IRA Clean Energy Credits *with* Labor Standards

Can Boost Union Jobs *and* Economy *in* Appalachia

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The Ohio River Valley Institute is a think tank focused on the greater Ohio Valley region. Our team of experts produces substantive research on the region's most pressing issues and delivers them with effective communication strategies. We strive to help the region mark out a path toward shared prosperity, clean energy, and more equitable civic structures.

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Executive Summary

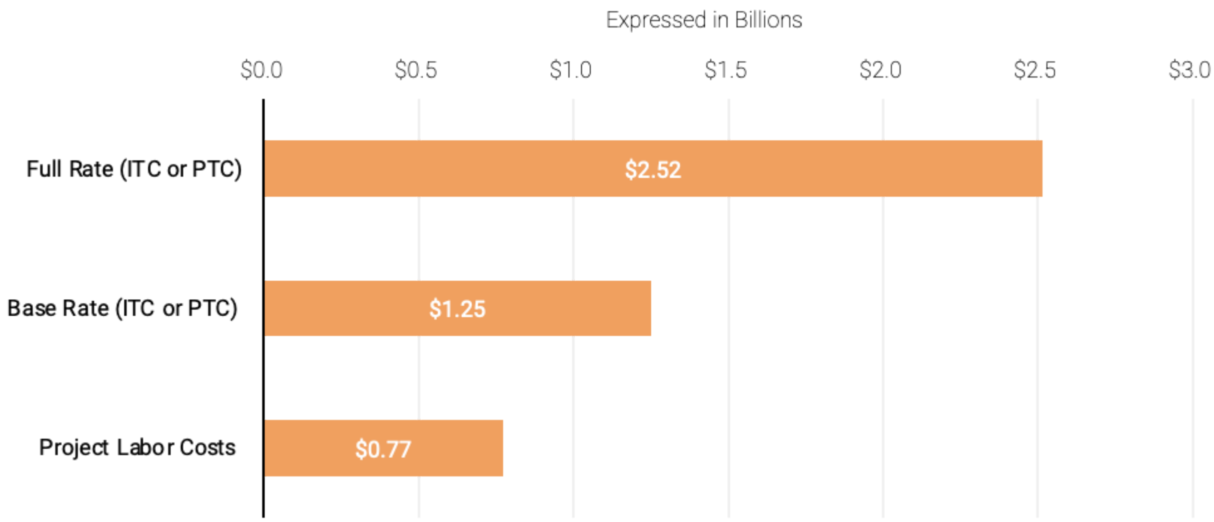
The Inflation Reduction Act (IRA) is the largest federal policy action to date to combat climate change and reorient our economy toward cleaner energy. One of the IRA's largest impacts is on clean electricity investments and production through expansions of the generation-based Production Tax Credit (PTC) and the capital-based Investment Tax Credit (ITC). The PTC and ITC account for more than one quarter of the IRA's estimated $900 billion in anticipated expenditures by 2031.[1] Included in the PTC and ITC, along with ten other tax incentives in the IRA, are targeted labor and workforce development standards. These standards include primarily prevailing wage and registered apprenticeship targets that increase the value of the PTC and ITC five-fold, with the aim of improving job quality and workforce training pathways in clean energy production, which traditionally has lower job quality and less union density than fossil fuel energy production.[2]

According to the US Department of Labor, there are 76 IRA-powered clean energy power projects in Kentucky, Ohio, Pennsylvania, and West Virginia, including 57 in the pre-construction phase of development. The 57 clean energy projects in the four-state region include 33 solar, 20 hydroelectric, two wind, and two battery storage projects. Approximately 32 of these pre-construction clean energy projects are in "energy communities" that have been reliant on fossil fuels and are consequently eligible for a bonus ITC or PTC credit.

Achieving the "high road" labor standards required for the full tax credit rates could double project tax benefits, more than compensating for labor costs.

Altogether, these 57 clean energy projects represent $5.1 billion in capital investments and are estimated to create between 3,400 and 9,300 construction jobs. These projects are potentially eligible for the PTC or the ITC at either the base rate or the full rate if they can meet prevailing wage and apprenticeship (PWA) requirements. Based on estimated capital costs, electricity generation, and other factors, the 57 projects could receive total tax benefits of $1.25 billion if they receive the base rate. By paying workers prevailing wages and hiring apprentices, the 57 projects could receive the full rate amounting to $2.52 billion, more than double the base rate. To put this in perspective, the additional $1.27 billion in tax benefits from the full rate PTC and ITC is more than enough to pay for the entire estimated labor costs of $774 million for all 57 clean energy projects. It is unclear how many of the 57 projects will be completed and this analysis has not judged the merits of each of the projects. These figures are mainly for illustrative purposes to highlight the increased tax benefits of the full rate that include PWA requirements.

Figure 1: Estimated Tax Benefits and Labor Costs for 57 Clean Energy Projects in Four-State Region



Source: Ohio River Valley Institute analysis of federal data. See Appendix A.

Prevailing wage requirements impose few additional costs, and they can boost productivity and wages, strengthen workforce development, and spur local economic growth.

While paying construction workers prevailing wage rates will likely increase the amount workers are paid on these 57 clean energy projects, extensive research shows that the cost difference is marginal. This is because prevailing wage rates are generally tied to union labor that is more highly skilled and productive, resulting in faster project completion, lower worker turnover, and better workplace safety. Paying qualified and experienced workers more to work less (productivity) compared to unskilled workers that must work more hours can result in little differences in labor costs.

Compensating workers with fair wages imposes few, if any, additional project costs, and it can have large ripple effects that improve local economies and workforce development by increasing the supply of highly skilled workers. Investing in union apprenticeships is also highly beneficial as it provides career ladders to the middle class and increases the supply of skilled workers. The more project developers utilize enhanced credits that meet prevailing wage and registered apprenticeship requirements (PWA) as opposed to the base credits, the more positive impact the projects could have on boosting wages and local economic development.

The ITC and PTC tax credits may lower household electricity bills.

The economic impact of the ITC and PTC on local economic development and electricity rates is unclear, but electricity producers who receive the base or enhanced tax credit could pass some of the credits' value onto consumers in the form of lower household electricity prices in the region. However, more research is needed to determine the tax credits' impact on local electricity rates.

Prevailing wage requirements can help build a better Appalachia.

The prevailing wage and apprenticeship requirements (PWA) that have been recently finalized in the IRA offer an unprecedented opportunity in Appalachia to greatly expand clean energy investment and electricity production, reduce pollution, produce high-paying quality jobs, and boost local economies in the region.

Overview of Enhanced Clean Energy Credits

In June of 2024, the US Department of the Treasury released their final rules on the PWA-enhanced credit provisions of the IRA.[3] The IRA includes twelve clean energy tax incentives and additional incentives that can be increased fivefold if project developers pay construction and maintenance workers (such as laborers, mechanics, carpenters, and operators) prevailing wage rates and employ apprentices from registered apprenticeship programs for at least 15% of all hours worked on a project (2024).[4]

Prevailing wage rates, also referred to as "Davis Bacon" wages, are set by the US Department of Labor (DOL) through the Wage and Hour Division's voluntary survey of compensation paid by private contractors to construction workers on public projects in 3,000 counties and localities across the nation. The result is rates that are based on fair market wages by job classification. The Davis Bacon Act wage determinations are listed publicly by the federal government's System for Award Management (SAM) by state, county, and construction type.[5] The wage rates (wages and fringes) are periodically updated. Registered apprenticeship programs are defined by the DOL as "paid on-the-job training with classroom instruction to prepare workers for highly-skilled careers."[6] These "earn as they learn" apprenticeships are registered with the DOL's Office of Apprenticeship or a DOL recognized State Apprenticeship Agencies.[7]

To qualify for the enhanced or full rate tax credits and deductions, developers must meet record keeping and reporting requirements. The rules also provide a "good faith" exception for developers if they are unable to hire apprentices for reasons outside of their control or if the program fails to respond within five business days. In cases where the exception doesn't apply, the developer can still satisfy the PWA requirements if they make a penalty payment ($50 per labor hour for which the Labor Hours Requirement or the Participation Requirement was not satisfied for construction, alteration, or repair work on the qualified facility). This exemption was (presumably) added because of labor shortages or lack of workers in registered apprenticeships to build and maintain clean energy facilities.[8] According to a recent study by the Political Economy Research Institute (PERI) at UMASS-Amherst, there is an expected worker shortage of nearly 1.1 million among 20 occupations—mostly in the construction sector—for projected direct jobs created by the Bipartisan Infrastructure Law (BIL), IRA, and CHIPS and Science Act.[9] Companies and labor organizations may also sponsor new apprenticeship programs to meet PWA requirements.

