GREEN ENERGY AND ECONOMIC FABULISM

Jonathan Lesser

The Global Warming Policy Foundation
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About the author

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Summary

The Inflation Reduction Act (IRA) has expanded the availability of subsidies for green energy, especially investment tax credits. Over the next ten years, direct spending is estimated to be more than $1 trillion. However, given rising US deficits, much, if not all, of the tax credits for green energy, especially wind and solar, will be financed with additional debt. The resulting interest payments will add several trillion dollars to the overall cost of these subsidies.

In addition to claims that these subsidies will address climate change, a primary justification for this increased spending is the idea that it will increase economic growth and provide millions of new jobs in green industries. The economic reality is far different, with the subsidized costs of these jobs far exceeding the actual salaries of workers who may be hired. For example, based on several offshore wind developers' estimates of the numbers of jobs their projects will create, the subsidies average between $2.2 million and $2.4 million for each job *per year*.

The staggering amounts of money made available for green energy subsidies under the IRA, far more than even was spent by the government during the Great Depression, will have long-lasting and adverse consequences on energy supplies, economic growth, and the well-being of the citizenry. Under the IRA, the subsidies on offer will continue until carbon emissions decrease by 75% below 2005 levels. Only then will they gradually decrease.

Based on the Administration's estimates of the amounts of wind and solar capacity needed to reach that goal, the investment tax credit (ITC) subsidies will total over $1 trillion, even if the inflation-adjusted costs of those resources fall by 40% over the next 20 years. If, instead, the inflation-adjusted costs of those resources remain constant over time, then the ITC subsidy alone would exceed $3 trillion. If US interest rates increase as the country's deficit soars, the subsidy alone could exceed $4 trillion or more. Production tax credits for wind generation will add hundreds of billions more to these totals.

The subsidies will further distort energy markets. They will crowd out more productive private investment and reduce the resources available for more efficient forms of generation, such as nuclear power, especially small modular reactors. As in Europe, the subsidies will result in higher energy prices, which will cause economic and job losses throughout the entire economy. These losses will far exceed the gains provided by the subsidies themselves. Thus, the net economic impacts on jobs and output will be negative.

Although some policymakers may choose to ignore basic economic principles in favour of political expediency and, in some cases, personal gain, those principles will not ignore them. Eventually, the profligate spending on costly, but low-value, green energy will collapse under its own economic weight. The unanswered question is how high an economic and social price the US will pay for this folly before that occurs.

1. Introduction

Since the first OPEC oil embargo a half-century ago, the United States – at both the federal and state levels – has enacted a variety of policies designed to develop new energy technologies and 'solve' various energy-related 'crises'. The initial energy 'crisis' was seen as US dependence on foreign crude oil (even though basic economics demonstrates that the OPEC embargo was self-defeating, which is why it collapsed just months after it began), together with forecasts of domestic resource exhaustion. Thus, it was not surprising that US energy policies first focused on development of non-existent technologies, called 'moonshot' programs, such as the manufacture of 'synthetic' crude oil and electricity generation via controlled nuclear fusion, as if entirely new technologies could be created by legislative fiat. Subsequently, they turned to policies that subsidized alternative energy resources.

Today, dependence on foreign crude oil is no longer a stated policy concern. In fact, energy policies enacted under the Biden Administration have restricted domestic crude oil (and natural gas production), as well as access to uranium supplies, through the recent designation of a new national monument in Arizona that will place almost one million acres of land off limits to mining.

Although policies to subsidize renewable energy resources, particularly wind and solar, and 'low carbon' resources, such as biofuels, are not new, they have been enhanced under the Biden Administration, notably through the ill-named Inflation Reduction Act of 2022 (IRA), as well as federal administrative agency rules and individual state government actions.

This report focuses on subsidies for green energy resources. Although the largest of these is the federal investment tax credit (ITC), which is available to numerous technologies, the US government also provides a production tax credit (PTC) for wind energy developers and for 'green' hydrogen production.[1] In addition, there are tax credits for the purchase of electric vehicles and chargers, development of carbon-capture facilities, and subsidized loans for manufacturers of electric vehicles and their batteries, to name but three. The list is seemingly endless.

Nor are subsidies limited to monetary payments. There are increasingly stringent federal mandates to reduce GHG emissions, such as the recent Corporate Average Fuel Economy standards enacted by the US Department of Transportation, mandates for production of corn ethanol and 'advanced' biofuels, and mandates proposed by the US Environmental Protection Agency (EPA) to reduce carbon emissions from fossil fuel based electricity generating plants.

Subsidies and mandates have also been enacted in numerous states. The most common monetary subsidies are additional tax credits for the purchase of electric vehicles and the related charging infrastructure. For states developing offshore wind projects, monetary subsidies take the form of long-term power purchase agreements at above-market prices, tax credits, and subsidized construction staging facilities, along with tax forgiveness for new manufacturing facilities. Numerous states also provide loan guarantees and property tax reductions. New York state has enacted a law to prevent rural communities from objecting to siting large-scale wind and solar projects.

As for mandates, since the year 2000, 28 states, plus the District of Columbia, have enacted renewable portfolio standards (RPS) that mandate that increasing percentages of electricity be derived from renewable energy resources. Some standards lump all renewables together, while others have separate mandates for wind and solar energy. More recently, numerous states have adopted various 'zero-emissions' mandates, similar to those adopted by California, which require that all electricity supplied to consumers be carbon-free by as early as 2035, mandates to ban the sale of internal combustion vehicles, and mandates to replace fossil-fuel space and water heating with electric heat pumps. Several states have also enacted carbon cap-and-trade programs (which they euphemistically call 'cap-and-invest' programs) to reduce carbon emissions and subsidize a variety of politically favored projects, such as investments in low-income and 'environmental justice' communities.[2]

The myriad green subsidies on offer raise several important economic questions. First, do their benefits exceed their costs? Answering that question requires examining all of the projected impacts of the subsidies and comparing them to the projected benefits, notably the economic value of the GHG emissions reductions they are supposed to engender, but also the additional benefits of reductions in air pollution and, arguably, accelerated development of new technology. Alas, such an analysis is far beyond the scope of this report, as it would require a comprehensive evaluation of estimates of the social cost of carbon,[3] as well as an evaluation of epidemiological studies of pollution exposure and the estimates of the statistical value of a life used by economists.

Instead, this report focuses on an oft-stated political reason to subsidize green energy: economic development and job creation. However, subsidy proponents ignore a basic economic axiom: it is impossible to subsidize an economy to bring greater economic growth and prosperity. The reason is that governments that choose economic winners and losers, in this case green energy technologies, invariably choose poorly because the choices made both lack the discipline of markets and frequently reflect political favoritism. Consequently, the costs of creating these 'green' jobs is enormous, especially for offshore wind projects.

There is also a broader economic cost associated with misdirecting public investments from those providing higher returns to green energy investments that have low or negative returns. The result is a reduction in economic well-being.

Finally, despite promises and assertions to the contrary, green energy subsidies raise the costs of electricity and fuels. Not only do these higher costs reduce economic output and jobs, far more so than the subsidies create, there is an additional moral component.

Specifically, subsidies for green energy impose disproportionate economic harm on lower-income residents and small businesses; in effect, green energy policies are forcing the least well-off in society to subsidize the most well-off, increasing economic inequality.

2. The persistence, scope, and expansion of green energy subsidies

Green energy subsidies and mandates are not new. They began in earnest as part of National Energy Act of 1978, used to promote the use of domestic energy resources, notably coal, as well as to develop renewable and 'alternative' energy resources and promote energy conservation.[4] The legislation offered subsidies for renewable generators, notably wind and solar, but also small hydroelectric facilities, geothermal plants, and biomass facilities. It also included subsidies for corn-based ethanol to be blended with gasoline.[5]

Although the initial rationale for renewable energy subsidies was to promote US energy independence, by the early 1990s improving environmental quality had become a second justification. Initially, the focus of environmental policies was emissions associated with fossil-fuel generating plants operated by regulated electric utilities, but it also included GHGs. To promote renewable energy, the Energy Policy Act of 1992 introduced the Production Tax Credit (PTC) for wind and biomass generating plants. Although designed to be a temporary incentive, the PTC has been repeatedly extended. The Act also made permanent the investment tax credit (ITC) for solar and geothermal generating plants.[6]

In the late 1990s, state efforts to mandate renewable generation, both to reduce emissions and promote economic development, began in conjunction with efforts to deregulate the electric utility industry. The mandates took the form of the Renewable Portfolio Standards (RPS), which require increasing percentages of electricity supplied to retail customers to be sourced from qualifying renewable resources.[7] By 2010, more than half of all US states had adopted some form of RPS.[8]

The US government introduced the first tax credits for electric vehicles as part of the Energy Policy Act of 2005, although initially the tax credits were limited to hybrid vehicles (those containing both an internal combustion engine and a battery pack). Those subsidies were increased in 2009, with passage of the American Recovery and Reinvestment Act. Those subsidies are maintained under the the 2022 Inflation Reduction Act (IRA). Today, the maximum federal tax credit for an electric vehicle is $7,500, subject to certain income limits. Many individual states also offer tax credits and grants, including for home chargers.

