Browse episodes of Resources Radio at resourcesradio.org, or tune in on your favorite podcast app.
At RFF, we have been tracking all these developments. In this issue of Resources magazine, we amplify some of the work we’ve been doing across RFF’s Electric Power Resources radio and television series, and our new magazine, RFF Electric Power. Join us online at www.rff.org/electricpower as we continue to power our rigorous research and analysis into the future.

For many of us, the US presidential election this year dominates the landscape. Observers might suppose that little consequential policymaking will happen in the lead-up to November. However, for the electric power grid, key guidance and rules from federal regulators may shape the future of US electricity for years to come.

Two such regulations have been the talk of academics, government officials, industry leaders, and communities for years. The Federal Energy Regulatory Commission—a federal agency tasked with regulating interstate transmission of electricity, natural gas, and oil—is working to implement its anticipated new rule on electricity transmission planning and cost allocation. In addition, the US Environmental Protection Agency recently released final guidelines under Section 111 of the Clean Air Act, specifying emissions guidelines for existing coal plants and natural gas plants (the rule for existing natural gas plants has been delayed until after the election). Meanwhile, states are anticipating these changes and already are accelerating electric-grid technologies to improve an aging grid and work toward decarbonization goals.

At RFF, we have been tracking all these developments. In this issue of Resources magazine, we highlight some of the work we’ve been doing across RFF’s Electric Power Program, led by junior fellow Karen Palmer. This timely work includes analysis of how the Inflation Reduction Act and its implementation continues to impact this critical part of our energy system, new tax credits created to advance solar and wind technologies, and potential shortfalls of some of the most ambitious policy advancements.

In a Resources Radio episode at the start of this year, Karen lamented that we hadn’t seen much movement in 2023 on overcoming key barriers to investment in the electric power grid. Despite the election year, we anticipate substantial movement in 2024 toward net-zero emissions, and RFF researchers, along with our partners, are tracking and analyzing it all moving forward. In addition to reading what’s in this issue of Resources magazine, continue to check the RFF website for events, publications, and more analysis on what’s to come.

We hope you’ll plug into RFF as we continue to power our rigorous research and engage decisionmakers on widespread decarbonization of the electric power sector—a necessary step toward addressing climate change.

Sincerely,

Billy Pizer
President and CEO, Resources for the Future

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Tax Credit Choice for Solar
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What will US electricity markets look like in an emissions-free world? Economists at Resources for the Future (RFF) are always thinking about how markets operate and evolve in a world where policy and technology are constantly changing.

With the power sector going through a massive transformation and continuing to decarbonize, Resources magazine sat down with RFF Senior Fellow Karen Palmer and Senior Research Associate Molly Robertson to discuss what this transformation means for wholesale electricity markets and how current systems will need to adapt.

Karen Palmer: The markets that are run by the independent system operators are structured to provide an incentive for generators to bid into the competitive energy market at their marginal cost of producing electricity. At that price, the generator is indifferent to either operating and receiving the price, or not operating and saving the fuel and other operating costs.

Generators are selected for operation starting with the lowest bid price. When an auction price reaches a value that ensures equivalent supply and demand of electricity, the market has "cleared." For electricity markets, generators make money when the clearing price is higher than their marginal cost. These monetary gains go toward paying down the fixed costs incurred by the generators and, hopefully, contribute to profits.

What happens if a generator isn’t selected to operate during the auction process?

KP: If a generator’s marginal costs are consistently higher than the marginal costs of competitors, then the generator may clear the market only at rare times when demand peaks or when other generators are out of service. In some cases, these infrequent periods of operation yield revenues that are sufficient
to cover the generator's costs. If particular generators can't operate often enough to earn revenues that are sufficient to cover their fixed costs, then those generators are forced to retire.

**MR:** The energy market, in which generators are paid to provide electricity to the grid, is the main way that most generators make money. But for the grid to operate reliably, other services are required, which generators could provide for a fee that helps support system reliability. For example, generators may sell capacity commitments, which require the generators to be on their power plants in order to operate. The payments for capacity commitments can be an important source of revenue for generators that are not operating at full load or that may still be needed in times of high demand.

Generators also may sell something called ancillary services, which refer to a suite of services that help grid operators keep their very complicated technical systems running smoothly. For example, a frequency-response service allows generators to sell the system operator very small, instantaneous adjustments in the generator's output to ensure that the grid maintains its necessary operating frequency. Only some generators have the ability to make those very small changes in generation instantaneously. Batteries have been slightly more successful in frequency-response services. Ancillary services generally are low-price products, but they're still in demand in the revenue stream for some generators.

**Markets have to accommodate a lot of components in a well-functioning power system. How do wind and solar resources play into all this?**

**MR:** Renewable energy resources like wind and solar are different from other resources, because the fuel they use to create electricity is free. When wind and solar resources offer their bids in the energy market, they typically can undercut the fossil fuel competition. In some cases, subsidies that compensate renewable generators for operating encourage renewable generators to offer negative bids into the market—the generators essentially offer to pay the market to allow them to operate and collect the subsidy. At low quantities on the grid, renewable resources are all expensive, low-cost, zero-carbon resources.

At high levels of penetration, however, renewables challenge current market mechanisms by decreasing electricity prices and therefore decreasing the expected revenue in the day-ahead and real-time energy markets. Uncertainty over these low prices may make it more difficult for developers to determine if they should invest in new electricity generation.**KP:** The other key characteristic of renewables is their intermittency. The fuel may be free, but you can't control the weather. A solar farm doesn't have to pay for sunshine, but it also can't change the weather if the forecast calls for clouds and rain. Although wind and solar may offer low-cost electricity during many hours of the day, they may disappear altogether at other times. To ensure that these situations of intermittency don't lead to outages, the grid has to find a way to ensure that enough backup resources are ready to jump in. Because these backup resources are expensive and available to recover costs.

Many market operators observe that a market with high penetration of renewable energy will face very large swings in energy prices if the generator that sets the auction clearing price switches between the low-cost renewables and the expensive backup resources. In some cases, auction-clearing energy prices may exceed the cost of the backup resources if the sellings are not paid for additional energy, known as the value of lost load, exceeds the offer price of the backup resources. Prices set at this relatively higher level could signal the value of future investments, but such pricing is generally restricted by regulator-imposed price caps.

**Price big swings in wholesale markets a problem for generators?**

**KP:** Price swings driven by variable resources pose a problem in terms of the long-term investment signals for power generators, particularly because the frequency of high-cost periods hinges largely on weather patterns that are difficult to predict. Generators are expensive, and they take a long time to build, particularly in terms of permitting and interconnection systems and can add years to development timelines. Investing in generation becomes increasingly risky because large swaths of time could pass during which expensive generation may be required. If the costs of generating electricity would need to make sure they are available during the hours that prices spike, so they can recover their costs. The uncertainty over the frequency and duration of those price spike periods makes it difficult for generators to determine the necessary financing for significant project investments.

**MR:** These price swings could be mitigated through solutions such as building up storage technologies and allowing electricity users to respond to prices. By holding power in batteries or other technologies, energy-storage operators can buy excess energy when the price is low, store it (perhaps through time-of-use rates or frequency-shaving) and can make stored energy available for sale in the market when prices go higher (like when the sun goes down).

On the demand side, opportunities are available for electricity providers to change the way consumers use energy as energy prices fluctuate. For example, if electricity prices are high, some generators have the ability to make those very small changes in generation instantaneously. Batteries have been slightly more successful in frequency-response services. Ancillary services generally are low-price products, but they're still in demand in the revenue stream for some generators.

**What kinds of adaptive measures could help address these issues?**

**KP:** Economists are considering how to redesign electricity markets to provide improved investment signals and ensure that the generators that are needed on the system can make sufficient revenue to continue operating. Current market structures rely on different mechanisms, such as capacity markets, power purchase agreements, minimum contracting obligations, or shortage prices, to facilitate enough power on the grid to serve demand. But these mechanisms may be insufficient or inefficient in providing the right mix of resources.