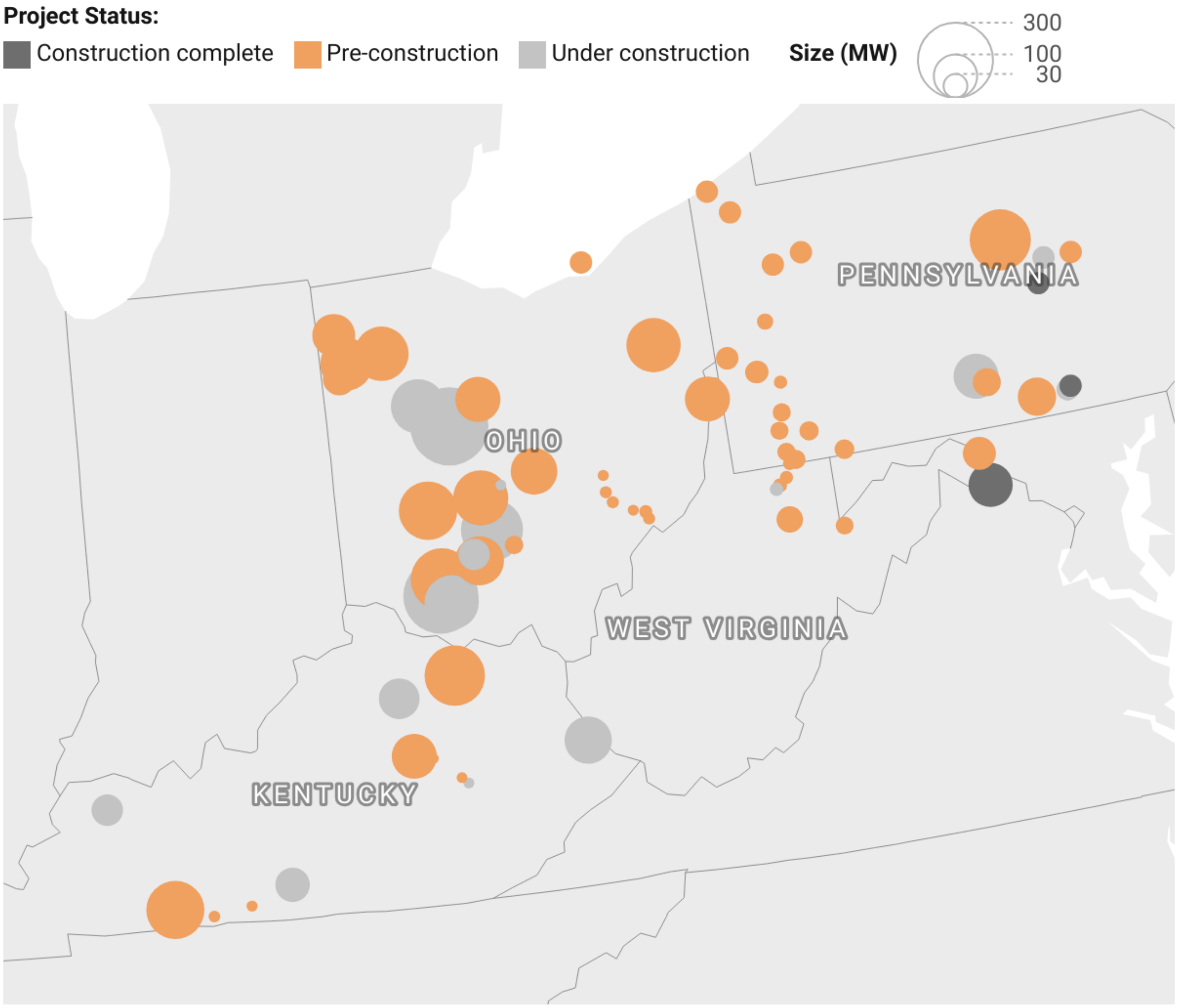
The new rule also strongly encourages project labor agreements (PLAs), which are contracts between a construction project's owner and one or more labor unions. Penalties for failures to meet PWA requirements can be waived for project developers if they are under a qualifying PLA that meets certain requirements.

Potential Impact of Enhanced PWA Credits in Appalachia

The US Department of Labor (DOL) has identified 76 clean energy projects in Kentucky, Ohio, Pennsylvania, West Virginia, including 57 projects in pre-construction, that could potentially qualify for enhanced PWA tax incentives and create between 4,148 and 10,752 jobs.[10] The 57 projects would potentially produce 2,904 megawatts (MW) of electricity, including 2,471 MW in solar, 161 MW in wind, 184 MW in hydroelectric, and 88 MW in batteries. Combined, they could generate a total 6.2 million MW/hours (6.2 TWh) of electric power annually once the projects come online (based on their respective capacity factors). [11] This would be enough to power roughly 580,000 homes annually.[12]

PWA Projects

The U.S. Department of Labor (DOL) has identified 76 clean energy projects in Kentucky, Ohio, Pennsylvania, West Virginia, including 57 projects in pre-construction that could potentially qualify for enhanced PWA tax incentives and create between 4,148 and 10,752 jobs.



Map: Ohio River Valley Institute • Source: US Department of Labor • Created with Datawrapper

[Click here to view an interactive version of this map.]

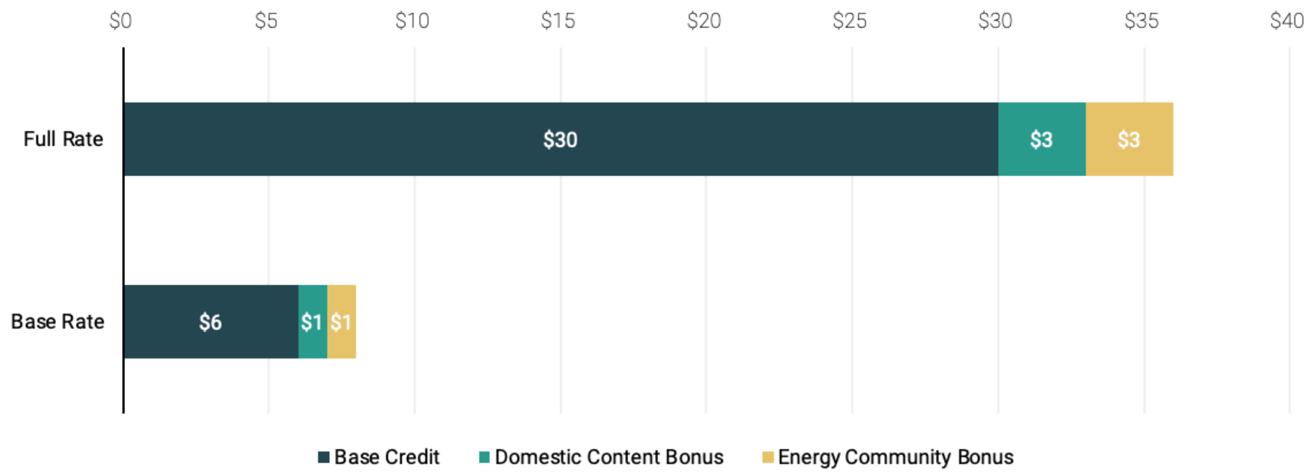
Solar, wind, and hydroelectric clean energy projects can choose the Production Tax Credit (PTC) or the Investment Tax Credit (ITC), while battery storage projects can only utilize the ITC. The ITC reduces the federal income tax liability for a percentage of the cost of a qualified clean energy system that is installed during the tax year.[13] Meanwhile, the PTC is a credit that reduces federal income tax liability based on clean electricity generated by qualifying technologies during the first 10 years of the system's operation. In other words, the ITC is based on capital investment, while the PTC is based on electricity production.

