION

For the last decade, the overall trend of clean energy technology costs has been consistent: Wind, solar, and storage prices have fallen rapidly. In 2022, Energy Innovation analysis found that the levelized cost of building new renewable energy projects was cheaper than continuing to operate 99 percent of the existing U.S. fleet of coal-fired power plants, signaling the inevitable decline of coal and rise of renewables. Recently, renewable energy prices have leveled off and have risen in some instances. While this does not mean utilities should slow the pace of coal retirements and clean energy acquisition, it does merit greater attention from policymakers and utilities that have several tools to keep prices in check and even drive them back down.

We interviewed industry experts and evaluated publicly available data, finding that recent price instability represents a confluence of temporary and sticky trends. Energy regulators have tools to address some of these cost pressures, but not all. For example, commodities prices in international markets and global trade policies that restrict the use of components manufactured in "countries of concern" are difficult to address without a change in federal legislation or diplomatic strategy. Some IRA provisions create new incentives for domestic manufacturing and materials production that offset these factors. High interest rates, which disproportionately affect clean energy projects because they are capital-intensive, are another unpredictable trend, yet low interest rates are accessible through government-backed lending via both the IRA and state programs. Grid access for renewable energy and competitive utility procurements are perhaps the most promising potential solutions that state utility regulators and regional grid operators can explore.

Ultimately, we find evidence that the forces driving cost increases are already abating and that the overarching trend of economies of scale for renewable energy and storage will continue to lower costs. Furthermore, fossil fuels are not a refuge from rising prices: The same near-term trends driving inflation in the wind and solar industries are largely present in other industries, including fossil fuel extraction and infrastructure construction. Policymakers can deploy several tools to reduce overall costs by ensuring clean energy resources encounter lower risk and lower the future costs of clean electricity resources.

WHAT'S HAPPENING WITH CLEAN ENERGY RESOURCES TODAY

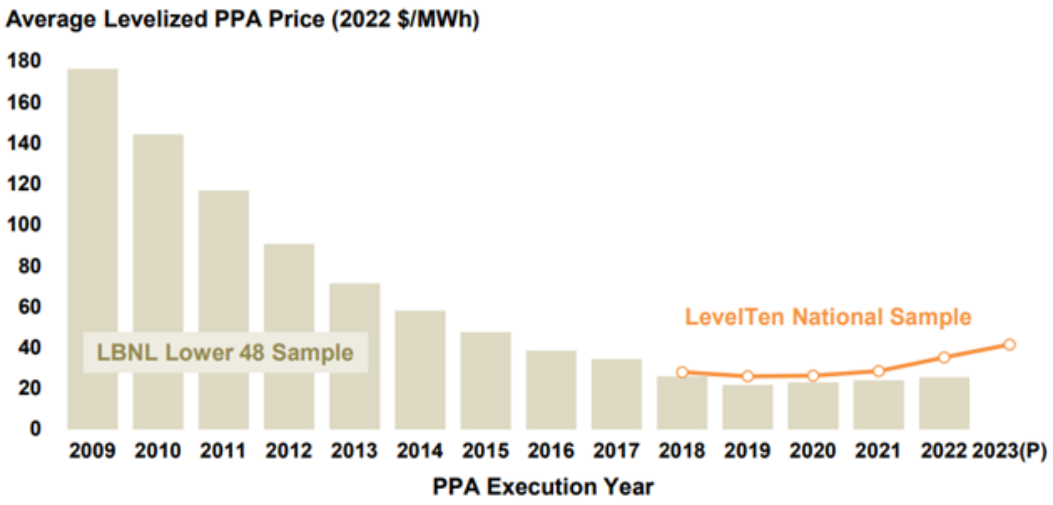
Getting accurate, up-to-date market information on renewable energy costs is difficult without access to paywalled data aggregators, but helpful free data sources still exist. Sources of publicly available cost data include the Lawrence Berkeley National Laboratory's (LBNL) utility-scale wind and solar cost series, which represent executed utility contracts for renewable energy, and LevelTen's aggregated data on corporate power purchase agreement (PPAs) offers (not necessarily

executed) for wind and solar resources. These two datasets represent different market segments with different characteristics and willingness to pay but are good proxies for market trends.

However, our industry interviews indicated that even these relatively up-to-date resources can be lagging indicators of today's costs—many contracts represent prices that were negotiated based on past market conditions. It is hard to know precisely what resources cost today without going out to market and soliciting bids. This dynamic raises the importance of open, competitive, and transparent procurement processes that frequently test market prices.

LBNL helpfully aggregates utility-scale PPA data and LevelTen PPA data in its *Utility Scale Solar 2023* report, showing that the trend of flattening and even mildly rising clean energy costs is consistent across the two datasets. LBNL points out that the IRA's 10-year extension of clean energy tax credits has helped keep PPA prices low, at an average of $25 per megawatt-hour (MWh) in 2022.

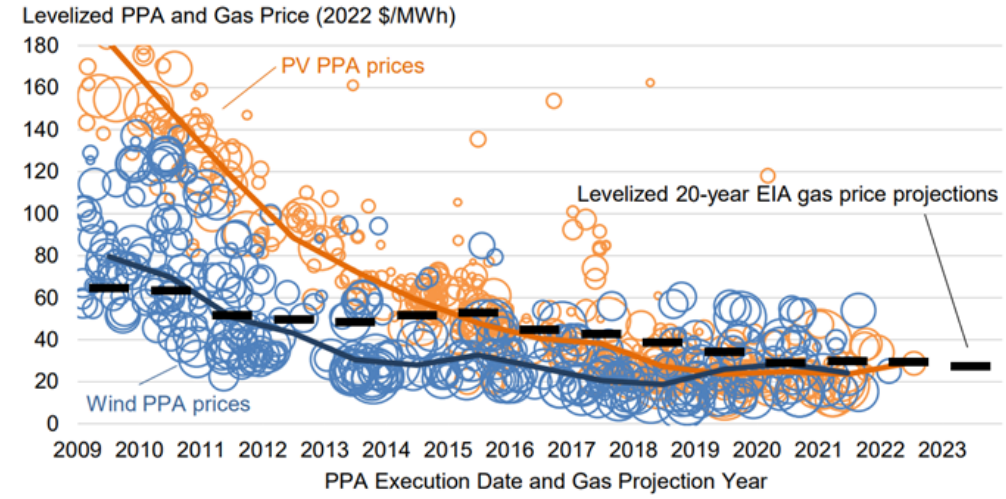
Figure 1. 2022 levelized PPA price of utility-scale solar



Source: Lawrence Berkeley National Laboratory[1]

Trends have been similar in the wind industry, where PPA prices have largely flattened out since 2020, around $32-38/MWh. While LBNL lacks 2023 data and has a relatively small sample size for 2021-2022, LevelTen data indicates that corporate PPA offers for wind increased in the first half of 2023, by approximately $10/MWh since 2021. Because utility-scale wind projects tend to be larger than corporate PPAs, it is reasonable to expect price increases for utility-scale projects to be less drastic. The next graphic, also from LBNL, shows that wind prices have also remained flat or risen slightly since 2019.