Jurisdictions outside the United States are exploring different ways of constituting the need for investment in important new resources, like forward contracts for energy (in which both parties agree to buy and sell energy at a specified price on a future date) or contracts for capacity (which pay buyers the generators the difference between the contracted price and the variable-energy market price when the resource is committed to operate and vice versa when the latter is greater), both of which can provide a stable, long-term revenue stream. Such solutions may provide more certainty for investors and help stabilize revenue streams for generators, but the details of the solutions matter for determining what types of energy projects actually get built and how much the systems cost to operate.

**As reforms to the electricity market are considered, what policies should regulators keep in mind?**

**MR:** We think about evaluating changes to electricity markets in various ways, and whether the changes can meet the needs of the system.

First, solutions should enable the market to find low-cost approaches to meeting the needs of the grid, whether these approaches might be insufficient in addressing system needs.

For both demand response and storage, we still have questions about how much we can expect these options to contribute to solving the problem of price swings. For example, if we see a sustained shortage in renewable resources and associated high prices, on the order of weeks in duration, then storage and demand response might be insufficient to address system needs.

So, integrating renewables comes with opportunities and challenges. What kinds of adaptive measures could help address these issues?

Finally, as decarbonization policies at the state and federal levels continue to evolve, market-design solutions should be developed with the impact of those policies in mind. Third, solutions should consider not only the ability of generators to increase supply, but also of customers to reduce demand.

Finally, as decarbonization policies at the state and federal levels continue to evolve, market-design solutions should be developed with the impact of those policies in mind. For example, if a state climate policy will require backup fossil generation to retire by a certain date, it should identify the necessary functions and new markets should provide sufficient signals for new sources of non-intermittent clean generation to be built by that date.

What is RFF doing in this space to inform policymakers?

**KP:** We are working across the country in this space and have a lot of ideas for how we can improve electricity markets. In an ongoing collaboration with Chiara La Prete of Penn State University, we are reviewing existing research and the international policy landscape to space to explore potential solutions to these market challenges.

The next phase of our work will involve a model of the power sector. We'll explore a subset of solutions in greater detail with the model to see if the proposed solutions could improve signals for investors.

We also are thinking about the role of emerging technologies in electricity markets, such as energy storage, and the challenges related to fitting them into the current structure.

Karen Palmer is a senior fellow and director of RFF’s Electric Power Program, and Molly Robertson is a senior research associate at Resources for the Future.
The Inflation Reduction Act (IRA) has been in force for the past year and a half, and the law’s provisions for clean technologies have begun to bear results. In January 2023, a solar-panel manufacturer invested $2.5 billion in a pair of facilities in Georgia as a result of the IRA. The US Department of Energy has loaned more than $10 billion to firms for building facilities that will manufacture batteries for electric vehicles, and loan applications in the agency’s queue total over $100 billion.

Yet, experts project that the United States will fall short of its near-term emissions-reduction goal to cut 2005 emissions levels in half by 2030, to the tune of about 10 percent below the goal. Hence, policies to complement the IRA are likely necessary. Familiar ideas for reducing emissions remain in discussion, such as a tax on carbon emissions, which many economists endorse. The idea of a carbon border adjustment mechanism has attracted interest in the US Senate, and the federal government has proposed regulations to target emissions from specific sectors of the economy. Debates over permitting reform, which could accelerate the pace at which new energy projects are approved and built, have spilled from wonkier circles into the mainstream.

So, what is the future of US climate policy in an IRA world? Resources for the Future (RFF)

Despite a year of high interest rates, a clean energy economy is growing.
I think we could envision a couple next steps. One, I’ve heard people make this point—which I think is valid—that the IRA makes decarbonizing the electricity sector really cheap, for instance. You could imagine states adopting increasingly strict renewable portfolio standards in a kind of virtuous cycle where—because of IRA subsidies, accelerating toward goals at the state level becomes politically more possible. I think that’s one direction. I also feel like the IRA does a lot with electricity, a lot with transportation, and maybe a bit with industry. It kind of depends on how you see carbon capture, utilization, and storage being adopted by industry. If the 45Q tax incentives aren’t taken up by industry, then the sector’s carbon emissions will continue to be hard to abate, with industry as the next frontier for climate policy.

More as hopescasting than forecasting: You could imagine a scenario in which the Trump tax cuts expire in 2025 as interest rates and deficits go up. We’ll want to put the tax cuts back in place, but we’ll be looking for revenue sources. I could imagine some kind of carbon price, at least in the industrial sector.

I’d also say it’s important to think about how our approach to climate change mitigation relates to international trade. How US policies interact with European policies will be important going forward. Most of the rest of the world’s developed world has some form of carbon pricing. The Clean Competition Act, a bill introduced by Senator Sheldon Whitehouse (D-RI), envisions something that resembles a carbon price—the bill proposes a border adjustment mechanism that’s paired with a fee (the bill doesn’t use the term “carbon tax”) on industrial facilities that are above the median in terms of pollution. It’s like a “dirty-emitters fee,” which tracks down over time. You start at the top half of facilities, charging those that exceed median emissions, and over time expand the number of facilities that are paying the fee. I could imagine a future of focusing on decarbonizing the industrial sector, and if the industrial sector develops new methods of transporting and storing carbon dioxide, the power sector will get those benefits too.

I do think that a sectoral approach is the most likely outcome, although I imagine that we’ll see spillers across sectors.

It’s interesting that the IRA is a kind of continuation of laws that have passed. The law includes a lot of tax credits and subsidies—a lot of carrots, and not a lot of sticks. But, in many ways, the IRA is a departure from the American Clean Energy and Security Act and other prior big climate bills. In addition to a sectoral approach, carbon border adjustment mechanisms, and maybe even a carbon tax in the industrial sector, all of which you’ve mentioned, what other sectoral policies could get the United States to our emissions goals in the post-IRA world?

I’ve been thinking a lot about methane emissions. From a trade perspective, the IRA contains references to methane from the oil and gas sector that aren’t aligned with what some of our trading partners are doing. I can imagine some kind of agreement with the Europeans, or an even broader set of countries, on a methane border adjustment policy based on the regulations that the US Environmental Protection Agency is working on and the methane fee that’s in the IRA.

A sector-based approach could be easier and a good glide path to something broader. For example, if the United States works with Europe on methane, we could make a lot of progress on methane emissions in some of the most highly polluting countries. In doing so, the United States could also gain experience working with Europe on border adjustments, climate change, and trade issues.

This doesn’t exactly answer your question about meeting US climate goals, as the IRA already has some serious methane provisions, but a trade agreement could lead to some very meaningful reductions worldwide.

I think the sector-based approach lets us have those conversations without having to talk about the whole entire climate change problem, and the whole economy, and all the carbon emissions in the world. Maybe we could consider it a lower-stakes way to have some productive conversations.

The electricity sector has a huge menu of policy options, and you’re talking about decarbonizing the industrial sector. What policies have potential to decarbonize the transportation sector?

I think that the Infrastructure Investment and Jobs Act, and its investments in charging stations, are important. The economics literature suggests that a dollar spent on charging infrastructure is very productive—more productive than a dollar spent on vehicle subsidies. We’re already employing this option, but I would definitely include more charging stations in the list for future consideration.

I don’t see much potential for a carbon price on gasoline. We might get to that eventually, but a lot of sensitivity surrounds gas prices, which makes a carbon price on gas somewhat unrealistic.

The IRA looks a lot like it’s a technology policy. Billions of dollars of investment are in the IRA, including demonstration funding and other subsidies for deployment. What do you think of subsidizing technology in the hopes of pushing down prices?

Theoretically, both a carbon price and a carbon subsidy could get us to similar outcomes, in terms of innovation. But if you think like an investor for hire, let’s say, direct air capture or small modular reactors, it’s probably a lot easier to estimate the amount you’ll get from a direct subsidy—whereas with a carbon tax, you need to work a bit harder to figure out what the wholesale power price will amount to, and how that figure translates into profits.

I think the certainty of the amount of money that you’ll get under the subsidy, and the IRA’s...
I think technological innovation is important, because it's one of the main things we can export to the rest of the world.