Companies can receive an increased or full tax credit rate if their project meets the PWA requirements discussed in the previous section. The current PTC base credit amount is 0.6 cents per kilowatt hour(kWh) or $6 per MWh, while the full credit that includes PWA requirements is five times this amount: 3 cents per kWh or $30 per MWh for 2024.[14] There are also two bonus credits, including an Energy Community credit and a Domestic Content bonus credit of $1 per MWh each for the base rate and $3 per MWh each for the full rate (See Figure 2).

Energy communities are places that have been historically dependent on fossil fuels and are defined by the IRA to include one of three categories, including a brownfield site, a statistical area that has disproportionality been reliant on fossil fuels for jobs and local tax revenues (0.17%+ employment in mining or 25%+ of local tax revenue from extraction industries), or a census tract where a coal mine has closed since 2000 or coal-fired electric power plant has retired after 2009.[15] The Domestic Content Bonus is available for projects that use domestically produced iron and steel, and where at least 40% of the value of other materials are from US manufacturers.

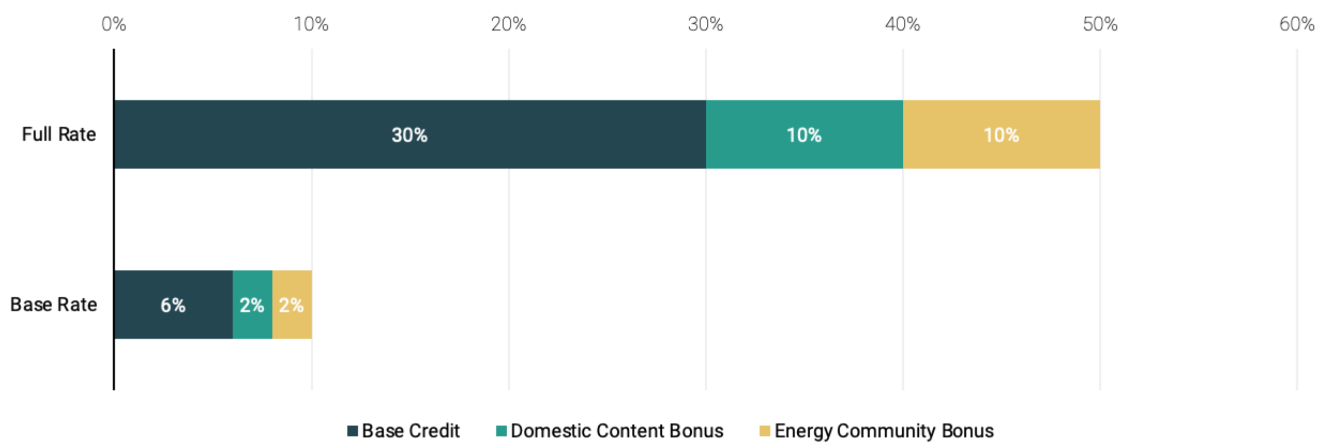
The ITC base credit is 6% of qualified investments and five times this amount, or 30%, for the full credit that meets the PWA requirements. The ITC also contains the Energy Community and Domestic Content bonus credits, which are 2% for each bonus credit for the base rate and 10% each for the full rate (Figure 2 and Figure 3). The ITC also includes a Low-Income Bonus credit for projects under 5 MW or on Tribal Land, but this is not included in the analysis since most of the solar projects do not qualify. In total, a project could receive 50% of the project's value if labor standards and both bonus credits requirements are met.

Figure 2: Production Tax Credit Rates Per MWh of Clean Electricity



Source: Internal Revenue Service, Treasury (2024)

Figure 3: Investment Tax Credit Rates for Qualified Clean Energy Investments



Source: Internal Revenue Service, Treasury (2024)

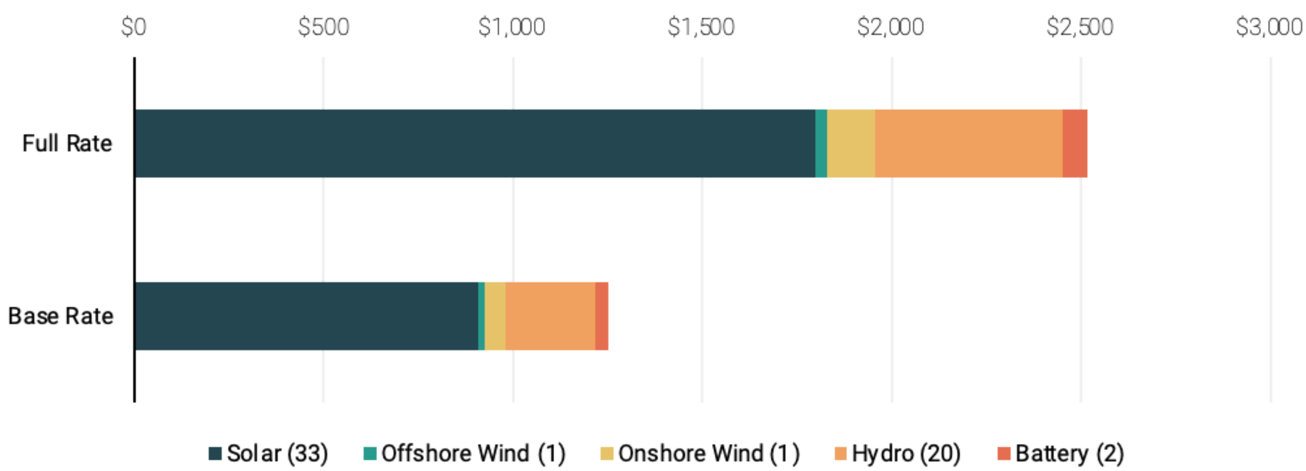
The decision of whether to choose the ITC or PTC depends heavily on the capacity factor, investment costs, and the bonus credits included in the tax credits. For example, the capacity factor—the ratio of actual energy output of a power plant compared to what it would produce if it were generating electricity at full capacity—of solar projects varies across the country and during times of the year. If a solar project has a capacity factor below 20%—meaning it only produced electricity 20% of the time—it may be more beneficial to choose the ITC, which is based on capital investment, than the PTC, which is based on electricity generated. More capital-intensive projects, such as hydroelectric, generally choose the ITC over the PTC.

Figure 4 below estimates the total PTC and ITC credit amounts over ten years (the life of the credit) for all 57 clean energy projects based on projected capital costs, electricity generation (PTC), depreciation amounts, tax liability, and whether they are in an energy community. This analysis adopts a methodology used by the US Department of Energy (Solar Energy Technologies Office) and incorporates energy data from the US Energy Information Administration (EIA) and the National Renewable Energy Lab (NREL).[16]

The estimates assume that each of the 57 projects claim the credit that gives them larger benefits, with solar and wind projects choosing the PTC and battery and hydroelectric power projects choosing the ITC. The credit amounts are discounted using a rate of 8%. Of the 57 projects, 32 of the projects—including 18 hydropower and 14 solar projects— are in a federally recognized "energy community" and are eligible for the Energy Community Tax Credit Bonus included in the PTC and ITC, which is included in the estimated tax benefits. Since it is unclear which projects may qualify for the domestic content bonus, it was excluded from this analysis, along with the Low-Income Bonus for small solar projects.

Altogether, the 57 projects could receive $1.25 billion if they qualify for the base rate ITC and PTC credits and $2.52 billion for the full rate credit if they meet the PWA requirements. This means that, if the 57 projects can qualify for the full credit rate, they would receive an additional $1.27 billion in tax benefits, nearly double the amount of the base rate tax benefits. The total estimated capital cost for all 57 projects is approximately $5.1 billion, with total tax benefits between 25% and 50% of project costs.