Figure 2. Levelized wind and solar PPA prices compared to gas



Note: Smallest bubble sizes reflect smallest-volume PPAs (<5 MW), whereas largest reflect largest-volume PPAs (400 MW)

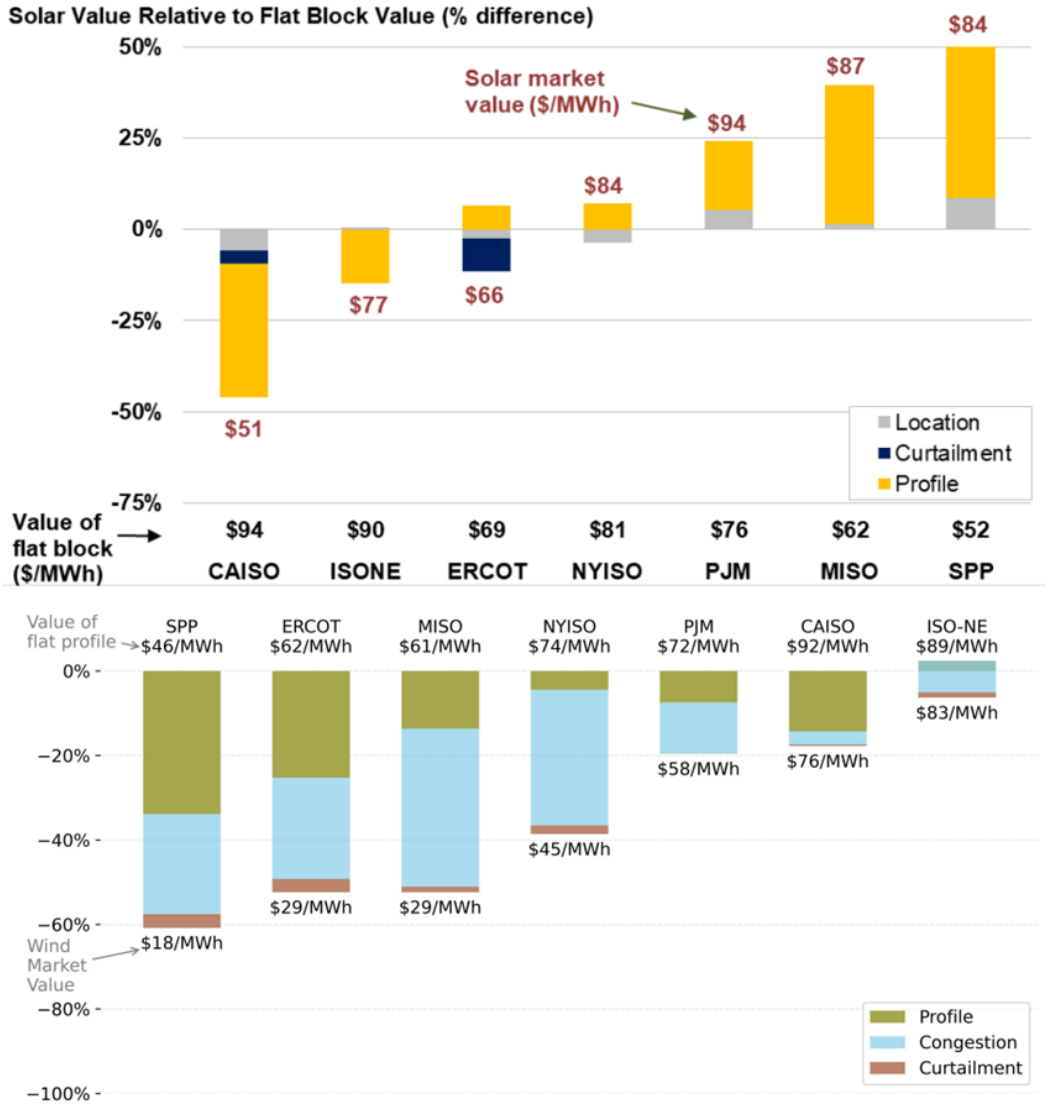
Sources: Berkeley Lab, FERC, EIA

Figure 52. Levelized wind and solar PPA prices and levelized gas price projections

Source: Lawrence Berkeley National Laboratory[2]

LBNL's data explores the relative value of these resources in a year when electricity prices rose dramatically due to inflationary pressure, including the global gas crisis caused by Russia's invasion of Ukraine. In 2022 the value of these resources increased, and in nearly all markets, an overwhelming business case remains for adding more wind and solar despite modest cost increases. Solar's market value ranged from $51 to $84/MWh in 2022, and wind's ranged from $18 to $83/MWh. These can be compared to average PPAs in the $20-40/MWh range in 2022. In low-value markets like the Southwest Power Pool and Electric Reliability Council of Texas, much of the value could be increased by new investments in regional transmission that address large congestion costs.[3]

Figure 3. Impact of transmission congestion, output profile, and curtailment on 2022 wind prices



Sources: Berkeley Lab, Hitachi, ISOs

Note: In ISO-NE, the temporal profile of wind provides a slight premium value over a flat output profile (+2%). The color shows as teal because the negative congestion penalty (-7%) is layered on top of the positive profile premium.