I think the true cost of the Inflation Reduction Act could end up being a lot more than $369 billion... but it could be less than that.
Tax Credit Choice for Solar and Wind Power in the Inflation Reduction Act

The Inflation Reduction Act has invigorated incentives for clean energy, including the investment tax credit and production tax credit. Wind and solar projects can choose between the two: What influences this choice, and what are the implications?

The Inflation Reduction Act (IRA) relies primarily on subsidies for clean energy technologies, particularly tax credits for corporations. The massive amount of funding for corporate tax credits comes from increasing the values and durations of clean energy tax credits and expanding eligibility to new technologies. Additionally, the IRA allows all projects that generate clean power to choose between two incentive structures: the investment tax credit (ITC) and the production tax credit (PTC). Although wind projects previously have had the benefit of incentive choice, this option is novel for solar power.

For utility-scale solar and wind projects, the choice between the ITC and PTC will be determined by three types of owners: project sponsors, tax equity investors, and regulated utilities. The choices these owners make will have substantial effects on clean power deployment and investment supply.
Based on the amount of renewable energy technologies, a tax credit, or the production tax credit, a tax credit can be applied for renewable energy projects. For example, the Investment Tax Credit (ITC) and the Production Tax Credit (PTC) are two of the most significant credits for solar and wind projects. How these credits can be used to establish in an energy community. For the ITC, 10 percent bonus credits are established in 2021 and 2022, 22 percent in 2023, and 10 percent thereafter. The ITC provides a tax credit based on the amount invested in setting up clean energy projects like solar or wind power.

**WHAT IT DOES**

The ITC provides a tax credit based on the amount invested in setting up clean energy projects like solar or wind power.

**HOW IT WORKS**

When an investment facilitates a project that generates solar or wind energy, the project gets a tax credit that amounts to a percentage of the total cost.

**EXAMPLE**

A solar or wind project that generates electricity can get a tax credit for each unit of electricity produced.

**DO YOU KNOW?**

Before the IRA, solar projects received nearly all ITC funding—the IRA was pivotal in diversifying the beneficiaries of the ITC.

Choosing a Tax Credit for Renewable Energy: Investment or Production?

The ITC and PTC will be determined by project sponsors, tax equity investors, and regulated utilities, each with distinct incentives and constraints. Utility-scale solar and wind projects have been predominantly owned by independent power producers, in which the producer is the project sponsor, but ownership also includes a tax equity investor. In regulated markets, utilities may own generation assets but are subject to the constraints of state regulators and various requirements.

**Project Sponsors**

The project sponsor would prefer the tax credit that provides greater present value. Whether a 30 percent ITC is worth more than a 10-year PTC of 2.75 cents per kilowatt-hour depends primarily on three project factors: capital cost, capital cost, capacity factor, and discount rate. A higher capital cost increases the benefit of the ITC, whereas a greater capacity factor increases the amount of electricity produced and thus the PTC’s value. A higher discount rate (determined by the cost of capital) will diminish the present value of the PTC. Additionally, if the project qualifies for bonus credits, the credits are proportionately more valuable under the ITC.

**Tax Equity Investors**

Tax equity investors are essential for efficient use of the tax credits and deductions for projects that are led by independent power producers, giving influence to tax-equity perspectives on the choice between the tax credits. The demand for tax equity is expected to grow with the increased incentives in the IRA from approximately $20 billion in 2022 to $50 billion by 2025. Furthermore, because the current pool of financiers has limited spare capacity, a large portion of the incremental demand must be met by new entrants.

The IRA restored the ITC and PTC to their full statutory amounts—30 percent and 2.75 cents per kilowatt-hour (in 2023$), respectively. Second, the credits will remain at those levels for projects that commence construction by 2032 (if not later) if projects meet the requisite standards for prevailing wages and apprenticeships. Third, the IRA established 10 percent bonus credits both for meeting domestic content requirements and for establishing in an energy community. For the PTC, each bonus credit adds 10 percent of the PTC value, but for the ITC, each bonus credit adds 10 percentage points—a 33 percent increase in value.

**Perspectives and Implications of the Choice between the ITC and PTC**

The PTC was established in 1992 at a rate of 1.5 cents per kilowatt-hour, and this rate applied for 10 years after a facility was placed in service. The PTC is adjusted annually for inflation, giving it a statutory rate of 2.75 cents per kilowatt-hour in 2023. As with solar and the ITC, onshore wind has received the most PTC funding to date.

Before the IRA, both the solar ITC and wind PTC had been scheduled to step down over time. COVID-19 relief legislation in December 2020 set the PTC to 60 percent of its statutory rate for wind projects that started construction in 2020 and 2021, with a planned expiration in 2022. The same legislation set the ITC to 26 percent for solar projects starting in 2021 and 2022, 22 percent in 2023, and 10 percent thereafter. The ITC has multiple advantages for tax equity investors, particularly new entrants. First, the timeline is shorter. The tax benefits accrue within five years, the majority of which are realized in the first year. Therefore, an ITC investor needs fewer years of predictable future revenue.

**What the IRA Made to These Two Incentives**

Among the incentives in the Inflation Reduction Act (IRA), corporate tax credits are the largest source of clean energy funding. Two of the biggest credits for solar and wind projects, the investment tax credit and the production tax credit, will produce different outcomes. Here’s a brief summary of both credits.
Economic Distortions Created by Two Tax Credits

Historically, the previous section considered the perspectives of project owners and their market effects, this section focuses on the perspective of the utility. The ITC and PTC quickly skew project choices.

The Tax-credit Value May Increase the Total Cost of Electricity Production

In subsidizing only the capital cost, the ITC can distort how projects weigh capital costs against capacity factors and maintenance costs. Therefore, the ITC has the potential to increase total levelized costs, inclusive of the subsidy cost to the government.

For example, to achieve a higher capacity factor than would be justified without the ITC, renewable energy projects consume more capital on technology or geography that involves excessive capital costs. A solar project might include equipment that allows panels to track the sun’s movements, or renewable energy projects could choose higher-cost locations that are windier or sunnier.

Additionally, projects could spend inadequate amounts on equipment maintenance. One study on wind projects by Joseph E. Aldy and others find that projects with an investment subsidy generate 10 percent less electricity than they would have with a production subsidy. Two-thirds of this reduction likely is attributable to projects being less available to generate power, a consequence of reduced maintenance spending.

Post-IRA, cost distortions from the ITC may be modest, as an increasing number of projects choose the PTC. Additionally, solar projects have less equipment risk than wind projects, so reduced power generation from diminished availability is less significant a problem. However, two caveats are important. First, offshore wind has high capital costs, making these projects likely to choose the ITC, and high equipment risk, which increases the availability effect if it is understated.

In allowing solar projects to elect the PTC, which is not subject to normalization, the IRA removed a disincentive to adding solar capacity in regulated markets.

The ability to choose between the investment tax credit and production tax credit will have considerable effects on clean energy deployment, investment supply, and subsidy efficiency.

Increasing the Value of Electricity Production

The Production Tax Credit May Reduce the Value of Electricity Production

Because the PTC subsidizes the quantity of power generation irrespective of the price of power, the PTC may incentivize lower-value electricity, perhaps to address the time-related components of low electricity prices. Energy storage can transfer a portion of low-value electricity to times when prices are higher, and flexible loads can be moved to be coincident with peak solar generation. To help equalize electricity production over space, increased transmission capacity is needed. Expanding transmission would require policy changes that address permitting delays in building new transmission lines and that provide incentives for implementing grid-enhancing technologies which increase the capacity of existing lines.

Conclusions

The ability to choose between the ITC and PTC will have considerable effects on clean energy deployment, investment supply, and subsidy efficiency. What explains many of these effects is the higher present value of the PTC for most utility-scale solar and onshore wind projects. Along with its greater value, the favorable treatment of the PTC for regulated utilities will cause additional, widespread growth in solar capacity.

With respect to finance, solar projects that switch to the 10-year PTC will increase the supply of tax equity over the short term. The continuing option of the ITC, with its shorter duration and lower investment risk, could prove important in attracting new investors in the long term. Separately, the IRA allows tax credits to be transferred, which has created a new and remarkably popular option for clean energy finance.