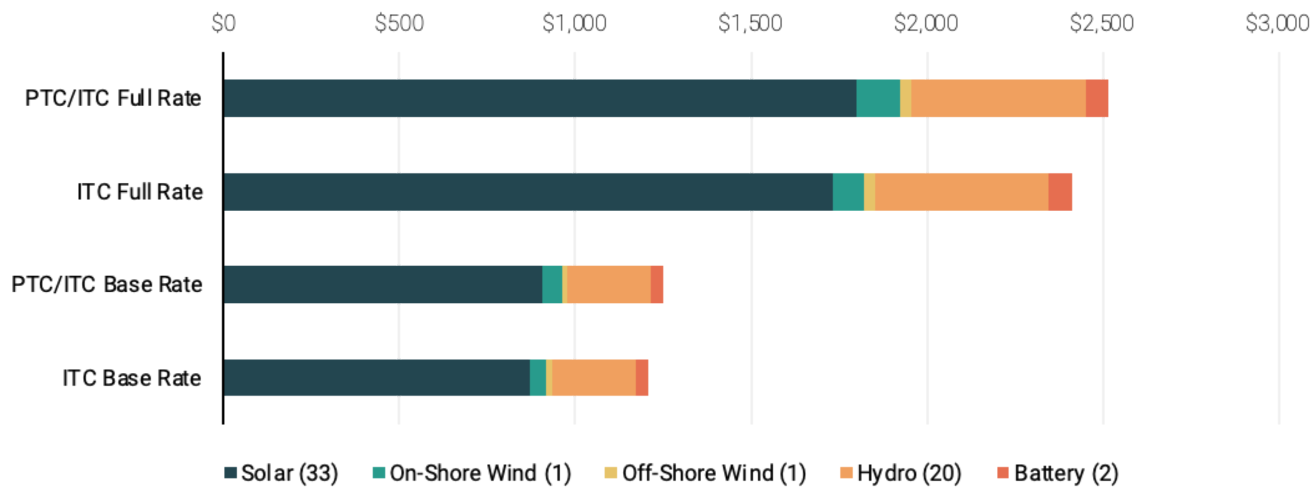
Figure 4: Estimated Value of ITC and PTC for 57 Clean Energy Projects (in millions)



Source: ORVI analysis of US DOL, NREL and US EIA data. See Appendix A.

As discussed above, the decision to choose either the ITC or PTC is project specific. Figure 5 below estimates the total tax benefits if all 57 projects chose the ITC. As Figure 5 illustrates, the difference is marginal. Total base rate tax benefits are just $44 million lower if all projects chose the ITC over the PTC, while the difference between the full rate benefits are $104 million. No matter whether a project chose the ITC or the PTC, the benefits of the full rate are clear and nearly double those of the base rate.

Figure 5: Estimated Value of the ITC for 57 Clean Energy Projects (in millions)



Source: ORVI analysis of US DOL, NREL and US EIA data. See Appendix A.

Impact of Prevailing Wage and Apprenticeship Requirements on Project Costs

Prevailing wages are local minimum wages for different types of skilled construction work on publicly funded projects. The purpose is to create a level playing field for contractors by ensuring that public money reflects local standards for compensation, craftsmanship, and safety.

Prevailing wage rates are an hourly wage rate plus fringe benefits for different skilled workers in trades by level of experience and by construction type. The fringe benefit may include insurance, pensions, apprenticeship costs, time off, or other bona fide benefits. The rates are set prior to the construction date and remain frozen until the project is complete.[17] Prevailing wage rates vary substantially across sectors, geographies, and trades. The rates are also reflective of union density and the cost of living. For example, the prevailing wage rate for an electrician (heavy construction) in Boone County, West Virginia (Southern West Virginia) is $29 an hour plus $17/hr in fringe benefits, whereas in Allegheny County, Pennsylvania, where Pittsburgh is located, the rate is $48/hr plus $31/hr in fringe benefits. This is a wage rate difference of 74%.

The inclusion of prevailing wage rates will increase the amount labor is paid on clean energy projects. For example, the median weekly wage for union construction industry workers in 2023 was $1,441, compared to $1,007 for non-union construction workers, a difference of 28.6%.[18] According to a recent report by NREL, less than a quarter of wind and solar projects used unionized workers in 2020. NREL estimates that non-union solar construction workers earned an hourly rate of $16 to $19 compared to $28/hr for unionized workers, a difference of 45% to 34%.[19] A recent study (2020) on the potential impacts of prevailing wage on solar costs in Illinois found that prevailing wage would increase labor rates (total labor compensation) by 23% to 41%.[20]

While there are profound increases in labor costs associated with the utilization of prevailing wage rate on clean energy projects, there is little impact on project costs since labor costs are a small part of project costs. A recent study for the state of Maryland by Pinnacle Economics found that labor costs on solar, wind, and battery storage range from 5.7% to 10.9% of total project costs, depending on size and type of system.[21] The study found that labor cost increases of 30%—without modeling impacts on worker productivity gains from using more highly skilled workers—would increase project cost between 2% and 3.3%. These findings were mirrored in the Illinois study that found prevailing wages rates would have "negligible impacts on solar costs," increasing utility solar projects by 1% to 2%. Another study by Erin Mayfield and Jesse Jenkins (Princeton University) found that a "20% increase in installation and construction labor costs would increase the installed cost of solar PV and wind projects by only 3% and 1%, respectively."[22] Mayfield and Jenkins estimated that labor costs as a share of installed capital costs comprise 17% for utility solar and 22% for land-based wind.

Table 1 below looks at the estimated labor construction costs (i.e. services subject to prevailing wage rates) as a share of total energy system project costs by resource/technology using data from the

National Renewable Energy Laboratory and the US Energy Information Administration. Labor costs as a share of total project costs range from 5.7% for batteries to 21.5% for hydroelectric power plants. Altogether, labor costs comprise an estimated 15.2% ($768 million) of the $5 billion in estimated project costs for the 57 pre-construction clean energy projects in Appalachia (KY, OH, PA, and WV). According to DOL, these 57 projects are expected to create between 3,427 and 9,348 jobs, which would equate to $225,775 per job on the high end and $82,770 on the low end using the projected $774 million in labor costs.

If labor costs were 30% higher from paying prevailing wage rates, total project costs would increase by just 4.5%, or $232 million, for all 57 projects. Hydroelectric power plants are more labor intensive than solar, wind or batteries, which helps drive the increase in total project costs impact from higher labor rates.

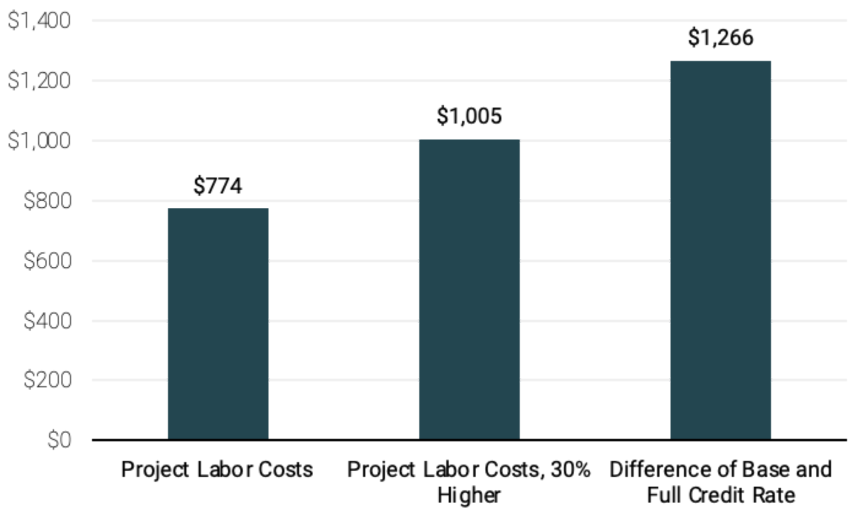
Table 1: Impact of Labor Construction Costs on Clean Energy Projects in Appalachia (in millions)