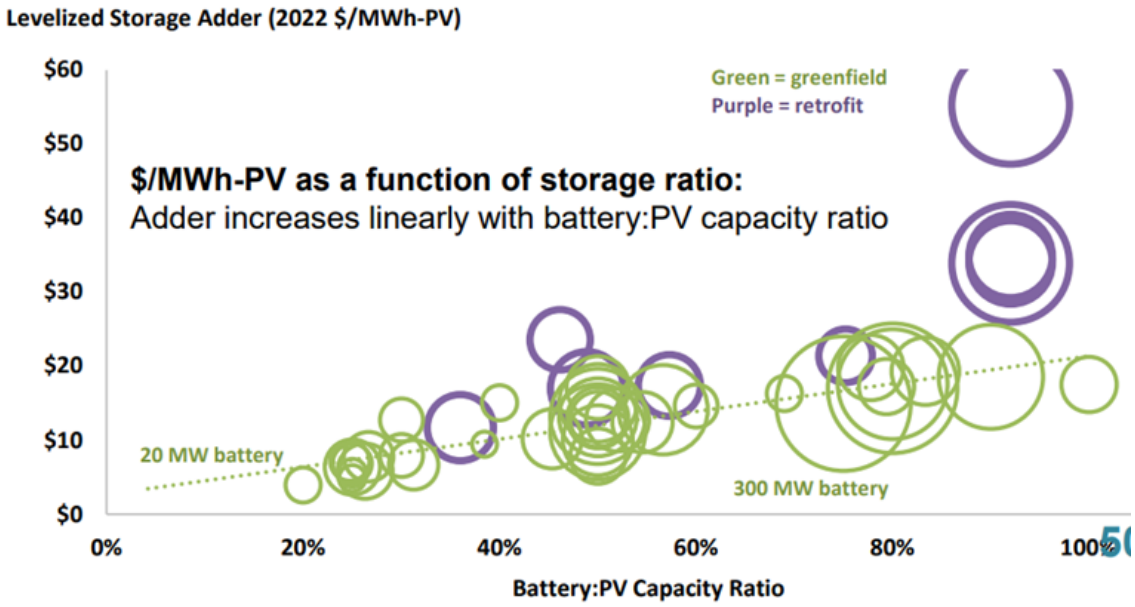
Figure 58. Impact of transmission congestion, output profile, and curtailment on wind energy market value in 2022

Source: Lawrence Berkeley National Laboratory[4]

Of course, utility procurement of clean energy has increasingly focused not just on solar and wind energy, but also on battery storage that can bolster the reliability and economic value of these resources. U.S. grid reliability has become a keen concern as coal retirements accelerate and grid operators grapple with changing climate, new policies, and evolving resource portfolios.[5] In late 2022, Bloomberg New Energy Finance observed that battery pack prices slightly increased from $141/kWh to $151/kWh, a first-time year-over-year price increase since Bloomberg began reporting data.[6]

Solar-storage hybrids are now the norm in new projects, representing 48 percent of proposed projects.[7] Hybridizing a storage project with diurnal battery storage adds a premium of $10-$20/MWh, depending on the size of the battery relative to the storage,[8] bolstering reliability and market value and leveraging the benefits of sharing equipment, interconnection, and physical sites.

Figure 4. Levelized cost of adding storage to solar projects



Source: Lawrence Berkeley National Laboratory[9]

Altogether, increases in wind, solar, and battery prices in 2022 and 2023 have been relatively modest. Wind, solar, and hybrid projects find ample market value at these prices nationwide. The next section will break down what trends are likely driving the recent increases.

FACTORS DRIVING COST INCREASES IN RENEWABLE ENERGY RESOURCES

Renewable energy market dynamics are less transparent than ever before. Constraints on supply chains, labor, and transmission capacity, coupled with changing interest rates and inflation, create cost uncertainty for developers even as the market grows. Most of the costs associated with renewable energy resources are capital expenditures—acquiring materials, up-front labor costs, and permitting and interconnection processes—which are more heavily impacted by inflation and other market dynamics than operating expenditures, which can be spread over the lifetime of the resource.

The industry is also in a bulge period—many of the resources that were procured in late 2019 and early 2020 are finally entering the construction stage. These resources were not subject to the price increases that have occurred in the past few years. But medium-term projects still in the development stage are likely to be heavily impacted by the issues explored below.

Supply chain disruptions, trade issues, and inflation take their toll on critical components

Renewable energy resources are being constrained by uncertainty and volatility around acquiring raw materials. The solar and storage industries are grappling with supply chain disruptions and trade issues that are significantly impacting development. Of primary concern, the Anti-Dumping and Countervailing Duties and Uyghur Forced Labor Prevention Act, including the uncertain guidance surrounding these measures, have created supply shortages for solar and battery components as foreign manufacturers struggle to get their products offshore and into the U.S. Though some developers are now looking to U.S. manufacturers for materials in response to these shortages, domestic capacity for these resources is not robust enough to meet demand, and domestic supply comes at a cost premium. IRA policies will likely grow the U.S.'s domestic manufacturing industry, but it will be several years before that supply chain can meet increasing demand.

Meanwhile, other critical components are also heavily impacted by supply chain disruptions and inflation. For example, semiconductors, which play a fundamental role in the operation of photovoltaics, have seen a significant supply crunch and price increases over the past year.[10] Inverter chip and transformer lead times are soaring, and both technologies will be hard to ramp up from nearly non-existent current domestic production. Commodities like copper and steel have suffered significant inflation—costs are about two- to three-times as high as before the pandemic, though those prices are expected to flatten out over the next several years. Photovoltaic module costs have risen 30-35 percent because of supply chain challenges and rising silicon prices.[11] The storage industry had been facing a spike in lithium and other raw material prices during the

pandemic, but costs have since come down to more favorable levels. Meanwhile, the wind industry is waiting for balsa wood, steel, and copper prices to ease.

Rising interest rates and labor constraints add complications and extra costs

Higher interest rates are impacting renewable energy development. As interest rates rise, the borrowing costs associated with financing renewable energy projects increase. Furthermore, the uptick in interest rates also affects the tax equity market, where investors provide capital in exchange for tax credits and other incentives. With tax equity rates up by a few percentage points, capital expenditures and total project costs have increased.

Like the rest of the economy, clean energy industries are contending with rising labor costs. Prevailing wage requirements have been added as a condition to receive full IRA tax incentives.[12] But labor-related costs and challenges have less to do with paying prevailing wages, and more to do with the logistics of documentation for compliance and bottlenecks for hiring qualified workers. Experts note the solar industry is already labor constrained and needs more robust workforce development programs. For offshore wind projects, these issues are compounded because companies need to utilize and service specialized construction vessels, which have significantly increased in price.