Lastly, cost distortions will diminish, and value distortions will increase, as solar projects cost less from the ITC to the PTC. Increased incentives in energy storage, flexible demand, and transmission capacity will be required to mitigate the divergence between PTC-induced generation and optimal additions of power to the grid, with supportive policies and permitting reforms playing critical roles.
he federal government has set the goal of reducing greenhouse gas emissions to 50 percent below 2005 levels by 2030 and achieving net-zero emissions by midcentury. Building a cleaner electric grid—replacing electricity that is generated by fossil fuels with electricity generated by renewable energy sources, like wind and solar—is a vital part of realizing these goals. Building a cleaner grid also will require a lot of construction, which needs to happen quickly to meet the climate goals for 2030 and midcentury.

The build-out of these projects has been slowed by the processes for permitting and approving renewable energy projects to comply with state and federal regulations, which has elevated the discussion of permitting reform to the national stage. Among the various steps, the required review process for compliance with the National Environmental Policy Act (NEPA) has become a key concern. NEPA was signed into law in 1970 and requires federal agencies to evaluate the potential environmental effects of federal projects. In a working paper I published with coauthors last year, we investigated the NEPA review process, with a focus on large solar projects.

New solar energy projects can take a long time to be approved, built, and connected to the grid. Some recent federal efforts that aim to accelerate project development have shown mixed results.
EPA was passed during a period of heightened attention on environmental issues in the United States. The law established an environmental review process for federal projects that may have "significant environmental impacts." These types of federal projects are funded, regulated, or organized by the federal government—or they are proposed by a firm or a state, local, or Tribal government and require federal approval or funding. The review process does not apply to fully privately funded projects on private land. NEPA also established the Council on Environmental Quality, which is responsible for implementation of the law across the federal government.

The heart of the review process mandated by NEPA is the environmental impact statement. This statement is completed by a federal agency and serves as a comprehensive study of the environmental effects of a project. Ultimately, environmental impact statements aim to provide information to public officials and the general public; those required statements ensure that the potential consequences of a project receive a fair look. An environmental impact statement includes a description of the proposed project and the affected areas; the reasons the project is necessary; benefits of completing the project; and an analysis of the environmental effects of the project, including adverse effects and any irreversible commitments of natural resources. A statement also must include reasonable alternatives to the project that would have a smaller effect on the environment. Notably, NEPA does not require a particular outcome, nor that an alternative with a potentially smaller effect on the environment will be chosen, the law simply requires the review process.

NEPA can pose a substantial burden for public officials and project developers, given the time and labor involved in conducting an environmental impact statement. The Council on Environmental Quality found in 2020 that, between 2010 and 2018, the average time to complete a statement was 4.5 years, while some major infrastructure projects took longer than 10 years. Lawmakers have pushed to tweak the NEPA review process in recent years to reduce delays in project approvals. Most recently, Congress included a provision in the Fiscal Responsibility Act, a spending bill that became law in June 2023, that directs the Council on Environmental Quality to modify NEPA to streamline the review process. The provision includes page limits on environmental impact statements, along with a two-year time limit on their completion. However, most of the changes to NEPA simply codify current practice that has been established through regulations and court decisions.

Observers expect NEPA to continue receiving attention both from policymakers who want to accelerate the clean energy transition and from others who want light-green new fossil fuel infrastructure.

The Long Road to Operationality

A working paper that I published recently with colleagues Andre Bellefontaine, Lindsey Rich Steinmetz, Valdysia Buffa, and David Storment, we examined the review process of NEPA. We identified 28 solar projects that underwent an environmental impact statement in compliance with federal law, spanning from 2009 to 2021 (Figure 1). We believe that these 28 projects account almost all the utility-scale solar projects for which an environmental impact statement was completed over this period. These NEPA projects account for less than 10 percent of the utility-scale solar projects that reached operational status in this period; most solar projects are located on state or private land and don't need to undergo the NEPA review process.

On average, environmental impact statements for the 28 projects took around 2.5 years—over 2 years less than the average time (4.5 years) for all environmental impact statements across all federal agencies. Our working paper shows that two-thirds of the projects completed the formal NEPA review process within 2 years (light blue bars)—a deadline adopted in the Fiscal Responsibility Act of 2023.

However, for more than half of the projects, a total of 7–10 years elapsed between the initial application for development and the initial application to notice of intent Notice of intent to record of decision Record of decision to operational Pending operation Project terminated 2008 2009 2010 2012 2014 2016 2018 2020 2022

Figure 01

Solar Projects That Completed Environmental Impact Statements Mandated by the National Environmental Policy Act between 2009 and 2021

Figure 01

A “notice of intent” is a public announcement of a forthcoming review under the National Environmental Policy Act with information about how the public can participate in the process. A “record of decision” explains the decision an agency made following the review process, any alternatives to the project that the agency considered, and how the agency plans to mitigate and monitor the environmental impacts that may result from a project.
Beginning of operation. The yellow and white bars in Figure 1 indicate delays in reaching operation after the completion of the NEPA review process. Additionally, 5 projects never reached operational status; the red-framed bars in Figure 1 indicate these projects.

We also evaluated 18 projects that completed an environmental assessment (a less demanding review process than the environmental impact statement) over the same time period. Of the projects for which we have data, assessments were completed in 1 year or less for one-third of the projects and within 2 years for another one-third of the projects.

A variety of factors contributed to these delays, which often occurred before or after formal NEPA reviews. The formal NEPA review is conducted less than 2 years after the initial application and involves a preliminary stage of refining and modifying the application. These modifications included shifts from concentrated solar technologies to photovoltaic technology, changes in ownership, and reductions in the planned production capacity and acreage of a project in response to concerns raised by federal agencies. The lengthy delays after some formal NEPA reviews may reflect difficulties that developers encountered in securing agreements to sell power to utilities and connect to the electric grid. Further research would help facilitate a more comprehensive understanding of the reasons for delays that follow NEPA reviews.

Speeding Up Solar Development on Public Lands in the West

Some agencies have more influence than others over the development of renewable energy projects, given the distribution of authority across federal agencies. For example, the US Bureau of Land Management (BLM) is responsible for much of the public land in the western United States and was the lead agency responsible for three-fourths of the environmental impact statements for the solar facilities in our sample.

The BLM received more than 150 applications for solar projects following the passage of a federal law in 2005 that established the goal of siting at least 10,000 megawatts on public lands by 2015. In response, the US Department of the Interior and the BLM have implemented several initiatives to try to expedite the review of applications for these leases. But available data indicate that the initiatives have had limited success, and developers continue to report delays in the BLM’s approval of leases.

The Western Solar Plan, which launched in 2012, was one of the agency’s major initiatives. The BLM identified 19 sections of public land in 6 southwestern states as suitable for solar projects. The agency determined that solar projects in these areas, known as solar energy zones, would be easy to connect to transmission lines for transporting electricity and have limited adverse social and environmental effects.

Implementation of the Western Solar Plan has proven to be complicated. The BLM took another four years to complete policy actions related to the plan, and the change in administration in 2017 resulted in further delays to the approval of new solar facilities. Under the Trump administration, the BLM reviewed past policy decisions about the broader use of public lands in the southwest and issues that were specific to solar development in the region. By December 2021, only two solar facilities were approved and operating in solar energy zones under the provisions of the plan.

The intent of the Western Solar Plan was for the agency to streamline the NEPA review process for individual solar projects by tying their approvals to prior NEPA reviews of earlier steps in the leasing process, such as the creation of broader land use plans and the designation of solar energy zones. However, additional measures, terms, and conditions to reduce potential environmental impacts could be identified through a final confirmation process, and the implementation of these measures would be required before the BLM allows the project to proceed.

Further, this approach has been vulnerable to delays that occur when the BLM carries out the procedures required for leasing parcels in the solar energy zones. Steps in this leasing process include completing necessary studies and evaluating the site, soliciting interest in parcels, providing notice about and conducting a competitive bidding process for the leases, and confirming that the selected developer’s plan aligns with the preapproved parameters for the parcel. Notably, the BLM has discretion over the timing of these steps.