As the focus on climate change has increased, a number of states have begun imposing mandates aimed at reducing GHG emissions, either through legislation or via executive orders. These have now become all-encompassing, requiring the acquisition of specified quantities of wind and solar generation, or mandating electrification of fossil-fuel end uses, such as space and water heating. Many states have also banned the sale of light-duty internal combustion vehicles by 2035 and the sale of diesel trucks by 2045.

The IRA also expanded the magnitude and scope of green energy subsidies. Under the IRA, the base ITC is set at 30% of the capital cost of wind, solar, and battery storage projects.[9] An additional 10% tax credit is available for any projects that use content produced by US manufacturing facilities. Still another 10% is available for projects built in 'energy communities'; that is, brownfield sites, such as an existing coal-fired plant or mine, or areas where there is oil- and gas-related activity. There is also a 10% tax credit available for projects built in 'environmental justice' communities or on tribal lands.

Green energy projects are also eligible for accelerated depreciation, which allows them to reduce their income tax burden. Wind, solar, closed-loop biomass,[10] and geothermal energy are also eligible for a production tax credit, currently equal to $27.50 per megawatt-hour (MWh), and indexed to the rate of inflation.[11] As with the ITC, the PTC can be increased by an additional $6/MWh for projects which both have domestic content and are sited at brownfield locations. However, developers cannot claim both ITC and PTC credits; they must select only one.

Unlike most other green energy resources, offshore wind also benefits from long-term, above-market power purchase agreements (PPAs), which states have either forced their local electric utilities to sign or have signed themselves, as happened in New York State. In either case, the above-market costs are paid by electricity consumers. There are also indirect subsidies stemming from socialization of the costs associated with providing additional transmission facilities to interconnect wind and solar facilities, and the costs of supporting the dispatchable generation needed to compensate for wind and solar energy's uncontrollable variability. As the percentage of that generation increases, additional resources are required to provide back-up: either generators that remain on standby or battery storage facilities.

In total, the US and individual state governments provide thousands of subsidies (including policy mandates) for renewable energy.[12] For example, New York State has 97 separate programs, Texas has 114, and California has 155. These run the gamut from direct payments for electric vehicle chargers and behind the-meter solar photovoltaic (PV) systems, to sales tax exemptions and even enhanced access to high-occupancy vehicle lanes on highways.

Not surprisingly, the highest-dollar subsidies are those offered by the federal government, many of which were enhanced under the IRA.[13] These are summarized in Table 1. For offshore wind, state-level subsidies also include development of port facilities, such as the $500 million port in southern New Jersey and the $700 million wind port in New York built for construction staging, and subsidies for needed transmission interconnection infrastructure (undersea cables and substations to deliver the electricity to the transmission

grid), which likely will total several billion dollars, depending on how much offshore wind capacity is actually constructed.

The cumulative extent of the federal subsidies on offer for green energy and electricity equipment is staggering. According to an April 2023 study prepared by Goldman Sachs, the IRA will provide an estimated $1.2 trillion in subsidies over its first ten years.[14] However, the Goldman Sachs estimate excludes all financing costs associated with the government's continued deficit spending. The most recent estimate of the Federal deficit for FY 2023 is between $1.5 trillion and $2.0 trillion, and the Congressional Budget Office projects the deficit to increase to $2.6 trillion by 2033.[15] At the end of FY 2023, US government debt totaled $33 trillion,[16] exclusive of future entitlements, almost 30% greater than the $25.5 trillion US Gross Domestic Product in 2022.[17,18]

Although the Goldman Sachs analysis covers only the first ten years of the IRA, the tax credits do not end after ten years. Rather, they will reduce only after GHG emissions from electricity generation have decreased to 75% below 2022 levels. Under the US Energy Information Administration's (EIA) most recent 'reference case' forecast, published in its *Annual Energy Outlook*, that reduction will not be achieved by 2050 (the last year of the forecast period), and under the agency's most aggressive 'low carbon' forecast the reduction would not be achieved until 2046.[19]

Wind and solar generators continue to be the largest recipients of federal and state subsidies. Currently, state-level offshore wind mandates total 80,700 megawatts (MW),[20] led by California's 25,000 MW goal, which would be met with still more expensive floating turbines.[21] As of 31 May 2023, the US Government estimates the total offshore ' pipeline' to be about 53,000 MW, comprising projects under construction, approved, and undergoing federal and state permitting, plus projects with development potential in existing lease areas.[22] The EIA, on the other hand, forecasts a total of just 23,600 MW of offshore capacity by 2035, remaining constant thereafter, and 344,000 MW of utility-scale onshore wind by 2046.[23] As for solar PV generation, the agency's most recent estimate under the IRA scenario is 898,000 MW by 2046, including both utility-scale and small-scale, behind-the-meter generation.[24]

Total ITC subsidy for wind and solar under the IRA

Using the current EIA capital cost estimates for wind and solar generation, it is possible to calculate a lower bound for *future* ITC payments; that is, excluding the additional credits available for domestic manufacturing, construction on brownfield sites, and so forth. To bracket the installed costs and resulting ITC costs, I develop two scenarios. The first assumes no increase in nominal costs over time, which implies a 38% reduction in real (inflation-adjusted) costs between 2023 and 2046, assuming 2% average inflation. The second assumes no increase in inflation-adjusted costs, thus implying that nominal costs over the period increase by 58%.

Table 1: Major green energy subsidies in the Inflation Reduction Act

Subsidy	Resource	Description
ITC	Wind (onshore and offshore), solar, municipal solid waste, biomass, landfill gas, battery storage facilities	Base credit 30% of overnight capital cost (i.e. excluding all financing costs). Additional 10% for projects meeting domestic manufacturing requirements. Additional 10% for projects built in 'energy communities' (i.e. brownfield sites). Additional 10% for projects located in 'environmental justice' communities. Maximum ITC credit 60%. For projects placed in service after 1 January 2025, the base ITC is 6%, with an additional 24% for projects meeting requirements for apprentices.
PTC: Electricity	Same as ITC, except battery storage	PTC payments during first 10 years of operation. 2023 value: $27.50/MWh. Additional $3/MWh for projects meeting domestic manufacturing requirements. Additional $3/MWh for projects built in 'energy communities'. Maximum PTC: $33.50/MWh.
PTC: Clean Hydrogen	Manufacture of 'clean' hydrogen	Sliding scale payment for 10 years, maximum of $3.00/kilogram, based on greenhouse gas emissions. Note: if electricity from a qualifying generating facility is used to manufacture hydrogen, both PTCs can be claimed.
PPAs	Offshore wind	Long-term contracts, up to 25 years, pay developers a price that is higher than the wholesale market price.
Grants	High-voltage transmission lines	Over $20 billion for transmission upgrades, integration of EVs, and grid 'innovation'.
Cost socialization	Transmission system costs; system reliability	Intermittent wind and solar generation require back-up generation and storage to maintain system reliability. Costs are socialized across all utilities and their retail customers.
Residential Clean Energy Tax Credits	Solar panels, wind turbines, fuel cells, solar water heaters, battery storage	Federal tax credit of 30%, reduced to 26% in 2033 and 22% in 2034.
Carbon Sequestration Credit	Requires sequestration of carbon from electric generating plants and other facilities	Base credit of $17/metric ton and $36/metric ton for direct air capture, increased to $85/metric ton and $185/metric ton for facilities that pay prevailing wages, for the first 12 years of operation. Values adjusted for inflation after 2026.[64]

According to the EIA, through the end of 2022, installed solar capacity was just over 81,000 MW and onshore wind capacity was just over 145,000 MW. Total offshore wind capacity was 42 MW, consisting of the 5-turbine, 30-MW facility off Block Island, Rhode Island, and a 2-turbine, 12-MW project off the coast of Virginia.

The overall ITC costs will depend on how the tax credits are paid for through a combination of additional debt or higher taxes. The former adds to the deficit and incurs additional costs in the form of interest payments. The latter results in foregone private investment and thus reduces economic growth and wealth, which adds to their overall cost.

Estimates of the direct financing costs depend on a number of factors, including the coupon rate on government bonds and notes, expectations about future interest rates, which determine whether those bonds and notes sell at a discount to their face value (if interest rates are expected to increase) or at a premium (if interest rates are expected to decrease), and how the government refinances maturing debt.