Interconnection costs and project delays slow industry growth

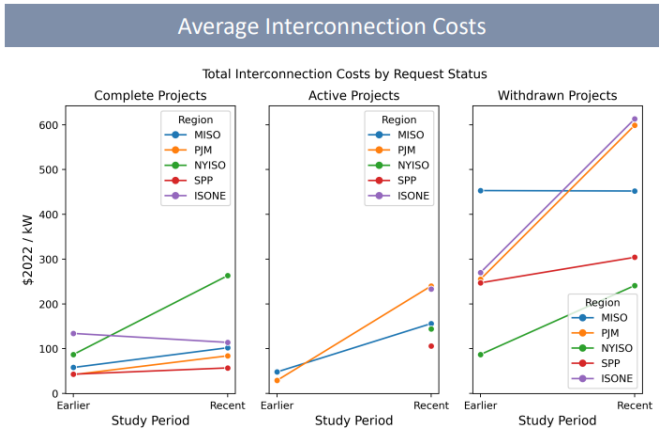
Renewable energy project developers now face considerably more risk due to rising interconnection costs and timelines. It now takes four to five years on average to move through the interconnection study process to completion—a doubling over the last decade.[13] The process of connecting renewable energy projects to the existing electrical grid has become more challenging as transmission capacity is constrained, necessitating costly grid upgrades to alleviate long queues of projects. When average interconnection times increase, developers face increased cost of capital and overall risk to projects.

Resulting delays are represented by the more than 2,000 gigawatts of generation tied up in interconnection queues across the country. Most of this capacity is wind, solar, battery storage, and renewable-battery hybrids, with a small amount of natural gas. Though grid operators are required to perform interconnection studies to work through these applications, the processes have been slow in part due to staffing capacity issues and the large amounts of smaller, more distributed, and often redundant resources applying for interconnection. As a result, independent system operators now are being asked to process many more applications than in the past, sometimes exceeding their capacity.

The cost allocation process for generator interconnection also cries out for reform. With many transmission systems already at capacity, new projects often trigger a need for new connector lines as well as upgrades to the backbone transmission system. By default, single generators are asked to pay these costs, which can represent more than 50 percent of project costs, despite the upgrades benefiting others in the queue. As the figure below shows, interconnection costs have increased in all markets over the last decade, with particularly high costs for projects that ultimately withdraw from consideration.

Figure 5. Interconnection cost increases across the U.S. over time

Interconnection costs have grown over time in all studied regions



Region	"Earlier" period	"Recent" period
MISO	(2000-) 2018	2019-2021
SPP	2010-2019	2020-2022
PJM	2000/2017 - 2019	2020-2022
NYISO	2006-2016	2017-2021
ISO-NE	2010-2017	2018-2021

- Average interconnection costs have grown across regions and request types
  - Often doubling for projects that have **completed** all studies
  - increasing even more for **active** projects currently moving through the queues.
  - Projects that **withdraw** have the highest interconnection costs

Source: Lawrence Berkeley National Laboratory[14]

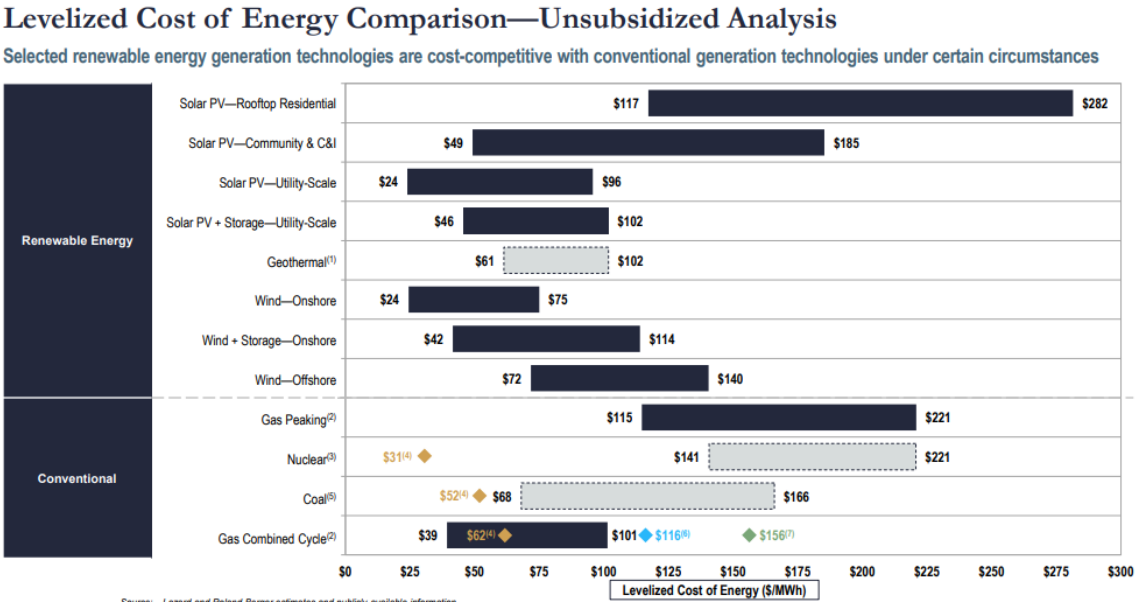
As discussed in "future trends" section below, Federal Energy Regulatory Commission (FERC) Order 2023 seeks to fix fundamental issues with the generation interconnection process, but more policy action will be needed.

Renewable energy remains competitive with fossil fuel prices

While renewable energy resource costs have risen after decades of significant cost declines, fossil fuel prices rose even faster in 2022. Coal and natural gas plants must contend with increased capital expenditures for building materials along with volatile and increasing operating expenses as fuel prices surge because of geopolitical events and inflation. A levelized cost of energy comparison shows that utility-scale solar and wind, as well as both resources coupled with storage,[15] are highly competitive with gas- and coal-fired power plants. Of course, these cost analyses should also

consider the real pollution costs and inequitable burdens imposed by burning fossil fuels, which dwarf any cost differential today.