Observations and Considerations for Future Policy

Looking Forward

The nation already may be behind schedule for reducing emissions from the power sector, compared to what analysts projected when the Inflation Reduction Act became law in 2022. Accelerating the development of solar energy facilities and other clean energy projects is imperative if the nation wants to meet US goals for reducing emissions. If policymakers want to speed up the energy transition, then NEPA reviews and other permitting processes deserve a careful look. First, the implementation of the plan involves several key steps. The delay associated with these steps has slowed the development of solar projects in the solar energy zones. Given the flexibility and discretion that are embedded in the leasing process for public lands, siting solar facilities on public lands probably won’t get significantly faster, even with the presumptive deadlines for formal NEPA reviews in the Fiscal Responsibility Act.

Second, interest has been limited in the land that lies in the original solar energy zones. Apart from some of the parcels in Nevada, parcels of land in these zones have received no bids or low bids from developers. Whether the agency’s selection of land reflects the most attractive locations for solar projects from the perspective of developers remains unclear. However, developers have proposed and received approval for projects outside solar energy zones in these southwestern states. If the BLM wants to promote project development on public lands, then the agency should consider facilitating more projects in areas outside solar energy zones.

Finally, the size of several solar energy zones is enough to accommodate only a single utility-scale solar project. Significant resources and time are required to designate an area as suitable for renewable energy development, and to take the additional steps to make the land available for auction. The BLM cannot expand the areas that are designated as suitable for renewable energy development, then the agency should prioritize larger areas that could accommodate multiple utility-scale projects.

Arthur G. Fraas is a visiting fellow at Resources for the Future.
Resources for the Future, we love breaking new ground when it comes to energy research—and we recognize the importance of unplugging from technology to replenish our mental batteries. The garden team literally breaks new ground to create our own fuel with the most original of energy inputs: the sun! Our rooftop garden provides an avenue for us to attentively nurture plants; share memories with colleagues (see the gigantic sweet potatoes); and, of course, reap the fruits of our labor. Much like our research, the garden would not function without its team of passionate individuals who deliberately work toward a common goal. And, in this case with our garden, we know that delicious snacks are guaranteed.
Crossed Wires: Modernizing the US Electric Grid

The Biden administration aspires to eliminate all carbon emissions from electric power production by 2030, mainly by substituting wind and solar for coal and natural gas. And that’s just the beginning: By substituting clean electricity for fossil fuels throughout the economy, the US government aims to achieve net-zero carbon emissions by midcentury—meaning that enough carbon dioxide will be removed from the atmosphere to offset any remaining emissions from human activity. Give the president credit for audacity. The Biden administration seeks to transform the massive, capital-intensive electric power sector in a little over a decade and to reshape all US energy use in less than three. But this is not mission impossible; it’s technically feasible, even on that ambitious timeline.

One major hurdle, though, could prove a deal-breaker. Increasing the role of electricity in transportation, heating buildings, and myriad other uses will increase electricity demand more rapidly than the overall rate of economic growth—which will require a disproportionate expansion of high-voltage transmission capacity. Indeed, a slew of studies agree that achieving net-zero emissions efficiently by 2050 will depend on increasing transmission capacity by at least 150 percent and perhaps by as much as 400 percent in less than three decades.

Although annual investment in US transmission roughly quadrupled from less than $5 billion before 2005 to as much as $25 billion since 2013, the sorts of investments in transmission that are needed to decarbonize the US electric power system at reasonable cost are substantially different from most of those made in the recent past. And these investments face more serious obstacles. Without fundamental reforms in planning and permitting, investments in cost-effective transmission can’t possibly keep up. Rapid economy-wide decarbonization still may be technically feasible, but the price tag probably would be politically unacceptable.
The Changing Role of Transmission

The Past

Failing from fossil fuel power generation to wind and solar power generation will require significant investments in the transmission system to connect wind and solar generators to the system, typically in areas that don’t have much existing transmission capacity. In the jargon of the business, this integration of power generators in the electric grid is called “interconnection.”

Historically, electric power was provided by regulated utilities or government enterprises, the only power providers in well-defined service territories. Each utility typically generated all the electricity in its service territory mainly by burning fossil fuels, delivering the power to customers over the high-voltage distribution lines and low-voltage distribution lines that it owned. The most efficient approach was to locate generators near the major demand centers.

In the 1960s and 1970s, transmission lines were built to link adjacent utilities, make electricity more reliable, and bring power from hydroelectric generators to demand centers. Regulating electric utilities was the job of state governments almost exclusively; centralizing power generation was a relatively small number of fossil-fuel-powered generators near demand centers, this process was relatively smooth.

The Present

Everything changed at the turn of this century. Investment grew in wind and solar power generation, thanks to a combination of federal subsidies, new mandates in many states for wind and solar energy, and dramatic declines in the cost of wind and solar power generation. Conventional gas-fired power plants, particularly the large coal-fired plants that had dominated production for decades, began to retire.

This rise in wind and solar power complicated the interconnection process in two ways. First, any utility-scale wind and solar power generation project must request lots of space and thus are far from where demand is concentrated. Second, utility-scale wind and solar power generation projects tend to produce less electricity than the fossil fuel–powered generators they’ve replaced. As a result, the number of connections between generators and transmission systems has increased in recent years, requiring_expensive upgrades to the transmission system. Moreover, connecting offshore wind generators involves building completely new underwater transmission networks and retrofiting the onshore transmission system.

The Interconnection Problem

Under FERC Order 845, issued in 2015, transmission system owners must make an interconnection request at the point of connection. If the request is approved, transmission owners can enhance overall reliability, increase the supply of energy, and reduce the average cost of power. Consequently, long-distance transmission of electricity (particularly interstates) has much greater value in systems that are dominated by solar and wind generation. Moreover, transmission owners that run primarily on fossil fuels. Planning investments in long-distance transmission at the national level will be necessary for an efficient, reliable national grid, however, no government entity has responsibility or authority for national-level transmission planning.

Despite their growing importance, new long-distance transmission lines were completed at a rate increasing more than twice as fast as the need for new connections was limited to relatively small number of fossil-fuel-powered generators near demand centers, this process was relatively smooth.

The Present

Beginning in the late 1990s, electric power systems in many parts of the country were restructured. Power generation was decoupled from transmission, and organized wholesale electricity markets for electricity were established. The ISOs that serves electricity demand. The ISO that serves over time to manage transmission systems and interconnections with the rest of the country. Moreover, being interconnected can enhance overall reliability, increase the supply of energy, and reduce the average cost of power. Consequently, long-distance transmission of electricity (particularly interstates) has much greater value in systems that are dominated by solar and wind generation. Moreover, transmission owners

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Connecting generation capacity at one point may require upgrades to relatively distant transmission lines. So, the process of assessing whether those local access costs can be quite complex—and easily disputed.

Applicants can withdraw from this process at any time and at little cost. So, a project developer has strong incentives to submit multiple interconnection requests for different interconnection points as early as possible. Applicants can simply walk away for any reason.

Between 2014 and 2022, interconnection requests nationwide increased by a factor of four in terms of generating capacity. At the end of 2022, the total proposed capacity of projects with active interconnection requests reached nearly 100GW. Most of those proposed projects will never get built. Of the projects with approved contracts (in terms of capacity) were completed by the end of 2022, in large part because most project applications were withdrawn. Fully 71 percent of the interconnection requests made in 2014–2017 were withdrawn by the end of 2022.

These withdrawals slow everything down. When one project interconnection request is withdrawn, it leaves voids in the schedule for projects that follow in the queue typically need to be realigned. Numerous withdrawals in recent years have contributed to the decision to spread the median time between interconnection request and interconnection agreement from less than 20 months in 2013 to around 35 months in 2022.

Recent Response from the Federal Energy Regulatory Commission

Under FERC Order 2023, adopted in July 2022, to have the right to build on the site it proposes to use and to post a deposit. Developers then may apply to be included in a cluster of projects that get included together, with the aim of reducing repetitive reevaluations of costs. Order 2023 also provides general rules for allocating the costs among members of a cluster. Transmission providers are obligated to show developers where interconnection capacity is available without major upgrades to the system, and that they can meet most strict deadlines for study completion.

Nationwide implementation of Order 2023 likely will shrink the queues of interconnection requests. But this policy ensures that the interconnection process will remain purely reactive and incremental, making it a poor vehicle for efficient expansion of the nation’s transmission grid. However, developers that have adopted many of the reforms in Order 2023 nonetheless still have long queues.