Pre-Construction Clean Energy Projects in KY, OH, PA, and WV (57) by Resource Technology	Total Project (Capital) Costs (57)	Labor Cost % of Project Cost	Labor Cost	Labor Costs (30% Higher)	Labor Cost Difference	Project Cost (30% Higher Labor Costs)	Increase in Project Costs w/ 30% Higher Labor Costs
Solar (33)	$3,704	14.48%	$536	$697	$161	$3,865	4.3%
Offshore Wind (1)	$75	9.31%	$7	$9	$2	$77	2.8%
Onshore Wind (1)	$204	7.08%	$14	$19	$4	$208	2.1%
Hydroelectric (20)	$964	21.50%	$207	$269	$62	$1,026	6.5%
Batteries (2)	$151	5.70%	$9	$11	$3	$154	1.7%
TOTAL	$5,099	15.18%	$774	$1,005	$232	$5,331	4.5%

Sources: Labor cost data from National Renewable Energy Laboratory (NREL) JEDI Model for Solar, Wind and Hydro and Feldman, et. al." U.S. Solar Photovoltaic System and Energy Storage Cost Benchmark: 2020Q1 for Batteries. Project cost data from U.S. Energy Information Administration (EIA), "Capital Cost and Performance Characteristics for Utility-Scale Electric Power Generating Technologies," January 2024. See Appendix for detailed methodology.

Figure 6 below compares labor construction costs and the additional amount all 57 clean energy projects would receive if they qualified for the full ITC and PTC credit. The difference between the base and full credit amount is $1.27 billion, while a 30% increase in labor costs would be $232 million, or just 18% of the additional credit value they would receive for meeting the PWA requirements. Notably, if all 57 projects received the full credit amount of the ITC and PTC it would be more than the entire estimated labor costs of $774 million. In other words, all labor costs would be covered if project developers (taxpayers) qualified for the full credit.

Figure 6: Full Credit Tax Benefits Higher than Labor Costs (in millions)



Source: NREL and EIA. See Appendix A.

It is important to note that estimates likely overinflate labor costs because this data does not include the gains from worker productivity that are associated with prevailing wage standards. Studies have shown that worksite productivity is 14% to 33% higher in states with prevailing wage laws.[23] The result is lower worker turnover, improved workplace safety, and faster project completion. While prevailing wage rates would increase wages, total labor costs may not increase. Paying qualified and experienced workers more to work less (productivity) compared to unskilled workers that must work more hours could mean that overall labor costs do not increase.

A comprehensive review of 20 peer-reviewed studies conducted since 2000 finds that, in 85% of cases, prevailing wage laws have no effect on construction costs for public projects such as schools, highways, and public buildings.[24] Moreover, a large comprehensive analysis and evaluation by Independent Project Analysis (IPA) finds productivity for union labor is 14% higher than open shop labor, resulting in a reduction in project costs of 4%, on average.[25] The analysis also found that projects are 40% less likely to experience shortages of skilled labor when union labor is sourced compared to open shop labor and that turnover of labor on projects— which leads to higher project costs and worse schedule outcomes— is one-third less with union labor compared to shop labor. The estimates above also do no account for the lower wage rates— typically half—paid to apprentices with less experience compared to journeypersons.

Beyond productivity, prevailing wage laws also provide many other benefits to the economy and workers. Research shows prevailing wage levels increase the hiring of local contractors and local workers, which keeps more money in the local economy and improves the labor supply of local high skilled workers. This is deeply important since contractors often report difficulty finding qualified craft workers, especially in clean energy occupations.

Construction workers who are more experienced and well-trained in their crafts are also less likely to make mistakes. This ensures workers are safer and that projects get completed on time. Prevailing wage laws can also boost homeownership and state and local taxes, improve health insurance and retirement coverage, and lower poverty and public assistance costs, according to studies. By ensuring equal pay for workers and contributing to career development opportunities, prevailing wages also ensure less discrimination based on race, gender, and ethnicity.

Benefits of Apprenticeship Utilization Requirement

Prevailing wage laws are also pivotal to supporting registered apprenticeship programs. This is because many union apprenticeship programs are funded through contributions from participating employers, which are negotiated as part of collective bargaining agreements. Some unions establish training funds jointly with employers to pool resources to fund apprenticeship, and a portion of union dues is often allocated to support apprenticeship programs. Because of links between unions and apprenticeship, research shows that the apprenticeship share of the construction workforce was 14% higher in states with prevailing wage laws compared to 8% in states without prevailing wages.[26]

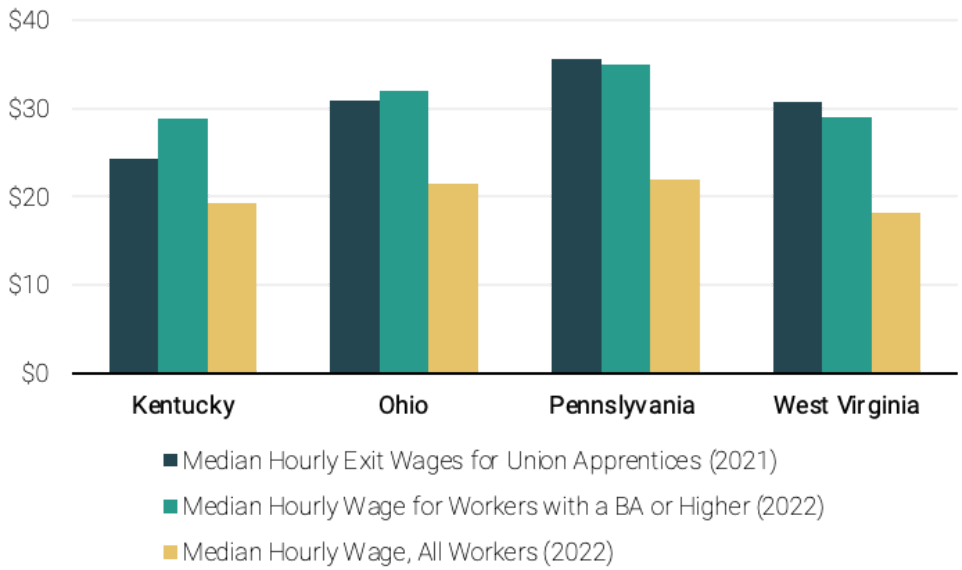
According to the DOL, there are 30,094 registered apprentices in the construction industry in the four-state region of Appalachia (FY2024). Approximately 79%, or 23,895, of these apprentices belong to a union.

When projects pay prevailing wage rates it can incentivize union firms to work on those projects and sign project labor agreements (PLAs). When union firms are supported, it allows them to take on, train, and pay new apprentices, which in turn, creates a highly-quality workforce.[27] This also puts pressure on other non-union firms to raise wages, benefits, and other workforce standards, thereby helping more workers achieve a higher standard of living.

Union registered apprenticeship programs can have many advantages over employer-only programs. This includes a more structured and consistent training experience, higher wages and benefits, and better job security and career advancement. Registered apprenticeship programs have been studied extensively.[28] Overall, studies show that they result in higher earnings, improved employment outcomes, skills development, reduced skill mismatch, greater social mobility, and they are crucial to maintaining a skilled workforce, especially in the trades. The inclusion of the registered apprenticeship requirement for the enhanced tax credits can boost the demand for apprenticeship enrollment now and in the future.

Union construction apprentices can earn nearly as much as—or more than—what workers with a four-year college or higher degree earn in Appalachia. A recent analysis by the Keystone Research Center found that union construction apprentices who completed their apprenticeships in Kentucky, Ohio, Pennsylvania, and West Virginia over the last two decades received a median (the middle of the wage distribution) hourly exit wage of between $24 and $36 upon graduation (2021 dollars). As Figure 7 below highlights, these exit wages for union apprentices exceed each state's median hourly wage. In Pennsylvania and West Virginia, the median exit wage for union apprentices was higher than the median hourly wage for workers with a four-year college degree or higher. In Ohio and Kentucky, the median exit apprenticeship wage was just below the median hourly wage for workers with a college degree.