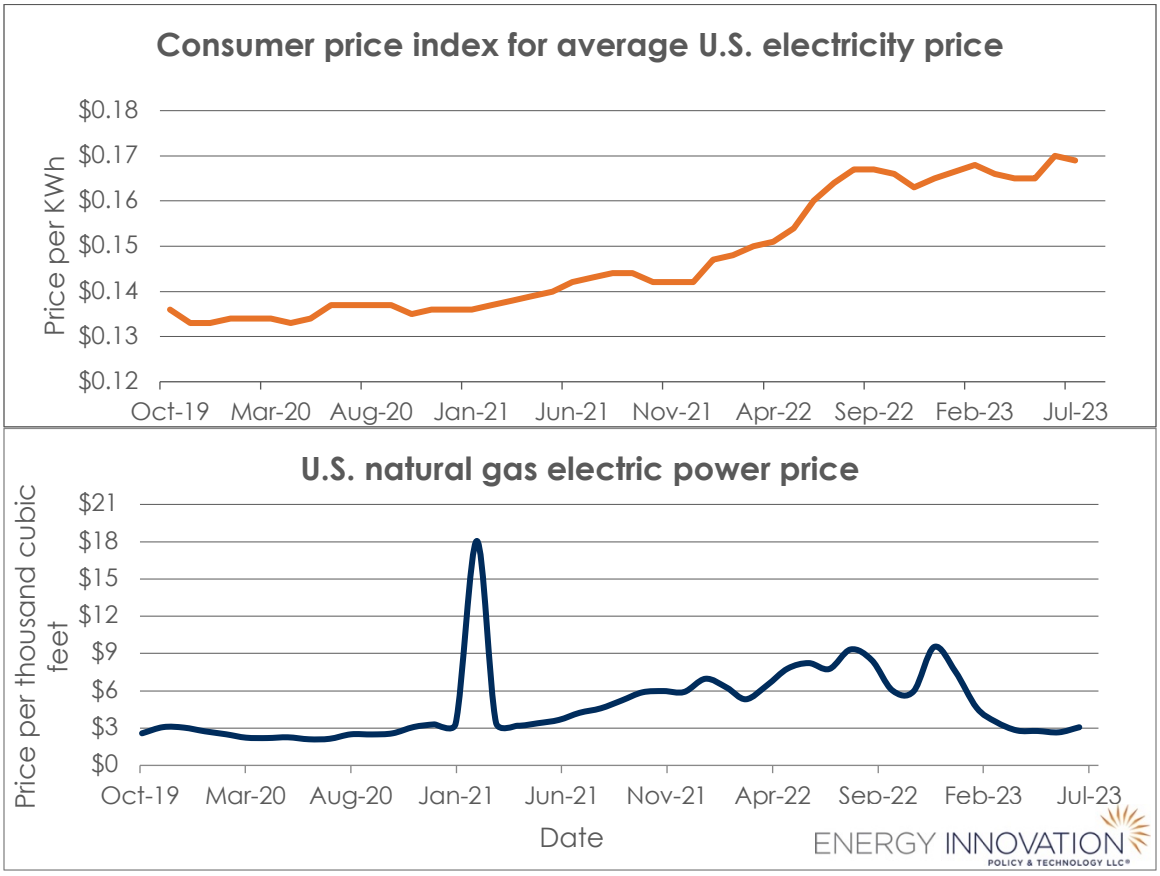
Figure 6. Levelized cost of energy, unsubsidized



Source: Lazard Levelized Cost of Energy Analysis — Version 16.0. Note that the actual anticipated prices of wind and solar are lower than displayed due to IRA tax incentives.[16]

While raw material prices have especially affected wind and solar projects, raw material price increases do raise the cost of building new gas and coal infrastructure, while recent fuel-price volatility and spikes have significantly impacted customers' electricity bills. In 2022, consumer electricity prices surged more than 14 percent on average,[17] largely due to gas cost spikes. The flip side of volatility also holds – gas prices came back down in 2023. Once built, renewable costs remain fixed over the long-term. An electricity grid with significant renewable energy supply reduces exposure to unstable fossil fuel prices, tempering price increases on consumers' utility bills.

Figure 7. Changes in electricity price compared to natural gas price over time



Source data: U.S. Bureau of Labor Statistics and U.S. Energy Information Administration[18,19]

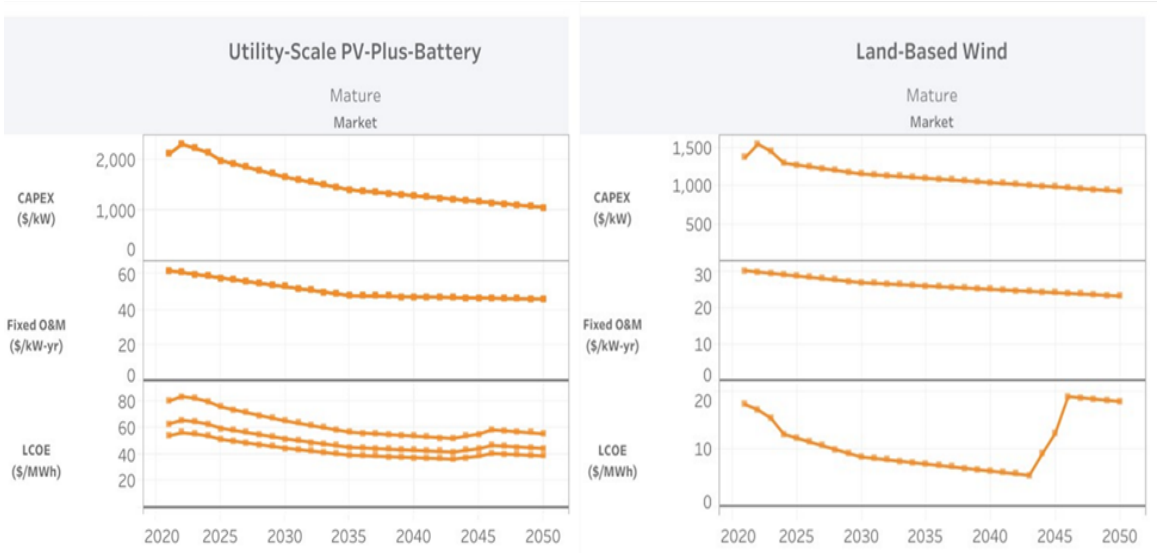
Grid reliability, including future power systems' ability to meet growing demand, is crucial to understanding how clean energy resource costs compare to fossil alternatives. As coal retirements continue and potentially accelerate, utilities are concerned about a lack of dispatchable resources as well as uncertainty around the reliability contributions of clean energy resources. In comments to the U.S. Environmental Protection Agency, industry representatives raised concerns that clean energy may not come online fast enough to meet grid reliability needs as fossil plants retire. Increasingly severe weather and lack of reliable natural gas delivery during times of grid stress add to this unease, highlighted by a recent FERC/North American Electric Reliability Corporation examination of 2022 Winter Storm Elliott.[20] Many of the policy solutions that address the cost of clean energy resources can also assist the timely addition of wind, solar, and storage to bolster grid reliability through this transition.

EXPECTED FUTURE TRENDS

The National Renewable Energy Laboratory (NREL) Annual Technology Baseline (ATB) is a publicly available industry-standard tool for projecting future cost trends in energy technology.[21] NREL's 2023 ATB tracks the current trend of flattening and slightly increasing costs from 2021 to 2023, but then forecasts consistent declines in technology costs, due in large part to sustained support from IRA tax incentives.