Alternative Approach to Interconnection

A better way is possible. An alternative, proactive process was applied in the highly interconnected states in the Midwest and on the East Coast Energy Zones (CREZ) transmission project in Texas. In 2001, the Texas legislature ordered the Public Utility Commission of Texas to plan and supervise the construction of utility-scale wind and solar power generation capacity by demand by developing a transmission upgrade can go forward. An interconnection agreement is signed, and the transmission upgrade can go forward. Applicants can withdraw from this process at any time and at little cost. So, a project developer has strong incentives to submit multiple interconnection requests for different interconnection points as early as possible. Applicants can simply walk away for any reason.

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high-voltage lines across all Texas ratepayers and by granting authority to a single agency (the Public Utility Commission of Texas) with the power of eminent domain.

Other ISOs have begun to follow this model of planning the expansion of transmission lines to accommodate the new power generation that’s expected.

The Long-Distance Problem

In 2005, a prescient US Congress attempted to bulldoze the barriers of this decentralized approach by empowering the US Department of Energy to designate National Interest Electric Transmission Corridors. If a state failed to approve a proposed transmission project in one of these corridors in a timely fashion, FERC would have the authority to compel the project. But the courts effectively gutted this authority, which has been moribund since 2011.

In 2011, the law was amended to give FERC siting authority for corridor projects that had been rejected by one or more states. The Department of Energy and FERC currently are developing rules that would give FERC's recently reinvigorated backstop siting authority to coopt the project. But the courts effectively gutted this authority, which has been moribund since 2011. In 2011, the law was amended to give FERC siting authority for corridor projects that had been rejected by one or more states.

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The contrast between the system in the United States and the system in the European Union is dramatic. In the European Union, an expert agency called the European Network of Transmission System Operators for Electricity prepares development plans that span 10-year periods and the entire European Union. The agency has the authority to accelerate important projects that cross national borders.

The permitting problem for long-distance projects like SunZia may be as least as important and difficult to solve as the problem of planning an efficient national transmission system. Getting the permits to allow SunZia to begin construction in 2023 reportedly required 17 years and involved 10 federal agencies, 5 state agencies, 9 local authorities. Moreover, the route of the transmission lines was changed many times during construction. The boundaries of these stakeholders, becoming circuitous in the process. The implications are ominous: if a long-distance transmission line proposed in 2023 could not even begin construction until 2040, then decarbonization will happen much too slowly for the United States to reach its midcentury goal.

Another source of long delays is lawsuits that charge environmental violations. The issue is not whether the lawsuits filed against any project have merit; serious claims that a project violates environmental laws deserve their day in court or before a federal regulator. The problem is that the litigation is time-consuming and incremental. As a result, costs will be higher than they could be if transmission providers would follow the CREZ model and proactively build high-capacity lines that can integrate wind and solar power generation. Several ISOs are moving in this direction. Another helpful step would be for FERC to require all regional transmission managers to follow suit.

Business as usual clearly cannot produce an efficient national transmission system; comprehensive interregional planning is necessary. But despite FERC’s initiatives, such planning is rare, and plans that cover more than one FERC region do not exist. As in the European Union, a single agency with the power and responsibility to get the job done would help—and would require a substantial concentration of authority. Even with such an agency, the permitting delays for long-distance transmission projects can be without end because the transmission lines would remain a formidable barrier.

With sufficient political will, the US power sector can decarbonize by 2035, and the United States can reach net-zero emissions by midcentury. With sufficient political will, the US power sector can decarbonize by 2035, and the United States can reach net-zero emissions by midcentury.
Economy-wide decarbonization requires large-scale decarbonization of the electricity sector. Hence, large-scale advance planning to expand transmission capacity and boost renewable power sources may be needed. But let’s look at trade-offs to be navigated.

To address this need for expansion, regulators and many decarbonization advocates have proposed replacing the currently incremental, request-based method with a different process for expanding transmission through large-scale, long-term planning. The potential downside is that this kind of planning could adversely affect competition in electricity generation. The benefits of that competition—namely, cost-based pricing and fostering entrepreneurship through independent choices—have justified policies for more than three decades that bring competition to wholesale generation. Proposals to introduce collective planning may sacrifice these benefits that competition brings. Large-scale, long-term transmission planning can come with trade-offs.
The costs of limiting competition among power generators may be mitigated within the transmission-planning policy itself. For example, the transmission planning process could be flexible enough to vary plans as market conditions warrant. Public research funding may be needed to make up for any attenuated incentives. Decarbonizers must recognize that the longer the planning horizon, the more likely are expensive and politically controversial mistakes. And ensuring buy-in from all affected parties may require effective carbon pricing, so the monetized benefits of decarbonization can cover the costs of expanding transmission.

Why Might Policy Intervention Be Necessary?

Simple economics suggests that new transmission lines presumably would be built only if they were profitable or if expanding the capacity of current lines exceeds the costs of doing so. If such lines are not being built, then something must be standing in the way.

A first step in understanding the need for transmission policies and how to design them is to see if the historical record supports claims that something prevented the construction of beneficial lines. In its justification for Order 1000 in 2011, the most recent major prior federal inter-state transmission planning, the Federal Energy Regulatory Commission (FERC) found that “the narrow focus of state planning requirements and shortcomings of current cost-allocation practices create an environment that fails to promote the most efficient and cost-effective development of new transmission facilities,” a claim much like the arguments made today in favor of proactive national transmission planning.

At that time, FERC did not provide much of a record of failure. The agency included no examples of transmission lines for which the expected benefit exceeded the expected cost. It might seem that a transmission plan would be flexible enough to vary plans as market conditions warrant. Public research funding may be needed to make up for any attenuated incentives. Decarbonizers must recognize that the longer the planning horizon, the more likely are expensive and politically controversial mistakes. And ensuring buy-in from all affected parties may require effective carbon pricing, so the monetized benefits of decarbonization can cover the costs of expanding transmission.

For instance, long-term planning should be necessary to decarbonize the US economy. For over 25 years, a primary objective of national energy policy has been to promote the more efficient and cost-effective transmission, the Federal Energy Regulatory Commission (FERC) found that “the narrow focus of state planning requirements and shortcomings of current cost-allocation practices create an environment that fails to promote the most efficient and cost-effective development of new transmission facilities,” a claim much like the arguments made today in favor of proactive national transmission planning.

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At that time, FERC did not provide much of a record of failure. The agency included no examples of transmission lines for which the expected benefit exceeded the expected cost. It might seem that a transmission plan would be flexible enough to vary plans as market conditions warrant. Public research funding may be needed to make up for any attenuated incentives. Decarbonizers must recognize that the longer the planning horizon, the more likely are expensive and politically controversial mistakes. And ensuring buy-in from all affected parties may require effective carbon pricing, so the monetized benefits of decarbonization can cover the costs of expanding transmission.

For instance, long-term planning should be necessary to decarbonize the US economy. For over 25 years, a primary objective of national energy policy has been to promote the more efficient and cost-effective transmission, the Federal Energy Regulatory Commission (FERC) found that “the narrow focus of state planning requirements and shortcomings of current cost-allocation practices create an environment that fails to promote the most efficient and cost-effective development of new transmission facilities,” a claim much like the arguments made today in favor of proactive national transmission planning. 
What’s coming up for energy and the environment in this major election year? Here’s a digest of the headline topics that speakers at Resources for the Future have discussed recently.

The experts quoted in this article include:

- Vicki Arroyo: Associate Administrator for Policy at the US Environmental Protection Agency
- Lisa Heinzerling: Professor at Georgetown University
- Joseph Majkut: Director of the Energy Security and Climate Change Program at the Center for Strategic and International Studies
- Robinson Meyer: Founding executive editor of Heatmap and a contributing opinion writer for the New York Times
- Karen Palmer: Senior fellow at RFF and director of RFF’s Electric Power Program
- Rich Powell: CEO of Clean-Energy Buyers Alliance and former CEO of ClearPath
- Kevin Rennert: Fellow at RFF and director of RFF’s Federal Climate Policy Initiative

Resources for the Future (RFF) stays on top of the most important developments in energy, the environment, and natural resources, particularly in the climate policy space.