A detailed discussion of the potential economic and financial impacts of continued deficit spending on interest rates is beyond the scope of this report. Instead, I make three simplifying assumptions. First, I assume that interest rates remain constant and, consequently, all US government Treasury notes and bonds sell at their face value. Second, I assume that the government refinances the ITC payments for wind and solar generation using one-year Treasury notes, which are refinanced when they fall due. I further assume that the interest paid to bondholders is refinanced, net of federal tax collections for the portion of debt held by the US public. (The Technical Appendix provides the details of the ITC financing calculations.) Finally, I assume that ITC payments end after 2046 and that all outstanding debt is then recouped solely through higher income taxes.

To estimate the finance costs, I assume constant interest rates between 5% and 7%. As discussed in the Technical Appendix, the average current yield for all US Treasury bonds is just over 5%. Prior to quantitative easing, which artificially suppressed interest rates from late 2008, the average yield on one-year US Treasury notes was 6.54% over the previous 40 years. The average yield on 10-year US Treasury bonds over that same 40-year period was 7.44%. Moreover, during that period, deficits as a percentage of US GDP were far smaller than today.

Table 2 shows the results. Under the first scenario, the overnight capital cost of the wind and solar capacity installed totals approximately \$1.78 trillion. The combined total of the 30% ITC and accompanying financing costs are between \$1.28 trillion and \$1.74 trillion, based on the 5% and 7% cost of debt assumptions, respectively. Under the second scenario, the overnight capital cost increases to about \$2.76 trillion and the ITC costs range between \$3.00 trillion and \$3.72 trillion.

As shown in Figure 1a, using an assumed 5% interest rate and financing solely with one-year Treasury notes, the additional

Table 2: Estimated investment tax credits for solar PV, onshore and offshore wind by 2046						
	Capacity				ITC ($bn)	
Resource	As at 2022 (MW)	In 2046 (MW)	Overnight capital cost (2023$/kW)	Installed cost ($bn)	At 30% ($bn)	With 100% deficit financing ($bn)
	[1]	[2]	[3]	[4]	[5]	[6]
Scenario 1: Constant nominal costs						
Solar PV	81,109	897,500	1,488	1,215	365	704–941
Onshore wind	145,178	345,000	2,156	431	129	250–334
Offshore wind	30	23,600	5,486	129	39	75–100
Total	226,317	1,266,100		1,775	533	1,028–1,375
Average ITC subsidy per kW:			$989–1,322			
Scenario 2: Constant inflation-adjusted costs						
Solar PV	81,109	897,500	1,488	1,608	482	885–1,161
Onshore wind	145,178	345,000	2,156	570	171	314–4122
Offshore wind	30	23,600	5,486	171	51	94–124
Total	226,317	1,266,100		2,349	705	1,293–1,696
Average ITC subsidy per kW:			$1,244–1,631			

[1] Source: EIA, Form 960.
[2] Source: EIA Annual Energy Outlook 2023, Table 16.
[3] Source: EIA, Cost and Performance Characteristics of New Generating Technologies, Annual Energy Outlook 2023.
[4] Equals: {[2] – [1]} × [3] .
[5] Equals: (0.3) × [4].
[6] Assumes ITC financed with 1-year US Treasury notes, at 5% (low) and 7% (high).

financing costs alone would be $496 billion. At an assumed 7% interest rate, the additional financing costs would increase to $842 billion. Hence, under the assumption of constant nominal capital costs, the total ITC costs would average between $43 billion and $57 billion per year. In Figure 3, where nominal capital costs are assumed to increase at the rate of inflation, total ITC costs would average between $54 billion and $71 billion per year. By comparison, total government spending during the New Deal was estimated to have been just over $800 billion in today's dollars.[25]

As shown in Table 1, under the first scenario, the overall ITC *subsidy* averages between $989/kW and $1,322/kW. Under the second scenario, the subsidies range between $1,244/kW and $1,631/kW. By comparison, the EIA thinks the average overnight capital cost for a new combined-cycle natural gas power station to be $1,367/kW. Hence, under these financing scenarios, which are, if anything, conservative, on a per-kW basis the ITC subsidies alone would be as large or larger than the entire overnight capital cost of a combined-cycle plant.

As discussed, these two scenarios encompass a wide range of capital costs, with the first scenario assuming a reduction in real, inflation-adjusted capital costs of 40% by 2046. If inflation rates are higher than the 2.35% assumed value used by the EIA, the reduction is even larger. For example, if inflation averages 3.0% per year, Scenario 1 would imply a reduction in inflation-adjusted costs of over 50% by 2046.

If one examines a recent analysis of the 'Net-Zero Pathway' using the so-called Rapid Energy Policy Evaluation and Analysis Toolkit (REPEAT), which was prepared by the Princeton University

Figure 1: Wind and solar costs

(a) nominal capital costs constant,
(b) real capital costs constant

'ZERO' Lab, the annual costs would be even higher.[26] The Net-Zero Pathway envisions a total of 915,000 MW of utility-scale and distributed (i.e. behind-the-meter) solar photovoltaics, 103,000 MW of offshore and 583,000 MW of onshore wind, and 283,000 MW of storage, all by 2035.[27] Using a similar analysis over a 13-year period – that is, assuming the ITC is financed through 2035, after which all costs are recouped with higher income taxes – the average ITC cost would increase to between $146 billion and $167 billion per year. Combined with the estimated $2.8 trillion overnight capital cost, the total costs for wind, solar and storage would be between $4.9 trillion and $5.4 trillion (excluding private financing costs), or between $405 billion and $426 billion annually.[28]

It is difficult to imagine that the government would increase taxes sufficiently to avoid the need to finance any ITC expenditures. Under the REPEAT analysis, total ITC payments to cover all the installed solar, wind, and storage assets, assuming no change in nominal costs, would be between $1.8 and $2.0 trillion between 2023 and 2035, or between $146 billion and $167 billion annually. Raising taxes by that amount, especially if the tax increases were limited to 'the rich', as many politicians like to claim, would surely have many adverse economic consequences. These are discussed in Section 4.

Green energy proponents claim, contrary to recent evidence, that renewable energy costs will nevertheless decrease significantly over time because of improved technology and, especially in the case of offshore wind, economies of scale arising from ever-larger turbines. Suppose, then, one assumes an average annual reduction in nominal overnight capital costs of 2% per year. Then, by 2046, those costs will have fallen by 40% in nominal terms below 2023 levels and by 65% on an inflation-adjusted basis using the EIA's assumed inflation rate of 2.35% annually.

Given the dependence of green energy on basic raw materials such as steel, cement, and rare earths, then barring some unknown technological advance, it is difficult to comprehend how capital costs would decrease to this extent. Yet, even so, under this highly optimistic scenario, the installed cost for solar PV, onshore and offshore wind would still be over $1.4 trillion, a saving of around $350 billion versus the constant nominal cost scenario, as shown in Table 3. The resulting ITC subsidy would still range between $859 billion and $1,167 billion, using the same 5–7% range of financing costs, and the subsidy would range between $826/kW and $1,123/kW.

Case study: offshore wind subsidies and the cost of green jobs

One current justification for green energy subsidies is the creation of new industries and accompanying 'green' jobs, which together will spur economic growth, or so it is said.[29] This is especially true for offshore wind projects, which require long-term contracts at above-market prices, in addition to ITC payments, if developers are

Table 3: Sensitivity analysis – assumed 2% annual decrease in nominal capital costs						
	Capacity				ITC ($bn)	
Resource	As at 2022 (MW)	In 2046 (MW)	Overnight capital cost (2023$/kW)	Installed cost ($bn)	At 30% ($bn)	With 100% deficit financing ($bn)
	[1]	[2]	[3]	[4]	[5]	[6]
Solar PV	81,109	897,500	1,488	973	292	588–799
Onshore wind	145,178	345,000	2,156	345	103	209–283
Offshore wind	30	23,600	5,486	104	31	63–85
Total	226,317	1,266,100		1,421	426	859–1,167
Average ITC subsidy per kW:			989–1,322			

[1] Source: EIA, Form 960.

[2] Source: EIA Annual Energy Outlook 2023, Table 16.

[3] Source: EIA, Cost and Performance Characteristics of New Generating Technologies, Annual Energy Outlook 2023. Reported in 2022$ and inflated using the GDP Implicit Price Deflator published by the Federal Reserve Bank.

[4] Equals: sum of annual payments based on annual capital cost of $(\$1{,}488) \times (0.98)^t$, where t = years after 2023.

[5] Equals: $(0.3) \times$ [4].

[6] Assumes ITC financed with 1-year US Treasury notes, at 5% (low) and 7% (high).

to commit to their construction. To examine the implicit costs of these subsidies, consider seven offshore projects slated for development along the mid-Atlantic coast, as shown in Table 4.