ATB cost projections for solar hybrids with low, medium, and high solar resource regions are shown on the left side of the figure below, along with an average wind speed region on the right side.[1] NREL's baseline shows solar-plus-storage costs could fall 25-30 percent by the 2030s, while wind costs could fall more than 50 percent in a moderate scenario. NREL's baseline prediction signals continued technology improvements for wind, solar, and batteries, making these resources increasingly competitive against incumbent fossil resources.

Figure 8. Projected utility-scale solar plus battery and land-based wind prices



Source: National Renewable Energy Laboratory.[22]

Still, some cost drivers could be durable and undermine predicted cost declines. Trade policy, which is one of the main drivers of renewable costs, could be a persistent barrier to cost reductions. There are some concerns that restrictions on importing solar components will be expanded to other clean

[1] As solar-plus-storage is becoming the industry standard and an important component of reliable transition from retiring fossil plants, we choose to highlight these costs for utilities and regulators for which reliability is a growing concern.

energy resources. These restrictions are likely to continue causing both confusion and conservative procurement strategies that could slow solar and potentially battery growth in the next few years until domestic supply chains can catch up. But the IRA also offers relief—the decade ahead will see "domestic content" bonus tax credits for domestic manufacturing of wind, solar, and storage. And other manufacturing tax credits provide extra margins for U.S.-based solar, wind, and storage component manufacturers. These tax bonuses will likely drive greater reliance on and growth for U.S.-based components, and policymakers can do more to attract these manufacturing capacities to their states. However, experts we interviewed cautioned against reliance on domestic manufacturing incentives to fully mitigate the impacts of trade policy for the next several years.

While interest rates are high today, they are inherently volatile and unpredictable. The cost of borrowing affects the cost of capital-intensive renewables projects relative to more variable-cost sensitive resources like natural gas generators. With inflationary pressures recently cooling but still persistent, it is anyone's guess when and how quickly they will ease. As one example, Morningstar predicts interest rates will fall from an average of 5 percent (real) in 2023 to 2 percent in 2026.[23] For context, a 300 basis point reduction in interest rates would lead to a 20 percent reduction ($6/MWh) in the levelized cost of a typical utility-scale solar project as modeled in NREL's ATB.[2]

Another recent cost driver with increasingly favorable prospects for future mitigation is interconnection cost. As discussed in the previous section, the average cost of interconnecting a utility-scale wind, solar, storage, or hybrid plant has risen on average in all U.S. regions. Thanks to FERC Order 2023, FERC-regulated regional transmission organizations (RTOs) must take concrete steps to reduce interconnection queue wait times and fix the perverse incentives created by the project-by-project interconnection study process. A recent blog post from Advanced Energy United[24] highlights how this policy is likely to help, while the policy recommendations below can improve interconnection and transmission policy in the implementation of FERC Order 2023 and beyond.

For less mainstream renewable energy technologies like advanced geothermal and offshore wind, essential additional factors will be policy support and associated growth. Today, utilities are paying a premium for these important decarbonization technologies, and supply chain snags have hit emerging technologies hard, especially offshore wind.[25] Meeting the federal commitment to 100 percent clean electricity by 2035, as well as many states' and utilities' similar policies and goals, requires a diverse set of clean energy resources. This becomes even more imperative as we consider the rapid growth in electricity demand that will come from successful climate policies and electrification of transport, industry, and buildings.[26] For these less mature technologies to

[2] Energy Innovation performed this calculation using the NREL 2023 ATB Excel Workbook, available at https://atb.nrel.gov/electricity/2023/data.

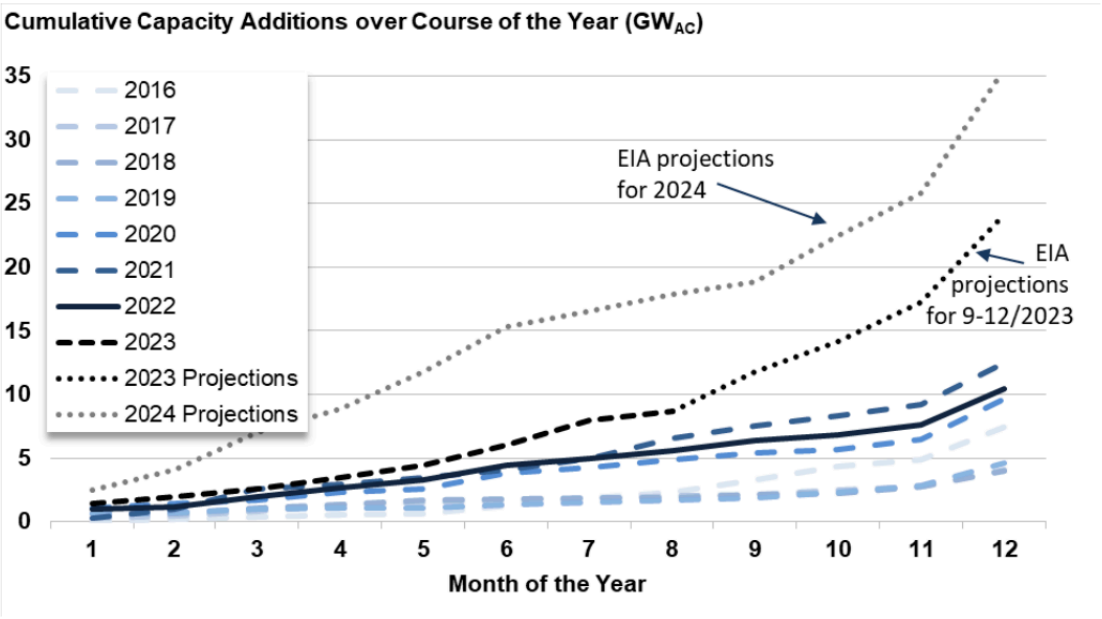
succeed, early and consistent support in the form of procurement targets, contracts that reflect supply chain risks, and supporting infrastructure will help them benefit from the same cost reduction curves that wind, solar, and storage have enjoyed.

POLICY RESPONSES

Recent cost increases make it more important than ever that policymakers push forward with supporting renewable energy and mitigating underlying barriers responsible for some of these increases. Slowing down on renewable energy would forgo significant benefits including public health, reliability, consumer savings, and job opportunities. For example, renewable installations now can hedge against future fossil fuel price shocks with 2023 installations of solar expected nearly double the previous deployment record set in 2021.[27] Continuing to find ways to reduce risk for clean energy projects will help prices continue to fall and minimize future disruptions.