RFF’s ongoing events and weekly podcast help bring perspectives together on these topics; this article shares insights from seven experts who have visited RFF’s venues to discuss what developments they’re watching this year. With 2024 being the fourth year of the Biden administration and a presidential election year, the stakes are high for policy planning and strategies in 2024 and beyond.

So, what’s coming up for energy and the environment? Here’s a digest of the headline topics that speakers at RFF have discussed recently.

What to Watch …

… in the Year Ahead
Making a lot of stuff requires a lot of energy. We want to move manufacturing back into the United States, where we want to be at the technological frontier for microchips, clean energy goods, and pharmaceuticals. It’ll be interesting to see how much of this renaissance of manufacturing will change our energy forecasts, our energy needs, our plans for decarbonization, and fundamental energy reliability.

Take the case of Texas from the last couple years: Because of its population trends and economic growth, the power system there has gotten strained. It’s failed at different times and is still at fairly high risk. This situation may become the story for a lot of the United States, where we want to be at the industrial and power sectors. If 45V is both a broadly used and broadly supported credit going forward.

This tax credit is significantly open to litigation risk because of some of the very counterintuitive interpretations of the statute that were taken in its crafting. I’m particularly talking about whether existing nuclear plants can take advantage of the credit in the way that the statute explicitly says they can: a requirement was added in the Treasury’s regulations to establish that these plants are necessary to meet demand for energy. I’m thinking particularly about whether existing nuclear plants can take advantage of the 45V credit. For example, the Infrastructure Investment and Jobs Act incentivized hydrogen production, research, development, and demonstration programs at the US Department of Energy. The act also appropriated $9.5 billion to commercialize hydrogen production and create foundational regional clean hydrogen hubs, including four that would use nuclear energy for hydrogen production. The tax credit was meant to complement the policies in the Infrastructure Investment and Jobs Act and boost the economic potential of hydrogen.

The challenge for the United States, when you think not just the framing of energy security and geopolitics, but that critical mineral supply chains are almost wholly dominated by China. This challenge has been an interesting, under-the-radar trend that we might see more of going forward: how resource-rich countries capture value from the resources they have and that they know the world needs going forward.

Relatively, we need to think carefully about the role of the United States in the global energy system. I’m thinking particularly about expanding US export capacity for liquefied natural gas, which is going to be a big political debate over the coming years because, in the aftermath of the European energy crisis, we’re seeing a huge expansion of that capacity. The United States plays a significant role in global energy security yet the role comes with climate implications and potentially domestic-market implications. I think that’s going to be a big conversation—we’ll see different dynamics arise over time, and that’s something to watch in the coming year.

Robinson Meyer: I think the United States is already busy playing catch-up. China and Europe have no problem actively subsidizing industries through all kinds of means. They see these industries as part of their industrial policy—China, especially. So, the upcoming election does not necessarily determine the path that the United States follows in terms of its decarbonization, but also the role of US firms and the US economy in global decarbonization more broadly. And that’s a very big deal. Climate is very much going to be on the ballot.
Social Cost of Carbon

Kevin Bennet: As a part of the oil and gas rules that were finalized last year, the Environmental Protection Agency updated its social cost of carbon, which is the metric that federal agencies use to quantify the benefits or costs related to emissions increases or decreases. This update to the social cost of carbon, which was based on the current state of the science, revised the number substantially upward. What are the implications of that change?

Vicki Arroyo: The updated estimate nearly quadrupled the social cost of carbon to roughly $110 billion through 2038. The Environmental Protection Agency has been struggling with this estimate for many years, and it’s really driven by the science. The science is getting better, the models are getting better. We are moving forward with plans to ban per- and polyfluoroalkyl substances as hazardous substances under Superfund, and move forward with the PFAS drinking-water rule. That’s just the tip of the iceberg, but those are some of the regulatory developments coming up.

New Regulations and Policies

Rich Powell: All the incentives in the Inflation Reduction Act occur in an environment in which permitting at all levels is a devastating problem. Federal environmental reviews, federal-state permits, regional interconnection queues, state and local technology-specific zoning and setback requirements—all these things are having a massive drag effect on deployment of clean energy technologies alongside very high interest rates. We actually can get a bipartisan legislative deal on permitting reform. I was heartened by some remarks in January from Senators Joe Manchin (D-WV) and John Barrasso (R-WY) they said they’re hoping to pave the way for a deal that may be possible by the end of this year. I certainly hope that’s the case and we’ll be able to move forward on permitting that this year probably is slowing the pace at which the promises of the Inflation Reduction Act will be delivered.

Supreme Court Decisions

Vicki Arroyo: In 2014, the US Environmental Protection Agency is going to launch big programs that invest billions of dollars in clean cars, zero-emission heavy-duty vehicles, improved methane monitoring, and capping abandoned wells. We will finalize several regulatory actions over the energy- and environmental-policy landscape in the coming year. In particular, one of the most important things that was finalized last year, the Environmental Protection Agency updated its social cost of carbon, which is the metric that federal agencies use to quantify the benefits or costs related to emissions increases or decreases. This update to the social cost of carbon, which was based on the current state of the science, revised the number substantially upward. What are the implications of that change?

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Kevin Remore: The courts will have a big say over the energy- and environmental-policy landscape in the coming year. In particular, one of the most important things was finalized last year, the Environmental Protection Agency updated its social cost of carbon, which is the metric that federal agencies use to quantify the benefits or costs related to emissions increases or decreases. This update to the social cost of carbon, which was based on the current state of the science, revised the number substantially upward. What are the implications of that change?

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Technology Trajectories

Clean Energy

Robinson Meyer: Solar manufacturing in the United States is doing very well. There’s this great chart that uses Q3 in 2022 as a baseline and shows the before and after. What you see is that solar installation is taking off. Solar already was going at a fast clip before the Inflation Reduction Act passed. It’s continuing at an even faster clip, which is kind of expected. All these bounties are being paid directly, and a relatively small number of companies can take advantage of them—and we know those companies are taking advantage of them.

Battery manufacturing is doing quite well, too. That’s exactly what we see in the factory data and the industrial data, as well. Just enough points of investment so that the electric vehicle “Battery Belt” is being built over time.

Where it then starts to get a little slower is wind energy, both offshore and onshore. Last year wasn’t a great one for wind energy. Just the three largest offsite contracts signed for carbon management would have more net effect on emissions reductions than all the electric vehicles that currently are on the road in the United States. We saw multiple billion-dollar acquisitions of companies that will provide either carbon-capture technologies or provide carbon dioxide movement and storage infrastructure, as well. I think the expansion of the 45Q tax credit is helping, as well.

Electric Vehicles

Joseph Majkut: I’ll be very interested to learn more about what states are doing on electric vehicle deployment. One of the biggest uncertainties in the medium term for climate and energy issues is, how quickly does the American consumer embrace electric vehicles—everything from e-bikes to the Cybertruck? I’m quickly about what states can do to accelerate uptake, what consumers really need to see for demand to increase, how states will deal with balancing the electric grid and charging stations, and all the other things that have to be financed to create a full ecosystem for electric vehicles. This is an area in which I think states have a lot of authority. Some states clearly want to have a leadership position in this space, so I’ll be watching for that in the coming year.

Vicki Arroyo: A good example is the US Postal Service. The Environmental Protection Agency has a unique role in reviewing and commenting on environmental impact statements from other federal entities. In combination with White House efforts and incentives in the Inflation Reduction Act, the Environmental Protection Agency helped move the Postal Service from purchasing electric vehicles as 10 percent of their fleet to 62 percent, in part because the agency urged the Postal Service to evaluate and consider the true benefits of shifting to electric vehicles for their government fleet.

Interest Rates

Rich Powell: First and foremost, capital is the fuel that will power the clean energy transition. And capital is extremely expensive right now. For every 50 basis points of additional interest rates that a project has to deal with, the cost of the project doubles. We’ve seen 50 basis points added to interest rates as a measure to control inflation. And while that regime remains in place, clean energy will be much more expensive, whereas I think our entire policy space and policy advisory space became very comfortable over the last decade in a world of extremely cheap capital. We had the idea that we were going to constantly see the learning curves come down for all these technologies. And that expectation then became built into all the models that we all use for decisionmaking.