The developers of these projects all emphasize, among other benefits, the jobs they will create during both construction and ongoing operations. Ørsted, the developer of the Ocean Wind I windfarm, which is planned for the coast of New Jersey, claims the development will create 3103 direct job-years during the two-year construction period.[30] (A 'job-year' is economic jargon for one full-time-equivalent job for one year, hence two half-time workers employed for one year would be equivalent to one job-year.) They also claim it will require 69 full-time operations and maintenance (O&M) workers. Over an estimated 25-year project lifetime, that is the equivalent of 1,725 O&M job-years.

Calculating the subsidy amounts for each job-year entails estimating: (i) the ITC amounts for each project, including the additional costs to finance the ITC by issuing government debt;[31] and (ii) the subsidies embedded in each project's PPA cost relative to forecast wholesale market prices. (The details are presented in the Technical Appendix.)

Using the EIA's most recent estimates, the estimated overnight capital cost to construct these seven projects will be $51.4 billion, which implies an ITC of $15.4 billion. The additional ITC financing costs depend on the form of government financing. For example, if one assumes the ITC costs for each individual offshore wind project are financed with one-year Treasury notes that are subsequently repaid with higher taxes the following year, then the financing costs would be only $687 million (after accounting for tax revenues

Table 4: Estimated direct construction and O&M job-years for selected offshore wind projects					
			Job years		
	State	Capacity (MW)	Construction	O&M	Total
Empire Wind I	NY	816	1,892	1,902	3,794
Empire Wind II	NY	1,260	2,921	2,937	5,858
Beacon Wind	NY	1,230	2,851	2,867	5,718
Sunrise Wind	NY	880	1,600	2,723	4,323
Atlantic Shores Wind	NJ	1,510	3,500	2,200	5,700
Ocean Wind I*	NJ	1,100	3,103	1,725	4,828
Revolution Wind	RI	704	1,632	1,641	3,273
Totals		7,500	17,499	15,995	33,494

Source: Ocean Wind I COP, Individual project websites, and calculations by the author. *On 1 November 2023, Ørsted, the developer of Ocean Wind I, and its companion project, Ocean Wind 2, announced it was cancelling those projects for financial reasons.

collected on the interest). If, however, the projects were financed with 10-year US Treasury bonds, after which the costs would be recovered with higher income taxes, the financing costs would increase to $8.4 billion.

Table 5 shows the resulting subsidies per job-year, for this range of ITC financing, and based on an assumed interest rate of 5%. They range from between $360,000 and $580,000 for the Revolution Wind project,[32] to between $3.53 million and $3.76 million for the Beacon Energy Wind project, based on its higher PPA price.[33] Although the requested price increases were rejected by the authorities,[34] it is likely the developers will simply rebid at those higher prices in subsequent auctions. Taken together, the estimated subsidies per job-year for all seven projects average between $2.2 million and $2.4 million. It should be emphasized that these are annual values. Thus, even under the lowest-cost financing assumption, taxpayers and electric ratepayers will be forced to pay subsidies far greater than the actual annual salaries that workers will be paid.

3. The false justifications for green energy subsidies

Justifications for subsidies for renewable energy have changed over time. Initially, there were four arguments. The first was an 'infant industry' argument; that is, renewable energy technologies were new and could not immediately compete fairly with their fossil fuel counterparts. After 45 years (and counting) of continuous subsidies, it is difficult to argue that wind and solar generation remain 'infant' industries. As such, this argument is nowadays rarely employed although in the last few years, protective tariffs have been introduced on solar panels with the aim of restricting imports of lower-cost panels from China.

Table 5: Calculated subsidies per job-year for selected offshore wind projects

Project	ITC subsidy, incl. finance costs ($m)	PPA subsidy ($m)	Total subsidy ($m)	Subsidy per job-year ($m)
Empire Wind I	1,754–2,596	9,370	11,124–11,966	2.93–3.15
Empire Wind II	2,707–4,008	16,051	18,758–20,059	3.20–3.42
Beacon Wind	2,644–3,914	17,560	20,204–21,474	3.53–3.76
Sunrise Wind	1,892–2,800	7,496	9,388–10,296	2.17–2.38
Atlantic Shores Wind	3,245–4,804	4,088	7,017–8,576	1.23–1.50
Ocean Wind I	2,364–3,499	3,772	6,136–7,271	1.27–1.51
Revolution Wind	1,513–2,239	(340)	1,173–1,899	0.36–0.58
Totals	16,118–23,880	57,997	73,799–81,541	2.20–2.43

Source: Author calculations.

A second argument put forward was that renewable energy would promote energy independence by reducing imports of crude oil and exposure to volatile fossil fuel prices. Although the 'energy independence' argument is still invoked, recent actions by the federal government have increased dependence on foreign supplies of crude oil (and uranium for nuclear plants). Moreover, there is no empirical evidence that increased renewable energy has reduced the volatility of petroleum, natural gas, or coal prices.[35] Moreover, even if there were such evidence, it would be less costly to use existing financial hedging instruments to reduce volatility.

Increased quantities of wind and solar capacity have *increased* price volatility of electricity in wholesale power markets.[36] The reason is that, under organized wholesale power market rules, generators offer to supply electricity at their marginal cost, which for wind and solar power is effectively zero. During hours when they are fully available, this suppresses market prices and drives fossil fuel generators (primarily gas-fired power stations) from the market. However, when they are not available, electricity supplies are reduced, causing prices to shoot upwards. This has created what California refers to as the 'duck curve'. In which market prices collapse in the middle of the day when solar generation peaks and the increase rapidly in the early evening when solar generation disappears.[37]

A third argument was that, because of high upfront capital costs, renewable energy faced 'market barriers'. Which required subsidies to overcome. But high costs, such as the rapidly escalating costs for offshore wind generation (discussed in the next section), are *not* a market barrier. If they were, then one could argue that Rolls-Royce faces market barriers because the cars the company manufactures are expensive.[38]

A fourth argument is that green energy subsidies increase the rate of technological innovation, which subsequently reduces cost.

In a similar vein, advocates claim that subsidies for end-use products accelerate adoption of these new technologies by consumers. This is the most common justification for electric vehicle subsidies.

Although subsidies for research and development activities can increase economic growth,[39] subsidies that reduce firms' capital and operating costs *reduce* the incentive to innovate. Just as a tax on emissions increases the incentive for a firm to adopt new technology that reduces its emissions and, hence, its tax exposure, subsidies provide a competitive 'crutch' that allows otherwise uncompetitive firms and technologies to participate in a market. Moreover, when governments provide subsidies for specific technologies, they are selecting 'winners' and 'losers'. There is no empirical evidence that the selections made are economically sound. Indeed, the history of such selections, such as the bankruptcy of solar panel maker Solyndra, which received a half-billion-dollar government loan in 2009 and went bankrupt in 2011,[40] and the 2023 bankruptcy of Proterra, a maker of electric buses, which had received a \$10 million government loan, is dismal. Not only do governments have no expertise in identifying technologies with the highest potential economic value, but public choice theory suggests that the granting of subsidies to specific technologies is primarily concerned with rent seeking, rather than increasing economic well-being.[41]

Green energy subsidies distort energy markets

Green energy subsidies distort competitive energy markets. In wholesale electricity markets, for example, subsidised wind and solar plants crowd out other, unsubsidized generators, in what I have previously termed 'Gresham's Law of Green Energy'.[42] In other words, subsidized wind and solar generators can bid into the market at zero – and, in the case of wind, negative – prices, while still earning a profit. By increasing the supply of wholesale power in the market, previous generators that had set the market price are pushed out. For example, nuclear plants in Illinois, New Jersey, and New York have been granted subsidies, in part to account for their inability to compete in a wholesale market with increasing quantities of zero-marginal-cost wind and solar generation. More recently, the Texas legislature passed legislation to provide low-interest loans in support of the development of the 10,000 MW of new gas-fired generation needed to improve system reliability when wind and solar generation (also subsidized) is not available. Enacting subsidies to counteract the market-distorting impacts of other subsidies does not promote a well-functioning competitive market.[43]

As discussed previously, California's 'duck curve', which has been caused by the development of subsidized solar PV and thus an excess of solar generation during the day, has distorted that state's wholesale electricity market. In hours when solar generation peaks, the state often must pay to export solar generation to other states. More broadly, as solar and wind generation has increased, there are more hours where wholesale prices are below zero. The reasons are twofold: (i) wind generators that receive the PTC can bid into the market at a below zero price and still profit; and (ii) some generators, especially nuclear plants, but also baseload coal plants, cannot be cycled on and off. Therefore, they must bid their generation into the market at all hours. When prices turn negative, owners of those generating resources must pay to dispose of the electricity generated.[44]

The additional subsidized generation thus crowds out generators that are both more efficient and vital to maintain grid reliability. Hence states such as Illinois, New Jersey, and New York provide subsidies to nuclear plant owners to ensure they do not shut down, and the associated jobs are not lost. Moreover, as peaking natural gas generators – critical when electricity demand is at its highest – become uneconomic to operate because of a flood of subsidized wind and solar power, they too must be subsidized if they are to continue operating. A system of subsidies that causes economic distortions in electricity markets, necessitating further subsidies to overcome them, is true economic madness.