Figure 7: Union Graduate Apprentices Wages Compared to College Graduate Wages



Source: Keystone Research Center analysis of data from the US DOL (RAPIDS), Economic Policy Institute Current Population Survey Extracts, and US BLS Occupation Employment Statistics (OES) data.

Economic Impact of Enhanced Clean Energy Tax Credits on Electricity Prices

If companies meet the requirement for the enhanced PWA credits in the PTC and ITC, it is unclear how the value of those credits are distributed. Some economic analyses of the ITC and PTC assume that the full value of the credits will be passed along in the form of lower electricity prices to end-use consumers, but many of the producers may also pass along the value of the credits to their company shareholders.[29] The "tax incidence" or distribution of who ultimately receives the benefits of the tax credits is not well understood and currently relies on many assumptions.

Whether the tax credits value is passed through to consumers in the form of lower electricity costs largely depends on the degree of market competition, market structure (traditionally regulated regions vs. competitive wholesale markets in RTOs/ISOs), state and local policy environments, interest rate, supply and cost of labor and materials, and the price elasticities of supply and demand. For example, if the regional electricity market is relatively uncompetitive, companies have little incentive to pass the savings from the IRA credits onto household consumers. A recent paper published by top scholars in the power sector concluded that "the extant literature does not provide empirical evidence of pass-through for historical utility-scale wind and solar credits in US markets."[30] In other words, where the money goes after the company receives the credit is not well understood. Despite the lack of empirical evidence, some economic models simply assume that the tax credits flow exclusively to end users (i.e. customers).[31] This assumption relies heavily on classroom economic theory more than reality and it is unlikely to reflect the highly regulated nature and complexity of electricity markets.

If the value of the tax credits is passed along in the form of lower electricity prices (a big "if"), the ITC and PTC could act as a negative capital tax for industry that could raise capital stock and overall productivity. A model by Resources for the Future (RFF) estimates that the PTC and ITC credits will lower electricity prices by 7.3% over the next decade, saving consumers $288 to $345 billion in electricity costs.[32] By 2030, RFF finds that the federal tax credits will be larger ($49.7 billion) than total resource cost changes and that profits for clean energy producers will fall by $7.7 billion.

Will the clean energy tax credits lower electricity rates? It depends on what assumptions are made. While the tax credits could lower wholesale electricity prices because the credits are larger than the wholesale prices creating "44% of hours with zero or negative prices," this could also increase system costs in capacity markets.[33] Baseline power plants could struggle to stay online due to a lack of revenue at zero prices. This could then mean additional costs for grid reliability from dispatchable baseload power plants and substantial investments in energy storage and transmission. These costs could be larger than the IRA tax credit benefits—which means that the net effect may not be to reduce overall retail electricity rates, but instead to raise them. This also assumes that the credit values are passed through entirely to benefit consumers. Some critics suggest that "no government production tax subsidy should ever be so large that it creates an incentive for a business to actually pay customers to take its product."[34] One benefit of the increased tax credits is that they could allow developers more room in a higher interest rate environment to secure financing for clean energy investments.

An analysis by Jason Furman (Harvard University) of the PTC and ITC finds that most of the benefits flow to the top 1% of income earners and that the incidence of after-tax income changes increases more for higher-income households than middle-income households.[35] Furman notes that 60% of electricity consumers are commercial and industrial users and that the subsidies "are more like a corporate tax cut," which could be saved or fall on producers over time rather than show up in lower-priced goods and services. Moreover, Furman concludes, "giving money to businesses and hoping that money eventually gets to the people" is "less certain and deserves more attention." According to LAZARD, the sensitivity to the PTC and ITC subsidies lowers the Levelized Cost of Energy (LCOE) for utility solar PV substantially.[36] For example, the full PTC credit (including meeting the PWA requirements and Energy Community Bonus, which is $30.50 MWh) lowers the LCOE of solar utility projects on the lower end from $29 MWh (unsubsidized) to just $6 MWh, which is a difference of $23 per MWh, or $7.50 per MWh lower than the full credit. For onshore wind, LAZARD estimates that the subsidized LCOE is $0 per MWh on the low end with the full PTC credit compared to $27 MWh unsubsidized LCOE for onshore wind based on 2023 tax rates.

According to the National Renewable Energy Lab (NREL), the PTC and ITC, along with the bonus credits, can "affect the prices US customers will pay for PV [Solar Photovoltaic] systems" but the "impact of the tax credits is unclear because market competition within the US PV section—and from competing sources of energy—already creates margin pressure."[37] In addition, NREL finds that since the tax credits have existed for over a decade and will continue over the next decade that they are "part of the long-term market" and not included in cost modeling.

Another aspect of the value of the PTC and ITC is tax credit monetization in the IRA. Historically, for-profit project developers are allowed to monetize certain tax credits like the PTC and ITC and depreciation amounts (Modified Accelerated Cost Recovery System, or MACRS) by transferring them to other taxpayers, which allows clean energy project taxpayers to sell credits for cash to finance their projects. Because private clean energy developers often do not have income tax liability to benefit from the credits, they are allowed to partner with tax equity advisors (usually banks) to monetize or sell the value of the credits to an investor. In exchange, the investor or bank provides upfront cash to the developer to finance the project and receives an ownership stake in the project along with future use of the tax credits. In 2020, the ITC and PTC generated around $18 billion in tax shelters that were almost entirely claimed by the largest banks in the US.[38] In essence, these tax credits are paying mostly wealthy equity payers "to invest in renewable energy on the government's behalf."

Under the IRA, developers can now sell all or a portion of the credits to unrelated eligible taxpayers for cash, which eliminates many of the financial hurdles and costs associated with forming legal partnerships with investors. However, the credits are usually sold between 89 to 95 cents on the dollar.[39] These transactions are usually insured, costing around 1.5% to 2% of the credit amount.[40]

While the distributional aspects of the tax credits are not clear, there is good evidence that the credits do induce investment in clean energy power systems and can result in lower carbon emissions, which improves public health.[41] Taking the 'social cost of carbon' (SCC) into account in the development of clean energy projects is important. One recent analysis found that the benefit-to-cost ratio of the IRA's clean energy credit was 4 to 1, meaning that the benefits (lower carbon emissions) outweighed the costs of the credit fourfold.[42] These beneficial impacts should be considered along with direct economic consideration since decarbonizing the electric power sector can provide many long-term benefits to society.

Conclusion

The 57 clean energy projects in Appalachia that are in the pre-construction phase could receive an additional $1.27 billion in tax credit benefits if the projects meet the PWA requirements contained in the PTC and ITC. The additional tax benefits for meeting the PWA requirements are estimated to be more than the labor costs for all 57 projects. The benefits of using local union labor and union apprentices have large impacts across the economy and construction industry by increasing the supply of skilled qualified workers in the region and lifting wage, safety, and compensation standards that can have positive spillover effects in nonunion construction firms. The projects analyzed in this report are only a small portion of the clean energy projects in the region that are being built and planned. To maximize the benefits of these projects, project developers should aim to meet the PWA requirements to not only lower costs but to improve the long-term economic prosperity of the region for decades to come.

Appendix A: Detailed Methodology for Calculating Value of Tax Credits and Labor Costs

To illustrate the potential impact of the enhanced IRA credit provisions for clean energy projects, this analysis models 57 clean energy projects in the pre-construction phase in Appalachia (Kentucky, Ohio, Pennsylvania, and West Virginia) provided by the US Department of Labor (DOL).[43] This includes two battery projects, two wind projects, 20 hydro-electric projects, and 33 solar projects in Kentucky, Ohio, Pennsylvania, and West Virginia. 55 of these projects (wind, solar, and hydro) qualify for the Investment Tax Credit (ITC) or the Production Tax Credit (PTC), while 2 battery projects qualify for just the ITC.

Capital Cost Estimates

Table A1 on the following page includes the estimates for overnight capital (per KWh) costs (CAPEX) for solar, wind, and battery projects from the US Energy Information Administration (EIA) used to estimate project costs for 37 clean energy projects. The CAPEX estimate for the 20 hydroelectric power plants is from the National Renewable Energy Laboratory (NREL) using non-powered dams (NPD) 5 (low cost, lock) for 2020.