We’ve seen a hard asymptote. In fact, we’ve seen a number of technologies come back up that curve—offshore wind and onshore wind, in particular. We need to get overall spending under control, so we can get inflation under control, so we can start to bring interest rates back down. That’s the most important thing for the clean energy transition.

Picking a President

Robinson Meyer: The biggest decision of all in 2024 will be made by several hundred thousand voters who are concentrated in Arizona, Colorado, Nevada, Michigan, Wisconsin, Georgia, and maybe Ohio. As many of us know, it’s a hugely consequential election for energy and environmental policy. It’s an election that will determine not only the role that the United States takes with decarbonization in its own path—whether the United States meets Paris Agreement goals, US participation in international climate processes—but also the role that American companies and the American economy plays in the global decarbonization process.

What’s interesting about the industrial policy that the United States has embarked on, through the three big Biden-era statutes, is that in some parts of this policy, we’re playing catch-up, for instance, with growth in electric vehicles. But in some areas, the United States is at the technological frontier—say, in software. These different areas require very different kinds of policy playbooks. I think it’s the areas where we’re playing catch-up that could be most at risk in a future administration.

Elizabeth Wason is the senior manager, editorial, at Resources for the Future.
Thinking about Giving, Impact, and the Future

Resources magazine recently spoke with Resources for the Future (RFF) Board of Directors Member Barbara Kates-Garnick, who is a professor of practice and senior research fellow at the Fletcher School of Tufts University. She previously served as the undersecretary of energy and as a public utility commissioner for the Commonwealth of Massachusetts, a corporate officer at a major US utility, and a consultant on strategic energy initiatives. Below are excerpts from the conversation, which covered Kates-Garnick’s approach to philanthropic giving and the importance of looking at problems holistically.

Barbara Kates-Garnick: I was first introduced to RFF when I was a graduate student, and I relied on RFF to provide an analytical framework for the work that I was doing—and, I feel like I’ve been part of the organization indirectly for many, many years. Linking the environment and energy has been important for my entire career. This linkage continues to be important as new actors, players, and imperatives move the energy transition forward. For me, my interest in these topics revolves around my passion for future generations.

Given that you’ve worked in the energy and environmental fields in different sectors—government, academia, and elsewhere—what would you describe as the role for RFF’s independent research and analysis?

RFF is critical for understanding the nexus between environmental policy, energy policy, and a successful energy transition. I think RFF is a “crown jewel” that helps decisionmakers in Congress, the federal government, the states, and the private sector as they all wend their way through very complex problems of long-term duration.

This issue of the magazine focuses on the future of the US electric grid. What do you think RFF brings to the table on this key part of decarbonizing the economy?

The issue of electric grid transmission is critical to the energy transition. By unpacking the various aspects related to grid infrastructure, RFF is bringing to the forefront of consideration a knowledge of economics and an understanding of the significance of equity. RFF looks at problems holistically—from the perspective of the states, the federal government, economics, and industry. All of that comes together in RFF’s work.

What do you think makes RFF special?

The quality and depth of analysis are what sets RFF apart from other organizations. When you look at RFF research, you know that you are getting analysis that’s driven by facts and experience. It all comes back to the excellent RFF researchers who are engaged in the studies and dive into connecting the complex pieces of multiple topics.

You and your husband Marc have been donors to RFF for the past four years. When you consider your philanthropy, do you use any particular criteria to help shape your approach to giving?

When you think about giving, you must consider impact, and you must think about the future. These are important criteria that Marc and I use when we decide how to direct our philanthropic giving. I can think of no better place than RFF to support in the energy and environmental fields, based on RFF’s impact, its analysis, and the fact that it is evenhanded in how it approaches complex problems, which makes it an enduring institution.

What’s the first thing that comes to mind when you think about the impact of your financial investment in RFF?

First, I think about the researchers, I think about the hard work that they are doing to unpack highly complicated decisionmaking. In giving to RFF, I feel strongly that we are directly supporting the research and the people who are designing the studies and writing the papers. For me, that is the real pleasure and joy of directing our philanthropic dollars to RFF.

Resources: Let’s start out by asking what brought you to RFF. Why are you interested in improving environmental decisionmaking?

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3. Give through a donor-advised fund
   Donate through a DAF account at a community foundation or financial institution to support RFF while receiving favorable tax benefits.

4. Give through a will, trust, or gift plan
   Include RFF in your estate plans to provide meaningful, long-lasting support.

Discover other ways to give at rff.org/wesupport or contact Ryan Sabot at rsabot@rff.org
In Focus

The video series In Focus gives researchers at Resources for the Future (RFF) a platform to share insights related to current events in energy and the environment. The series launched in 2022; since then, In Focus videos have tackled topics that range from climate optimism to carbon dioxide removal.

Transcribed here is a video featuring Molly Robertson, a senior research associate at RFF. Robertson discusses how challenges in transporting electricity on the US electric grid may affect the clean energy transition. Renewable energy sources such as wind and solar often need to be located far from the centers of demand for electricity, and the construction of new transmission lines that connect electricity to consumers tends to be slow: costs and complex permitting processes can present obstacles to grid expansion.

Robertson shares various policy solutions that can help facilitate the build-out of new transmission lines—relevant insights, given that the Federal Energy Regulatory Commission, the federal agency that regulates the transmission of electricity across states, is working on a new regulation that could help accelerate the expansion of the grid.

This In Focus video was originally released on May 13, 2024. The transcript has been edited for length and clarity.

Connecting People to Clean Power

TEXT Molly Robertson, Annie M. Tastet, and Matt Fleck

The clean energy transition is likely to strain infrastructure on the electric grid in the United States in a couple of key ways.

The first way relates to electrification. We anticipate that the grid system will experience a lot more demand as sectors like transportation and buildings transition to using electricity, so the existing electric grid and existing transmission lines will have to transport a lot more electricity.

The other way relates to cleaning up the mix of sources of electricity generation and the power sector itself. As we move to a clean energy system, we’re going to see a lot more wind and solar on the grid.

New wind and solar can’t just be plugged into the grid wherever the connections to the grid already exist or where demand for electricity is highest. You have to look for places where the sun and the wind are available to be captured. We’re going to have to build generation in the places where that generation is most beneficial and transport the electricity. That sitting means that we’ll need more transmission lines that don’t currently exist.

Policymakers increasingly are becoming interested in solving this problem. A lot of proposals have been raised that potentially could deploy additional transmission lines. The first is tax credits for new transmission lines. A second is minimum electricity-transfer requirements between regions that would require new transmission to be built. The third is enhanced planning processes that would require regional transmission operators to think far in advance about transmission needs, where new generation and new electricity demand will grow, and how to connect those critical points of generation and demand.

We’re still waiting to see exactly how transmission policy will shape up, but a lot of people are thinking critically about how to solve these problems.

Photo Mike Harrington / Getty Images

Invest in a Healthy Environment

Support Resources for the Future (RFF) and join a diverse group of visionary leaders who value independent analysis and innovative solutions for solving the climate challenge.

“RFF is by far the leading economic research institute on the environment—and when I say that, I’m talking about the people. For me, engaging with RFF is a way to learn and to interact with people. And to this day, if I have questions about economics of the environment—in particular, climate—RFF is the place to go.”

Richard Schmalensee
Howard W. Johnson Professor and Dean Emeritus, Sloan School of Management, Massachusetts Institute of Technology; Chair Emeritus, RFF Board of Directors

“I see the value of RFF’s independent research in encouraging balanced decisionmaking. It’s important that decisionmakers have access to information that is fact based and independent, done by highly capable and committed individuals.”

Vicky A. Bailey
Founder and Principal, Anderson Stratton Enterprises, LLC; Co-Vice Chair, RFF Board of Directors

“RFF has experience, a track record, and smart people who are committed to moving the policy needle.”

Robert Litterman
Founding Partner and Chairman of the Risk Committee and Climate Policy, Kepos Capital LP

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