Not only do the subsidies for wind and solar require additional subsidies for other resources needed to keep the lights on, but increased generating capacity of intermittent wind and solar generation requires adding greater amounts of backup generation. In New York, for example, the system operator estimates that, if that state's mandates for wind and solar generation are met, the required 'reserved margin' to preserve system reliability will increase from its current 20% (around 6,600 MW) to over 100% (50,000 MW) by 2040.[45] Adding almost 40,000 MW of generation and storage just to maintain reliability will cost billions of dollars; money that could otherwise be invested elsewhere, such as in new nuclear plants that generate electricity around the clock and would not require higher reserve margins. (Reducing reliability, while avoiding back-up generation costs, will impose its own economic costs, especially given efforts to electrify most end uses, including transportation, all of which will increase electricity consumption.)

The broader economic impacts: foregone economic growth and lost jobs

Today, the most prominent justifications for renewable energy subsidies are that: (i) green energy will reduce the GHG emissions from fossil fuels and thus 'solve' climate change; and (ii) subsidies will create new 'green' industries, leading to increased economic growth and the creation of millions of new jobs.[46] A detailed discussion of the first argument is beyond the scope of this report, as it would require analysis of the life-cycle emissions of green energy investments and electrified end-uses, such as electric vehicles. In this report, I focus solely on the second argument.

The overarching economic fallacy of justifying green energy subsidies based on jobs created is that an investment's economic value is not measured by the number of jobs it creates. The purpose

of investing in electric generating resources and related infrastructure is to ensure that electricity supplies are adequate, affordable, and reliable. The purpose is not to create jobs. If it were, then the highest value energy resources would be the most labour-intensive ones.

In any industry, employers will hire employees so long as the additional economic value is greater than the cost of hiring them. Creating 'make-work' jobs, often called 'featherbedding', increases costs without commensurate benefits and thus reduces economic value.

Forcing consumers and taxpayers to subsidize green energy producers with a system of tax credits, federal and state mandates, and above-market price PPAs to create employment has the same adverse economic impact. Subsidizing green energy development may create new jobs for developers and their employees, but, when tallying the entire economic ledger, the net impact will be reduced economic growth. The reason is simple: it is *impossible* for a system of green energy tax credits and other subsidies to increase economic growth. To believe otherwise is to believe in 'free lunch' economics. Europe is learning this lesson through bitter experience. As green energy investments have increased in Great Britain and Germany, electricity prices have soared, leading to deindustrialization, as energy-intensive industries either shutdown or relocate to other countries with lower electricity costs.

As shown in Table 4, the economic cost of job subsides for offshore wind projects will be millions of dollars per year for each job created. If taxpayers and electric ratepayers are forced to spend, say, \$2 million per year to employ a single worker on a wage of, say, \$100,000, doing so cannot possibly improve economic well-being unless it can be demonstrated that (i) at least \$1.9 million in broader economic and social benefits will be realized by the remainder of the country; and (2) those additional benefits cannot be achieved otherwise at a lower cost. In the case of offshore wind, that is assuredly not the case, as it is one of the costliest and, owing to its inherent intermittency, least-efficient forms of electricity generation.[47]

In addition to the distortions to energy markets themselves, green energy subsidies induce broader economic distortions. First, by investing in technologies with low (or, in some cases, negative returns), government subsidies misallocate scarce resources that could be better spent on other, superior technologies, such as small modular nuclear power plants (SMRs), and basic research and development activities. Moreover, by diverting resources to less productive investments, green energy subsidies distort the price discovery mechanism, further reducing economic growth.

These results are not surprising. Consider the subsidy estimates shown in Table 2. Just seven offshore wind projects siphoned off between \$16 and \$41 billion in government spending that could have been invested in R&D for alternative generation technologies, especially SMRs. Unlike offshore wind, these can provide reliable electricity, avoiding the need to invest in additional backup generation and storage resources. They can also be sited close to cities, where electricity demand is greatest, and would avoid the likely economic and environmental damages associated with offshore wind, including damage to commercial and recreational fisheries, and harm to seabirds and whales, including the highly endangered North American right whale.

As another example, refinery owners are converting existing refineries to produce more costly 'renewable' fuels such as biodiesel to meet state and federal government mandates, and take advantage of the subsidies on offer.[48] For example, the Philips 66 refinery, outside San Francisco, will convert 120,000 barrels/day of capacity to produce biodiesel.[49] Reducing the productive capacity of existing refineries will, all else being equal, reduce the supply of traditional refinery products such as gasoline and diesel, and increase prices. At the same time, the average price of motor gasoline in the San Francisco area is already the highest in the nation.[50] Higher gasoline and diesel prices, in turn, will increase the costs to transport goods, leading to higher prices, and reductions in economic wellbeing. To take one example, in October 2023, the average price of diesel fuel in California was over $6 per gallon, double the average price in 2017.[51]

More direct government actions, such as GHG cap-and-trade programs in Washington and California,[52] create what are effectively government 'slush' funds. Washington state's program, for example, which began this year, is projected to raise over $2 billion dollars from the sale of emissions credits. The money will be spent on programs the state legislature and state agencies deem worthwhile, with little oversight, rather than on investments having the highest economic returns. This is public choice theory in action.

Second, government spending also can crowd out private investment. This is similar in concept to subsidized generators crowding out unsubsidized generators. Here, 'crowding out' refers to the adverse impacts of higher government spending on private investment. If government spending increases, but with no corresponding increase in total economic activity, the private sector is said to have been 'crowded out'.[53] Even increased R&D spending on green energy has been shown to crowd out private investment in more productive areas.[54] Another recognized issue associated with crowding out by government spending is higher interest rates caused by deficit spending, as the US is experiencing, in part because of the trillions of dollars in subsidies promised under the Inflation Reduction Act. Deficit spending that results in higher market interest rates reduces private investment by increasing opportunity costs for private investors.

Third, because subsidies increase energy costs, despite claims to the contrary, they cause a reduction in overall economic growth and jobs. For example, as shown in Table 3, the projected total of subsidies – in the form of above-market prices – paid to offshore wind developers is around $58 billion. These higher electricity prices reduce economic growth in several ways. Firstly, as seen in

Europe, electricity prices can become so high as to cause deindustrialization, because energy-intensive industries move elsewhere. The problem is particularly acute in Germany. Secondly, as electricity prices increase, consumers and businesses have less money to spend on other goods and services, which leads to reduced economic growth. In previous research, I have estimated the direct employment impacts of the increased spending owing to higher electricity prices in Pennsylvania to be the loss of six job-years per million dollars.[55] Hence, using the $58 billion estimate of above-market costs of electricity associated with the seven offshore wind projects, the resulting job losses would be almost 350,000 job-years, ten times larger than the number of jobs the projects claim they would create. As a result, the net economic impacts of green energy subsidies are negative, both in terms of jobs and economic output.

4. Conclusions

Over the last half century, the US government's track record of selecting 'winning' energy technologies has been a dismal failure. Current US and state government energy policies will be no different. The staggering amounts of money on offer through the IRA will have long-lasting and adverse consequences on energy supplies, economic growth, and the well-being of the citizenry.

Federal investment tax credits, which can be as high as 60% of the costs of certain green energy projects, must be paid for. Given the country's profligate spending and rapidly increasing deficit, for the foreseeable future, federal green energy subsidies are likely to be financed with additional debt. The financing costs alone to service that additional debt will be huge and will increase the deficit still further.

As growing deficits lead to increases in interest rates, they crowd out more productive private investment. Moreover, federal spending on renewable energy itself is inefficient, rewarding low-quality resources such as wind and solar energy, rather than high-quality ones, such as nuclear power. The subsidies for these low-quality resources then crowds out spending on higher quality ones by distorting competitive markets and raising energy prices. The impacts ripple through the entire economy and further restrict economic growth and wealth creation. Moreover, higher energy prices disproportionately affect the least well off in society. Advertising specific green energy projects for their economic development and job creation potential may be politically appealing, but the true economic costs will be far greater.

Politicians and policymakers may all choose to ignore basic economic principles in favour of political expediency and, in some cases, personal gain. However, basic economic principles will not ignore them. Eventually, the profligate spending on costly, but low-value, green energy will collapse under its own economic weight. The unanswered question is this: How high an economic and social price will the US pay for this folly before that occurs?