CAPEX estimates vary by resource/technology and by size of project. It is assumed all 57 projects are utility-scale size, even though this may not be the case since the MW size ranges from 2.5 MW to 200 MW. Commercial and Residential CAPEX estimates provided by the National Renewable Energy Laboratory (NREL) for solar electricity technology were all below 1 MW in size.[44] The EIA data was used to estimate CAPEX for each solar and wind project since EIA provides some estimates based on each state. Total capital cost was found by multiplying the per-KWh cost by the nameplate capacity, or MW size.

Table A1: 2023 Estimated Project (CAPEX) Costs Per KWh by State

	KY	OH	PA	WV
Battery (BESS): 150 MW, 600MWh (4hr)	$1,787	$1,727	$1,779	$1,743
Solar PV, Single Axis, 150 MW	$1,534	$1,486	$1,504	$1,515
Hydroelectric: 100 MW Net (New Stream)	$5,325	$5,235	$5,325	$5,325
Onshore Wind: 200 MW 2.8 MW Turbine		$1,455		
Offshore Wind: 900 MW 15 MW Turbine		$3,689		

Sources: "Capital Cost and Performance Characteristics for Utility-Scale Electric Power Generating Technologies," U.S. Energy Information Administration, Appendix A: Labor Location-Based Cost Adjustments, January 2024. (https://www.eia.gov/analysis/studies/powerplants/capitalcost/pdf/capital_cost_AEO2025.pdf); National Renewable Energy Laboratory, Annual Baseline Technology, Electricity, Hydropower (NPD 5, Lock), 2024. (https://atb.nrel.gov/electricity/2024/hydropower)

Labor Cost Estimates

Table 2A on the following page shows labor costs as a share of capital costs by resource/technology from two sources provided by NREL. The labor cost share of capital cost for solar, on-shore wind, and hydroelectric was found by using the NREL's Jobs and Economic Impact (JEDI) model, which provides total estimated labor costs for solar, wind, and hydroelectric power projects based on size. These estimates were in between other estimates from NREL that looked at "installation costs" as a share of capital project costs (See Appendix 2), which also include "equipment" costs. The labor costs for the two battery projects were derived from NREL's Q1 2020 report on benchmark costs for solar and energy storage systems. The labor cost share of capital cost for offshore wind is from Mayfield and Jenkins (2021).[45]

Table 2A: Estimated Labor Costs as a Share of Capital Costs for Energy Projects

Resource/Technology	Labor Cost Share of Total Capital Costs
Battery: 60MW (4hr) 240-MWh	5.67%
Solar PV, Single Axis, 150 MW	14.48%
Hydroelectric: 100 MW Net (New Stream)	21.50%
Onshore Wind: 200 MW 2.8 Turbine	7.08%
Offshore Wind: Fixed	9.31%

Source: National Renewable Energy Laboratory (NREL) Jobs and Economic Development Impact (JEDI) model, link; and Feldman et al., "U.S. Solar Photovoltaic System and Energy Storage Cost Benchmark: Q1 2020," NREL, Technical Report NRELTP-6A20-77324,, January 2021. Link ; Mayfield and Jenkins, "Influence of high road labor policies and practices on renewable energy costs, decarbonization pathways, and labor outcomes," Environmental Research, November 2021, Supplementary Data. Link

Annual Electric Generation Estimates

The total megawatt (MW) capacity for all 57 projects is 2,903.8. To find the annual electricity generation for each project (except batteries and hydroelectric) to estimate the PTC over ten years, this analysis uses a solar capacity factor of 23.3% and a wind capacity factor of 33.5% (Ohio). According to the National Renewable Energy Laboratory (NREL), the four-state region is primarily in resource class 9 for utility solar, which has an average AC capacity factor of 23.3%.[46] According to the US Environmental Protection Agency (EPA), the (unweighted) average solar PV capacity factor in the four states, which includes 10 power regions, is 23.4%, with a range of 21.7% in Pennsylvania (PJM) to 25.8% in Kentucky (SERC).[47]

The solar utility capacity factors from NREL (2024) and EPA (2023) are considerably higher than estimates from EIA in 2022, which were 16.7% in Kentucky, 21.9% in Ohio, and 19.5% in Pennsylvania.[48] Solar capacity estimates from the Lawrence Berkeley National Laboratory are also considerably lower than NREL and EPA estimates.[49] According to Berkeley Lab, the average solar capacity factor is 18.9% in Kentucky, 23% in Ohio, and 19.5% in Pennsylvania (no estimates for WV). However, EIA estimates that the average capacity factor for onshore wind in Ohio was 32.8%, which is close to the national onshore wind average capacity factor of 33.5%.[50] The net capacity factor for offshore wind is 45.3% for 2023, according to the National Renewable Energy Laboratory.[51]

EIA estimates that the hydroelectric capacity factor in 2022 was 45.5% in Kentucky, 56.8% in Ohio, 32.6% in Pennsylvania, and 55.2% in West Virginia. Given the relatively high capital costs of hydroelectric power per MW, each of the 20 small scale hydroelectric projects benefit far more from the Investment Tax Credit than the Production Tax Credit.

Table 3A: Estimated Capacity Factors by Energy Resource

Energy Resource	Capacity Factor
Solar (KY, OH, PA, and WV)	23.30%
Onshore Wind (Ohio)	33.50%
Offshore Wind	45.30%

Source: US Energy Information Administration and National Renewable Energy Laboratory
To estimate annual MWh electricity generation, the MW capacity of each project was multiplied by 8760 hours, then multiplied by its capacity factor, which equals annual MWh electricity generation. This analysis assumes a system degradation rate of 0.5% per year for solar and wind and is incorporated into generation figures over the 10 years of the PTC.

Estimated Value of Investment and Production Tax Credits (10 years)

The ITC rates for the base rate (does not meet PWA provisions) is 6% of qualified investment and an additional 2% each for the domestic content and energy community bonus credits. For the full rate ITC credit (meets PWA provisions), these numbers are multiplied by five (30%, 10%, and 10%). Excluded from this analysis is the Low-Income Bonus for projects under 5 MW.

Table 4A: Investment Tax Credit Rates (2024)

	Base Credit & Bonus Credits (% of Qualified Investment)
Base Rate (doesn't meet PWA requirements)	6%
Domestic Content Bonus	2%
Energy Community Bonus	2%
Total Possible Base Rate Amount	**10%**
Full Rate (meets PWA requirements)	30%
Domestic Content Bonus	10%
Energy Community Bonus	10%
Total Possible Full Rate Amount	**50%**

Source: International Revenue Service and US Treasury (2024)

For the PTC, the base rate credit for 2023 is $6 per MWh and $1 per MWh for each bonus credit (total of $8 per MW possible) based on the 2024 inflation adjustment factor from the Internal Revenue Service and the US Treasury for section 45 credit.[52] The full credit is found by multiplying the base credit by five ($30 per MW) and the bonus credits are $3 per MWh each (total of $36 per MWh possible).
The base credit is found by multiplying the base credit amount in 1992 of 0.3 cents per KWh by the 2023 inflation adjustment factor (1.9499) then rounding to the nearest multiple of 0.05 cents ($0.003 x 1.9499 = $0.00585 or 0.60 cents). The number is multiplied by 5 (0.60 cents x 5) to arrive at the full credit amount, which is 3 cents, or $0.0300. Multiplying the KWh credits by 1,000 yields the MWh credit amount ($0.0300 KWh x 1,000 = $30.00 MWh). The bonus credits are new and established in the IRA. They are $1 per MWh each for the base rate and $3 per MWh each for the full rate and are adjusted for inflation along with the base and full credit rates (Table 5A). The IRA PTC and ITC credits are available for energy systems that were placed into service in 2022 or later and that began construction before 2033. Table 5A provides the estimated value of the PTC credit over the next ten years using an annual inflation rate of 2.5%.