It is also a reliability imperative to accelerate developing as many new, diverse portfolios of clean energy as possible. As uneconomic coal plants have retired and new resources have been delayed, we need wind, solar, and storage resources to come online as quickly as possible to avoid future capacity shortfalls. These new resources, while facing short-term price increases, can save consumers money, particularly compared to aging and expensive coal plants.

Figure 9. Past U.S. utility-scale solar additions compared to future projections



Source: Lawrence Berkeley National Laboratory[28]

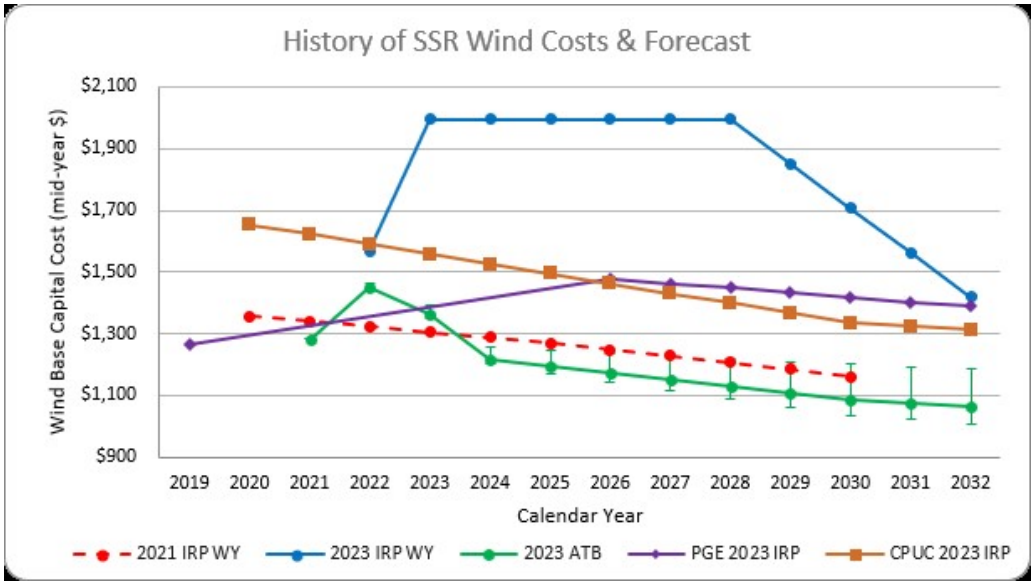
As previous sections show, any solar and wind cost increases have largely tracked the rate of inflation economy-wide.[29] For most of the country, wind and solar are worth it for customers on an economic basis, setting aside the health, climate, and jobs benefits. And policymakers need not sit on their hands and wait for costs to come down—they can take action. Several policy improvements can help ensure that we see these benefits and that renewable deployment stays on track.

Link market information to competitive procurement

Utilities and regulators work together in integrated resource planning to help determine which resources to procure and on what timeline. These plans often include utility estimates of cost, which heavily influence the "least cost" portfolio that results from this analysis. Ensuring those estimates are accurate and up to date is essential to protecting consumers and overcoming bias toward preserving the status quo.

A recent integrated resource plan (IRP) for Pacificorp, a six-state utility in the Pacific and Interior West, exemplifies this dynamic. In 2023, Pacificorp announced it would rapidly increase wind, solar, and storage deployment while accelerating coal retirements due to faster-than-expected cost reductions and IRA incentives.

Figure 10. Past and projected land-based wind costs in Pacificorp's IRP compared to NREL ATB



Source: Nick Pappas comments to Pacificorp Integrated Resource Plan, 2023.[30]

However, recent cost increases have led Pacificorp to question its own wisdom. Its updated IRP estimates wind costs will rapidly increase and stay elevated for the next five to eight years, defying other projections.[31] Pacificorp's regulators are right to take current cost data into account but must be vigilant in creating a process to continuously update these cost forecasts based on market conditions. Failure to do so risks missing out on consumer savings and avoided climate and pollution damage in the next five years.

Reexamine planning practices to leverage Inflation Reduction Act incentives

The clean energy tax credits in the Inflation Reduction Act include 10 years of tax support for clean energy resources, with bonuses for utility-scale projects located in energy communities and distribution-scale projects in low-income communities. Further support is available in the form of government backed loans under the Energy Infrastructure Reinvestment (EIR) program. EIR offers low-cost financing for clean energy projects that reduce greenhouse gas emissions from fossil infrastructure while reinvesting in those sites and communities. Together, these represent new ways of thinking about the "least cost" resources to meet customer load. Regulators need to revise planning practices to ensure place-based developments are adequately considered alongside new financing opportunities that offer access to much-needed cheap capital.

Regulators can and should require utilities to proactively assess the applicability and potential of IRA incentives and programs to reduce consumer costs. Part of the challenge of accessing energy community bonuses and fossil refinancing funds is it requires engaging with these communities to solicit their interest in developing local clean energy projects. Regulators can play this convening role, bringing utilities, energy community representatives, low-income community representatives, and labor interest together to make them aware of IRA tax credit bonuses. To get these projects going, regulators can consider requiring that solicitations for new resources include a tranche of projects that meet bonus requirements. Regulators can require the same examination of opportunities under EIR, applications for which must be utility-led. A recent brief from RMI highlights further policy considerations to ensure IRA incentives are fully considered in planning and procurement.[32]

Update interconnection processes

Increased interconnection costs have been one of the main drivers of recent cost trends, as detailed above. These costs stem from both direct interconnection processes and the consequences of poor long-term regional and interregional transmission planning. While FERC Order 2023 provides substantive reform of interconnection processes by improving the study paradigm, creating enforceable timelines, and decreasing potential for speculative projects, it is

unlikely to completely solve interconnection queue issues and does not address the underlying lack of transmission capacity we see nationwide.

Currently in most parts of the country, when resources try to connect to the grid, the grid operator determines what grid upgrades are necessary to guarantee a certain level of access to the grid. This is commonly known as "invest and connect." However, Texas has seen unique success connecting new resources, bringing three times the clean energy capacity online in 2021 as PJM, the largest wholesale market in the country, using an approach referred to as "connect and manage."[33] Here, developers take on curtailment risks as they are not guaranteed a certain level of transmission system use, but the only upgrades they must pay for are those that are needed to physically connect them to the grid. The Texas market structure assists this approach, as there is no capacity market revenue that would incent resources to invest in deliverability. The system then relies on congestion market signals to build new transmission to accommodate these new resources in the long term, meaning these resources could see less curtailment in the future. The option to connect as "energy resources" is available in other RTO markets, but for several reasons not in common use. Other markets lack standard transparent rules for connecting as energy resources, and may still choose to allocate upstream transmission costs to energy resources. Rather than streamlining connecting energy resources, these markets impose similar barriers that increase queue wait times similar to more fulsome interconnection studies. Furthermore, the use of congestion to signal the need for new regional transmission upgrades is not in wide use. To further decrease interconnection delays and costs, grid operators should explore using whether this approach, paired with proactive planning, can encourage development.