Technical Appendix: ITC financing costs calculation and application

How ITC payments are financed by the government

The alternatives are raising taxes, issuing new debt, or a combination of both. Hence, the total cost of the ITC will be the direct outlay plus the associated financing costs, *FITC*. So:

$$\mathrm{ITC_{total}} = \mathrm{ITC_{direct}} + \mathrm{FITC}$$

Assume that a percentage, ρ, of the ITC cost is financed, that all bonds have the same coupon rate r, and the same term of T years. The initial sale price of such a bond depends on the assumed path of interest rates. If, for example, current interest rates are expected to increase over time because of rising deficits, then bonds will sell at a discount and the financing costs will be higher. If interest rates are expected to decrease, then bonds will sell at a premium and the financing costs will be lower. For simplicity, I assume a constant interest rate over time, which means all bonds sell at their face value.

Although Treasury bonds do not compound interest (savings bonds do), refinancing bonds, including interest payments, results in compounding of the total ITC cost. Specifically, for an initial ITC expenditure, ITC_0, the interest expense, I_{ITC}, will equal:

$$I_{\mathrm{ITC}} = \rho \times ITC_0 \times (1+r)^T \tag{A-1}$$

where ρ = percentage of ITC financed with debt; r = annual coupon rate on that debt; and T = bond term in years.

Because 78% of Treasury bonds are held by the US public,[56] the interest payments on this percentage of bonds issued will be subject to federal tax collection, which reduces the ITC financing cost. For a given financing percentage, ρ, and income tax rate, t, the net financing cost, F_{TC}, is therefore:

$$F_{\mathrm{ITC}} = I_{\mathrm{ITC}} \times (1 - 0.78 \times t)$$

$$= \rho \times ITC_0 \times (1+r)^T \times (1 - 0.78 \times t) \tag{A-2}$$

where t = the weighted average tax rate paid by bond holders.

According to the Tax Foundation, the top 50% of taxpayers account for 98% of all taxes paid and pay an average tax rate of 14.8%.[57] I assume that all Treasury debt is held by these taxpayers. Therefore, the net ITC financing cost is:

$$F_{\mathrm{ITC}} = \rho \times ITC_0 \times (1+r)^T \times 0.891 \tag{A-3}$$

For the ITC financing costs shown in Table 1, I assume that the wind and solar targets for 2046 are acquired at a constant rate in all years, 2023–2046. I further assume that all of the ITC payments and after-tax financing costs are recovered by issuing more debt (i.e. that ρ = 100%) in the form of one-year Treasury notes, rather than through higher income tax rates. At the end of 2046, I assume all outstanding debt is recovered through higher income taxes.

Subsidy costs for offshore wind projects and calculations of costs per job-year

The total subsidy costs for an offshore wind project equals the ITC cost plus the above-market cost associated with long-term PPA contracts. (Projects cannot obtain both the ITC and the PTC. As the former is larger than the latter, I assume a rational developer opts for the ITC.)

Using estimates of the total overnight capital costs for seven offshore projects – Empire Wind I, Empire Wind II, Beacon Wind, Sunrise Wind, Revolution Wind, Atlantic Shores Wind, and Ocean Wind 1 – the next step is to calculate the ITC costs, including financing costs.

Capital cost and the ITC subsidy

Because offshore wind developers do not publish data on their construction costs, I estimate them using a recent overnight capital cost (i.e. excluding all financing costs) estimate published by the EIA, which is $5,338/kW (2022$), for a project assumed to be on-line in 2026.[58] In addition, the EIA includes a 25% technological optimism factor that 'reflects the demonstrated tendency to underestimate actual costs for a first-of-a-kind unit'. Applying this factor, the overnight capital cost of offshore wind units is $6,672/kW in 2022$. Adjusting this for inflation between 2022 and 2023, as measured by the Gross Domestic Product implicit price deflator (2023Q2 = 125.62, 2022Q2 = 122.22), yields an overnight capital cost of:

$$\$6{,}672 \times (125.62 \div 122.22) = \$6{,}858/\text{kW}.$$

In light of recent applications by offshore wind developers to (i) cancel existing PPAs (Massachusetts) and (ii) adjust the PPA pricing (New York) to reflect recently increased costs of key inputs, including raw materials and assembly costs,[59] the EIA's higher capital cost estimate is a reasonable baseline. Assuming an offshore wind project qualifies solely for the 30% ITC (but not the additional 10% for domestic manufacturing), the resulting ITC credit = (0.30) × $6,858 = $2,057/kW, or $2.057m/MW (2023$).

Financing costs for offshore wind projects

The low range of estimates of ITC subsidies for the offshore wind projects shown in Table 5 assumes the ITC payments are financed with one-year Treasury notes that, upon maturity, are recovered fully from increased taxes. Given the recent pattern of US deficit spending, that is almost certainly overly optimistic. The high range of ITC costs assumes the specific ITC payments are all financed with 10-year US Treasury bonds. Over the 10-year period, interest compounds as in equation (A-3). However, at the end of 10 years, the outstanding ITC costs are assumed to be recovered fully from higher income taxes.

Subsidies associated with above-market PPA pricing

An estimate of the subsidy associated with an offshore wind PPA depends on: (i) the specific terms of the PPA; and (ii) the forecast wholesale electricity price in the specific Regional Transmission Organization (RTO) in which the project will be located. The three RTOs where OSW projects will be located along the Atlantic coast are: ISO-NE, New York ISO, and PJM Interconnection.

The EIA Annual Energy Outlook 2023 publishes forecasts of average retail electricity rates, and the components (i.e. generation, transmission, and distribution) that make up those rates. Because New Jersey, New York, and most New England states restructured their generation industries, few plants are owned by regulated electricity utilities. Instead, most participate in the different RTO wholesale generation markets.

I assume the EIA generation cost forecasts (Figure A-1) are reasonable proxies for average annual wholesale prices for generation paid by distribution utilities and competitive suppliers. These generation costs include the price paid for electricity in the wholesale market, plus the additional costs for installed capacity, and ancillary services (i.e., maintaining sufficient reserve generation, voltage support, and frequency control).

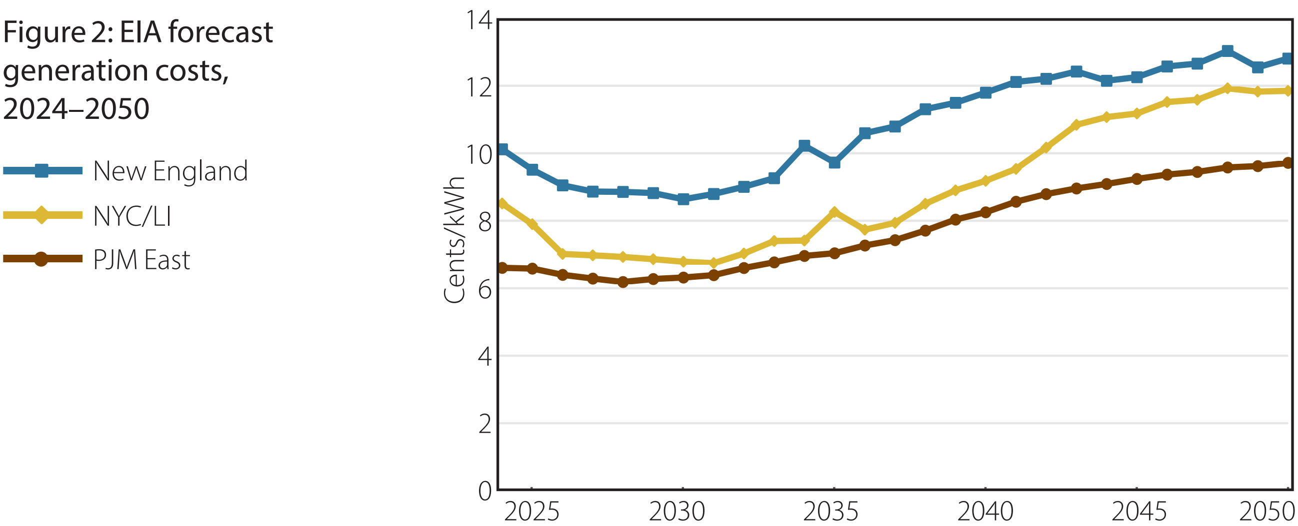
The resulting PPA subsidy, SPPA, for a project equals the difference between the prices set forth in the PPAs and the forecast generation costs in Figure 2 for the corresponding RTO, multiplied by the expected annual generation for the duration of the PPA:

$$S_{PPA} = (MW \times cf \times 8{,}760 \times \sum_{1}^{N}[p(n) - WP(n)] \qquad \text{(A-4)}$$

where MW = the rated capacity of the project, cf = the assumed capacity factor, $P(n)$ = the PPA price in year n, $WP(n)$ = the average wholesale electric price in year n, and N = the duration of the PPA project in years.

For each project, I assume an annual capacity factor of 45%. These are slightly lower than developers' projections. However, the average capacity factor for the Block Island Wind Farm, off the Rhode Island coast, and the only offshore wind project in operation in the US, has been 42% since the project's coming on-line in 2016,[60] lower than the initially assumed capacity factor of about 48%.

Figure 2: EIA forecast generation costs, 2024–2050



For example, because the Revolution Wind project is located in Rhode Island, the corresponding generation cost is the one shown for New England. The subsidies are calculated based on the stated duration of the PPAs. (I have also used the PPA price adjustments for the four New York projects requested by the developers, on the assumption that, absent those price adjustments, the projects will not be developed.)

Estimating annual full-time equivalent jobs

Estimates for the number of construction jobs and ongoing operations and maintenance (O&M) jobs for specific projects can be found either on the project websites or in the Construction and Operation Plans (COP) project developers are required to file with the Bureau of Ocean Energy Management. The only available COP with employment estimates for an offshore project comes from Ocean Wind I, which is to be built off the New Jersey coast.[61] The COP for Sunrise Wind treats the employment impacts as confidential, but the windfarm provides projected jobs data on its website. Both COPs project a two-year construction period, after which I assume a 25-year operating period. Although some offshore wind projects claim a physical lifetime of 35 years, observed failure rates for newer projects suggest 25 years is more realistic.[62] This also corresponds to the longest PPA contract term.

The Ocean Wind I project projects a total of 3,103 job-years during the construction period.[63] It projects a total of 69 O&M jobs each year for the project's operating life. Based on a 25-year operating life, that results in a total of 1,725 O&M-related job years.

The website for Sunrise Wind claims the project will create eight hundred construction jobs. Although no estimate of O&M-related jobs is provided, the Sunrise COP refers to a Massachusetts study that estimates between 35 and 64 O&M jobs for a 400-MW reference project, or between 0.088 and 0.160 jobs/MW. I use the average of these two values, which comes to 0.124 jobs/MW, which implies 109 annual O&M jobs for the project. For the remaining four projects, I use averages of the Ocean Wind I and Sunrise values.

Calculation of total subsidies per job-year

The total subsidy for each job-year for each project equals the sum of its corresponding ITC subsidy and its PPA subsidy, divided by the project's job-year estimates. Those estimates are shown in Table 5.

Notes

1. Traditionally, hydrogen is manufactured through reformation of natural gas. Advocates envision that 'green' hydrogen will be manufactured by electrolysis of water using 'surplus' electricity generated from zero-emission resources. The current administration has awarded $7 billion in subsidies to construct seven hydrogen manufacturing 'hubs' throughout the country, and the Inflation Reduction Act provides for a $3/kg subsidy for the production of green hydrogen, equivalent to $91/MWh based on hydrogen's energy content.

2. There is no single definition of 'environmental justice', although it might best be characterized as a form of distributive justice, along the lines described by the philosopher John Rawls in his *Theory of Justice*.

3. The social cost of carbon (SCC) is a theoretical estimate of the economic and environmental damage caused by a metric ton of carbon dioxide emissions. Estimates of the SCC have been based on models, called 'Integrated Assessment Models', which combine simple estimates of the sensitivity of world temperature to changes in emissions with estimates of the economic and environmental impacts of higher temperatures, such as changes in agricultural production, expenditures on protections against rising sea levels, and so forth.

4. The 1978 Energy Legislation included five separate Acts, including the Public Utility Regulatory Policies Act, the Powerplant and Industrial Fuel Use Act, the Energy Tax Act, the National Energy Conservation and Policy Act, and the Natural Gas Policy Act. The latter established new price controls of wellhead natural gas prices, further exacerbating forecasts of supply shortages. The Fuel Use Act mandated electric utilities and mandated that industry maximize its use of coal, which today is viewed as the *bête noire* of climate change. Among other things, the Energy Conservation Act established the Strategic Petroleum Reserve and Corporate Average Fuel Economy (CAFE) standards for automobiles. The Energy Tax Act provided an income tax credit for homeowners to install wind, solar, and geothermal energy, as well as subsidies for corn-based ethanol. It also created a sliding-scale 'Gas Guzzler' tax on passenger cars.

5. For a history of ethanol and other biofuels, see Wallace Tyner, 'The US ethanol and biofuels boom: Its origins, current status, and future prospects'. *BioScience* 58 (July 2008), pp. 646-653.

6. The Energy Policy Act of 2005 increased the ITC for solar generation from 10% to 30%. For a short history of the ITC, see Molly Sherlock, *The Energy Credit of Energy Investment Tax Credit (ITC)*, Congressional Research Service, April 23, 2021.

7. States vary in what qualifies as 'renewable' electricity. Pennsylvania, for example, considered electricity generated by burning tires to be renewable. The effectiveness of RPS mandates is debated. See, e.g. Magali Delmas and Maria Montes-Sancho, 'US state policies for renewable energy: Context and effectiveness'. *Energy Policy* 39: 2273–2288.

8. Although various bills have been introduced in Congress to impose a federal RPS, none has been enacted. See Ashley Lawson, *Electricity Portfolio Standards: Background, Design Elements, and Policy Considerations*, Congressional Research Service, Report R45913, October 21, 2020.

9. For projects placed in service after 2025, the base ITC will be 6%, with an additional 24% available for projects that meet wage and apprenticeship requirements.

10. Closed-loop biomass refers to facilities that burn biomass specifically grown and harvested to be burned. Open-loop biomass refers to facilities that burn agricultural waste products. The PTC for open-loop biomass is currently $14/MWh.

11. The adjustment is based on the gross domestic product implicit price deflator (GDPIPD), which is the broadest measure of inflation.

12. A comprehensive Database of State Incentives for Renewables and Energy Efficiency is published by the North Carolina Clean Energy Technology Center. The database includes both federal and state-specific programs, including tax credits, other financial incentives, and policies.

13. A more detailed summary can be found at: US Environmental Protection Agency, 'Summary of Inflation Reduction Act provisions related to renewable energy'. June 1, 2023.

14. Goldman Sachs, 'The US is poised for an energy revolution', April 17, 2023. The University of Pennsylvania's Wharton School of Business estimated total spending of $1.05 trillion on just the climate and energy provisions. See Penn Wharton, 'Update: Budgetary cost of climate and energy provisions in the Inflation Reduction Act'. April 27, 2023.

15. Source: Congressional Budget Office, 'CBO's projections of Federal receipts and expenditures in the National Income and Product Accounts: 2023 to 2033'. September 2023.

16. Source: US Treasury, 'What is the national debt?' Accessed September 20, 2023.

17. Source: Bureau of Economic Analysis, 'Gross domestic product, fourth quarter and year 2022 (third estimate), GDP by industry and corporate profits'. March 30, 2023.

18. An unanswered empirical question is whether the IRA spending will, by increasing the federal deficit, lead to higher interest rates. To the extent that the green energy subsidies in the IRA increase electricity prices, they will tend to increase the rate of inflation and, all else being equal, higher inflation rates will lead to higher nominal interest rates. The magnitude of the increases, and whether they will be countered through other governmental actions, is unknown.

19. According to the US Energy Information Administration (EIA), GHG emissions from electricity generation were 1.5 billion metric tons in 2022. A 75% reduction means emissions would have to decrease to less than 400 million metric tons for the subsidies to be phased out. EIA, *Annual Energy Outlook 2023*, Table 18.

20. See Adam Wilson, 'Strong coastal winds fueling US offshore industry looking to break through'. S&P Global, June 14, 2023. In New York state, legislation was introduced this past spring to increase that state's existing OSW goal of 9,000 MW by 2035 to 20,000 MW by 2050. See, Kate Lisa, 'Lawmakers eye mandating steeper offshore wind goals'. Spectrum News, June 2, 2023.

21. European data indicates the few floating OSW installations are far more costly than traditional OSW. See Gordon Hughes, *Wind Power Economics, Rhetoric and Reality, Vol. 1: Wind Power Costs in the United Kingdom*, Renewable Energy Foundation, 2020. The 88-MW Hywind Tampen floating offshore wind project off the Norwegian coast, the largest such installation to-date, cost $7.4 billion Kroner, equivalent to around $8,000–$8,500 per kilowatt, depending on the US-NOK exchange rate.

22. The 'pipeline' estimate does not include proposed offshore development in areas outside of existing lease areas.

23. EIA, *Annual Energy Outlook 2023*, Table 16. 'Behind-the-meter' solar refers to facilities developed on site by customers themselves, such as rooftop solar.

24. Ibid.

25. Price Fishback and Valentina Kachanovskaya, 'The multiplier for Federal spending in the states during the Great Depression'. *Journal of Economic History* 75: 125–162.