Increased funding for staff performing interconnection studies, improved transparency into transmission in the form of independent transmission monitors, and more coordination between state plans and grid operators can also help support faster interconnection.

Improve transmission planning

Interconnection reforms will not be able to solve the underlying fundamental need for more transmission capacity, particularly at the regional and interregional levels, to cost-effectively integrate renewable energy onto the grid. As the connect and manage approach in Texas demonstrates, faster interconnection—"connect" —should be coupled with proactive planning —"manage"—to maximize the value and speed of new resources. This can only be solved by long-term transmission planning, as would be required by FERC's proposed rule on planning for regional and interregional transmission capacity.[34] Similar to FERC Order 2023, this proposed rulemaking is not a silver bullet, as cost allocation for lines that cross multiple states is not addressed in a definitive way. Furthermore, state regulators have a role to play in encouraging their utilities to regularly explore regional transmission options. Strengthening the final rule to provide clear cost

allocation pathways, or congressional action to define transmission cost allocation according to benefits, would be an important step beyond this current rule.

Building more lines is not the only way to increase transmission capacity—grid-enhancing technologies (GETs) and advanced conductors are a cheaper and faster way to upgrade existing lines. For instance, GETs alone have potential to double renewable energy capacity,[35] and advanced conductors could double the capacity of existing lines.[36] However, because GETs and advanced conductors are cheaper than installing new lines but not the least cost option for a new line, utility incentives can be misaligned with their consideration and use. To take better advantage of existing rights of way, regulators should require utilities and transmission service providers to consider GETs and advanced conductors in their planning processes.[37]

Commitment by federal government and states to diversifying clean energy supply, focused on offshore wind

While much can be done to reduce the cost and risk for wind, solar, and batteries, policymakers should also focus on de-risking the next wave of important clean energy technologies. A diverse clean energy mix is a more reliable, resilient one, and helps to avoid the risks associated with overreliance on single technologies.[38] Policymakers should consider authorizing utilities to procure emerging technologies that complement variable renewables and storage, including geothermal, offshore wind, and long-duration energy storage.

In particular, policymakers in coastal states should enhance long-term commitments to offshore wind. The offshore wind industry is among the most capital intensive of mainstream renewable energy technologies, which means cost increases are felt even more keenly than in onshore wind, solar, and storage. Components are large and require specialized vessels, ports, manufacturing facilities, and materials. Because the U.S. is still in the process of building its first utility-scale offshore wind projects, the industry is on looser footing than it is internationally, creating higher risks for investors and developers. To help create certainty, the federal government and states should both continue to show commitment to the industry via goals and procurement targets and invest in supporting infrastructure that will be needed to get early projects off the ground. Additional short-term actions to help bring early offshore wind projects to fruition include finalizing guidance on the energy community bonus tax credit to allow projects that have marshaling ports, operations and maintenance ports, and second points of interconnection located in energy communities, as well as primary points of interconnection in energy communities. A recent Energy Innovation report details the policies that can support the growth of a low-cost, mature U.S. offshore wind industry.[39]

Continue investment in the domestic supply chain

The IRA provides incentives to bring clean energy manufacturing to U.S. shores, which should increase clean energy component supplies, reduce the impact of tariffs on costs, and create jobs across the country. But without state policymakers' focused support and additional guidance from the Department of the Treasury, we may not get the manufacturing we need to take advantage of the cost reductions available from IRA domestic content bonuses.

Already, over $85 billion in investment for clean energy manufacturing facilities has been announced, with 71 percent of that going toward battery manufacturing, both for stationary storage and electric vehicles.[40] With many announcements tied to chemistries typically associated with electric vehicle batteries, policymakers should also work to promote manufacturing of batteries used in stationary grid batteries. Solar manufacturing announcements encompass 11 percent of the investment, while wind manufacturing makes up only 1 percent. This lagging number for wind is partly because many wind components are already manufactured domestically, particularly towers and nacelles.[41] While this has generated excitement, solar and wind should see more commitment as renewable energy installations accelerate, both building on existing manufacturing capabilities and expanding to other arenas. Governors and state economic development offices in particular have power to attract manufacturing to their state, and should take this opportunity to identify suitable industries. In Georgia, for example, Governor Kemp has committed to making the state a leader in manufacturing related to electric mobility.[42] Investment has followed—since passage of the IRA, $15 billion has already been announced.[43]

In 2022, the Biden Administration authorized spending under the Defense Production Act to bolster our transformer supply chain,[44] but unfortunately Congress did not fund that provision. Because transformer shortages could further complicate the pace of grid expansion and interconnection,[45] it is important that Congress continue working to fund this provision.

CONCLUSION

Like most other goods and services, U.S.-based clean energy technologies have experienced inflation driven by supply chain disruptions, geopolitical events, volatile commodity prices, labor shortages, and high interest rates. In some cases, this has undermined utility enthusiasm for a rapid clean electricity transition. Higher costs lead to natural questions about what are the most "cost-effective" resources, whether policymakers should slow the pace of transition away from fossil fuels, and how long these trends will persist.

No precise answer exists for this problem, but the value of clean energy resources remains attractive in many parts of the country. Overall, prices have not risen so fast that they undermine the fundamentals of a rapid coal-to-clean transition, and price increases vary from project to project. Several aspects of price increases, including interest rates and trade policies, remain uncertain, while others like commodity prices and supply chains are headed back toward pre-

pandemic levels. The persistent decline in battery storage prices helps to bolster the reliability contributions of variable renewables as fossil plant retirements accelerate.

Over the long term, economies of scale will generally continue to drive down levelized costs, and sustained support from the IRA means that opportunities to save consumers money today via renewable energy deployment will grow. Policymakers concerned about cost increases have tools at their disposal to better integrate the changing cost dynamics of clean energy into decision-making, as well as to reduce the cost and risk associated with clean energy projects. Policymakers are on economically sound footing when considering accelerating clean energy deployment, while prioritizing policies that address barriers to rapid deployment, especially by improving how transmission infrastructure is assessed and planned.

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