26. Jesse Jenkins, et al., 'Climate Progress and the 117th Congress: The impacts of the Inflation Reduction Act and Infrastructure Investment and Jobs Act'. Zero-carbon Energy Systems Research and Optimization (ZERO) Laboratory, July 2023.

27. Ibid, p. 72.

28. A complete review of the REPEAT analysis is beyond the scope of this report.

29. For one such study, see American Wind Energy Association, *US Offshore Wind Power Economic Impact Assessment,* March 2020.

30. All of the projects also claim they will create indirect and induced jobs, based on input-output studies. As the estimates of these jobs are speculative, they are excluded from the analysis. Moreover, those estimates do not account for lost jobs owing to increased electricity prices that are caused by the projects' above-market electricity prices.

31. Because projects are not eligible for both the ITC and the PTC, I assume each project claims the ITC, which is larger.

32. Revolution Wind has not yet requested a change to its PPA contract prices. However, at the current average price of $99.04/MWh for the project, which does not escalate over the 20-year PPA term, a cash flow analysis demonstrates the project is not economically viable. Nevertheless, I have included the project in the job-year subsidy calculations.

33. The developers of Atlantic Shores Wind have also informed the state of New Jersey that the project may be cancelled if the state does not provide additional subsidies. See Wayne Parry, 'New Jersey's other wind farm developer wants government breaks, too; says project "at risk"'. AP, July 3, 2023.

34. New York Public Service Commission, *In the Matter of Offshore Wind Energy*, Case No. 18-E-0071, Order Denying Petition Seeking to Amend Contracts with Renewable Energy Projects, October 12, 2023. NYSERDA has adopted a mechanism that allows offshore wind developers to be paid higher prices if their costs increase, thus transferring the risk of higher costs to captive electric ratepayers.

35. Of course, it is true that, if renewable energy were to replace all fossil fuel consumption, there would be no fossil fuel price volatility.

36. All US regional transmission organizations (RTOs) oversee organized wholesale power markets. These include the California Independent System Operator (CAISO), the New York Independent System Operator (NYISO), the Electric Reliability Council of Texas (ERCOT), the Southwest Power Pool (SPP), the Midcontinent Independent System Operator (MISO), PJM Interconnection, and the New England Independent System Operator (NE-ISO). Only western states and states in the southeast are not included in these RTOs.

37. For additional discussion, see US Energy Information Administration, 'As solar capacity grows, duck curves are getting deeper in California'. June 21, 2023.

38. This is the most common argument made to justify continued subsidies for EVs.

39. See, e.g. Carl Davidson and Paul Segerstrom, 'R&D subsidies and economic growth'. *RAND Journal of Economics* 29 (Autumn 1998): 548–577.

40. David Boaz, 'Solyndra: A case study in green energy, cronyism, and the failure of central planning'. CATO Institute, August 27, 2015.

41. Public choice theory was developed by the Nobel prize-winning economist James Buchanan. For a brief introduction, see his article, 'What is Public Choice Theory?' American Institute for Economic Research 43 (May 2003).

42. Jonathan Lesser, 'Gresham's Law of Green Energy'. *Regulation*, Winter 2010/2011: 12–18.

43. In fact, once wind and solar reach a threshold level, wholesale competitive electric markets will collapse entirely. The reason is that generation owners will bid at their marginal cost (zero) when their resources are available, forcing the price to zero or near zero in most hours. But when wind and solar are unavailable, prices will skyrocket. Fossil fuel generators will be unable to compete and drop out of the market. If the number of zero-price hours is sufficient, then wind and solar generation owners will be unable to recoup their costs, leading to a complete collapse of the wholesale market. The aforementioned California 'duck curve' is a harbinger of this impact.

44. Corn ethanol subsidies are another example of a market distortion. Because ethanol production accounts for about 40% of the US corn crop, it artificially increases corn prices and thus prices for many foods. The resulting higher prices disproportionately affect the poor, both in this country and elsewhere, which can then require additional government programs to offset higher food costs.

45. New York State Department of Public Service, *Initial Report on the New York Power Grid Study*. January 19, 2021, Appendix E.

46. The REPEAT analysis, for example, claims that the proposed electrification policies will create three million new jobs, while causing the loss of only 133,000 jobs in the oil and natural gas sectors.

See *supra*, note 26, at p. 99.

47. For a comparison of costs, see US Energy Information Administration, *Levelized Costs of New Generation Resources in the Annual Energy Outlook 2023*, April 2023. Moreover, one must account for social costs. Wind and solar energy use tremendous amounts of land and, if developed to the extent envisioned, will require at least doubling the miles of high-voltage transmission lines to deliver electricity from remotely sited generators to urban load centers. Wind generation creates other economic and social costs, such as killing bats needed for pollination. Solar facilities have been sited on productive agricultural lands, lessening food supplies. And offshore wind will have adverse impacts on commercial and recreational fishing, and most controversially, may increase whale deaths, including of the endangered North American right whale.

48. For example, the state of California has a Low Carbon Fuel Standard (LCFS) that requires refineries and wholesalers of fossil fuels to meet GHG emissions standards that decrease over time. Because the GHG emissions from, say, gasoline and diesel, are fixed based on their chemical composition, the LCFS means that refineries and wholesalers must purchase emissions credits and sell increasing quantities of 'renewable' fuels, including biodiesel and renewable natural gas (e.g. natural gas produced from wastewater treatment plants, animal waste, and landfills).

49. Robert Brelsford, 'Phillips 66 progresses Rodeo Renewed refinery conversion project'. *Oil & Gas Journal*, August 3, 2023.

50. EIA, Weekly Gasoline and Diesel Fuel Update, November 6, 2023.

51. Ibid.

52. These programs are euphemistically referred to by their proponents as 'cap-and-invest' programs, because the money collected by state governments is then 'invested' in projects government officials choose. New York state is in the process of developing its own cap-and-invest program.

53. *See, e.g.*, William Butler, '"Crowding out" and the effectiveness of fiscal policy'. *Journal of Public Economics* 7 (June 1977): 309–328.

54. See, e.g. John Welche, 'Does green corporate investment crowd out other business investment?' *Industrial and Corporate Change* 28 (October 2019): 1279–1295. See also, Özgür Arslan-Ayaydin et al., 'The crowding-out effect of green energy innovation', in Andre Dorsman et al., (eds), *Energy Economy, Finance and Geostrategy*, Springer International Publishing, 2018.

55. Jonathan Lesser, 'Renewable energy and the fallacy of "green" jobs'. *The Electricity Journal* 23 (August/September 2010): 45–53.

56. Peter Peterson Foundation, 'The Federal Government has borrowed trillions, but who owns all that debt?' May 11, 2023.

57. Erica York, 'Summary of the latest Federal income tax data, 2023 update'. Tax Foundation, January 26, 2023.

58. Source: EIA, *Cost and Performance Characteristics of New Generating Technologies, Annual Energy Outlook 2023*. March 2023. The estimates are based on a 2019 study published by Sargent and Lundy.

59. For example, a June 7, 2023, filing by the developers of the 816 MW Empire Wind 1 and 1,260 MW Empire Wind 2 projects filed a petition to adjust the long-term PPA prices which calculates an overall increase of 23% for wind turbine materials alone, excluding higher financing costs and higher costs for interconnecting the projects to the mainland. See, *In the Matter of Offshore Wind Energy*, Case 18-E-0071, 'Verified Petition of Sunrise Wind LLC for an Order Authorizing the New York State Energy Research and Development Authority to Amend the Offshore Wind Renewable Energy Certificate Purchase and Sale Agreement'. June 7, 2023, p. 21. Similar increases are projected for the 924 MW Sunrise Wind and 1,230 MW Beacon Wind projects. Overall, NYSERDA shows that first-year prices would increase PPA prices: Empire Wind 1 would rise from $118.38 per megawatt hour (MWh) to $159.64/MWh and Empire Wind 2 from $107.50/MWh to $177.84/MWh. Beacon Wind would see the strike price rise from $118.00/MWh to $190.82/MWh.

60. Source: Generation data from EIA Form 923.

61. The developer of Sunrise Wind has also filed to increase its PPA contract prices to reflect increases in materials, construction, and financing costs. However, the filing does not contain any actual requested prices. To be conservative, I have inflated the current Sunrise PPA by the 23% materials price increase.

62. Gordon Hughes, *Wind Power Economics, Rhetoric and Reality, Vol. 1: Wind Power Costs in the United Kingdom*, Renewable Energy Foundation, 2020.

63. One job-year corresponds to one full-time-equivalent job for one year.

64. Angela Jones, 'The Section 45Q tax credit for carbon sequestration'. Congressional Research Service, August 25m 2023.

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