Table 5A: Inflation Adjusted PTC Credit Rates (2.5% per year, rounded to 0.05 cents)

	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033
PTC Base Rate (MWh)	$6.00	$6.00	$6.50	$6.50	$6.50	$7.00	$7.00	$7.00	$7.50	$7.50
PTC Base Rate DC or EC Bonus	$7.00	$7.00	$7.50	$7.50	$7.50	$8.00	$8.00	$8.00	$8.50	$8.50
PTC Base Rate DC + EC Bonus	$8.00	$8.00	$8.50	$8.50	$8.50	$9.00	$9.00	$9.00	$9.50	$9.50
PTC Full Rate (MWh)	$30.00	$31.00	$31.50	$32.50	$33.00	$34.00	$35.00	$35.50	$36.50	$37.50
PTC Full Rate DC + EC Bonus	$33.00	$34.00	$34.50	$35.50	$36.50	$37.50	$38.50	$39.00	$40.00	$41.00
PTC Full Rate DC or EC Bonus	$36.00	$37.00	$37.50	$38.50	$40.00	$41.00	$42.00	$42.50	$43.50	$44.50

Source: Internal Revenue Service and Treasury

This analysis adopts the accelerated and bonus depreciation methods used by the US Department of Energy included in IRS Publication 946 (2023) that include a five -year recovery period, a half-year convention, and a 200% declining balance method.[53] A corporate income tax rate of 21% was applied to calculate the net impact of depreciation deductions.

Table 6A below shows the 57 clean energy projects in Appalachia by state, type, and MW size. The table also includes estimated capital (project) and labor costs, along with estimated tax benefits from the PTC and ITC using the above methodology. The total megawatt (MW) capacity for all 57 projects is 2,903.8. The estimated project costs are $5.1 billion based on EIA and NREL capital cost data (see above). Total labor costs are estimated at $774 million. The estimated credit amount based on the base credit is $1.252 billion and full credit is $2.56 billion. This analysis assumes that energy projects choose the ITC or PTC based on its projected ten-year value. Many of these projects may elect a combination of rates and credits based on their individual project circumstances. If each project elected for the ITC, the total base rate benefits is estimated at $1.2 billion, while the full rate tax benefits are estimated at $2.39 billion.

Table 6A: Summary Table of Project Costs, Labor Costs, and Credit Values for PTC/ITC (expressed in millions)

Project Name	State	Type	Size (MW)	CAPX	Labor Costs	Base Credit	Full Credit	Credit Used
KY No. 11 L&D Hydroelectric Project	KY	Hydropower	2.5	$13	$3	$3	$8	ITC
Evelyn Hydroelectric Project	KY	Hydropower	2.8	$15	$3	$4	$8	ITC
SR Scottsville, LLC	KY	Solar	3	$5	$1	$1	$2	PTC
SR Warren, LLC	KY	Solar	3.5	$5	$1	$1	$3	PTC
AEUG Madison Solar, LLC	KY	Solar	100	$150	$22	$39	$76	PTC
SR Russellville	KY	Solar	173	$260	$38	$62	$124	PTC
AEUG Fleming Solar, LLC	KY	Solar	188.5	$284	$41	$68	$135	PTC
Philo L&D Hydroelectric Project	OH	Hydropower	3	$16	$3	$4	$8	ITC
Beverly L&D Hydroelectric Project	OH	Hydropower	3	$16	$3	$4	$8	ITC
Rokeby L&D Hydroelectric Project	OH	Hydropower	4	$21	$5	$5	$11	ITC
Malta L&D Hydroelectric Project	OH	Hydropower	4	$21	$5	$5	$11	ITC
Devola L&D Hydroelectric Project	OH	Hydropower	4	$21	$5	$5	$11	ITC
Lowell L&D Hydroelectric Project	OH	Hydropower	5	$26	$6	$6	$13	ITC

Project Name	State	Type	Size (MW)	CAPX	Labor Costs	Base Credit	Full Credit	Credit Used
Icebreaker Offshore Wind Farm	OH	Wind	20.4	$75	$7	$17	$32	ITC
Grover Hill Wind, LLC	OH	Wind	140.3	$204	$14	$55	$126	PTC
Salt City Solar Project - Hybrid	OH	Batteries	12.5	$22	$1	$5	$9	ITC
Steubenville Solar	OH	Solar	43	$64	$9	$16	$33	PTC
Great Bear Solar, LLC	OH	Solar	46	$68	$10	$16	$33	PTC
White Trillium Solar	OH	Solar	49.5	$74	$11	$18	$35	PTC
Springwater Solar, LLC	OH	Batteries	75	$130	$7	$30	$56	ITC
Mark Center Solar Project	OH	Solar	90	$134	$19	$32	$64	PTC
Nottingham Solar	OH	Solar	100	$149	$22	$38	$76	PTC
Marion County Solar Project	OH	Solar	100	$149	$22	$36	$71	PTC
Union Ridge Solar	OH	Solar	108	$160	$23	$39	$77	PTC
Ross County Solar, LLC	OH	Solar	120	$178	$26	$43	$85	PTC
Powell Creek Solar	OH	Solar	150	$223	$32	$53	$107	PTC
Stark Solar, LLC	OH	Solar	150	$223	$32	$58	$113	PTC
Springwater Solar, LLC	OH	Solar	155	$230	$33	$55	$110	PTC
Kingwood Solar	OH	Solar	175	$260	$38	$62	$125	PTC
Palomino Solar	OH	Solar	200	$297	$43	$71	$142	PTC

Project Name	State	Type	Size (MW)	CAPX	Labor Costs	Base Credit	Full Credit	Credit Used
Point Marion L&D Hydroelectric Project	PA	Hydropower	5	$26	$6	$6	$13	ITC
Braddock Lock and Dam	PA	Hydropower	5.3	$28	$6	$7	$14	ITC
Allegheny L&D2 Hydroelectric Project	PA	Hydropower	9	$47	$10	$12	$24	ITC
Maxwell L&D Hydroelectric Project	PA	Hydropower	12	$63	$14	$16	$32	ITC
Grays Landing L&D Hydroelectric Project	PA	Hydropower	12	$63	$14	$16	$32	ITC
Monongahela L&D4 Hydroelectric Project	PA	Hydropower	12	$63	$14	$16	$32	ITC
Emsworth BC Hydroelectric Project	PA	Hydropower	18.8	$98	$21	$24	$51	ITC
Emsworth L&D Hydroelectric Project	PA	Hydropower	20.4	$107	$23	$26	$55	ITC
Montgomery L&D Hydroelectric Project	PA	Hydropower	20.4	$107	$23	$26	$55	ITC
Gans Solar	PA	Solar	14	$21	$3	$5	$11	PTC
Pechin Solar	PA	Solar	14	$21	$3	$5	$11	PTC
Listonburg Solar	PA	Solar	15	$23	$3	$6	$11	PTC
Mountain Holly Solar	PA	Solar	20	$31	$4	$8	$15	PTC

Project Name	State	Type	Size (MW)	CAPX	Labor Costs	Base Credit	Full Credit	Credit Used
Sycamore Trail Solar	PA	Solar	20	$31	$4	$8	$15	PTC
Erie Solar, LLC	PA	Solar	20	$31	$4	$7	$14	PTC
Cobalt Solar, LLC	PA	Solar	20	$31	$4	$8	$15	PTC
Cardinal Solar, LLC	PA	Solar	20	$31	$4	$8	$15	PTC
Beaver Creek Solar	PA	Solar	34.2	$52	$8	$12	$25	PTC
Granite Hill Solar	PA	Solar	70	$107	$16	$26	$50	PTC
Goonies Solar Project	PA	Solar	194	$298	$43	$76	$148	PTC
Morgantown L&D Hydroelectric Project	WV	Hydropower	5	$26	$6	$6	$11	ITC
Opekiska L&D Hydroelectric Project	WV	Hydropower	6	$31	$7	$8	$16	ITC
Tygart Hydropower	WV	Hydropower	30	$157	$34	$39	$81	ITC
Marlowe Solar	WV	Solar	5.8	$9	$1	$2	$4	PTC
Wylie Ridge Solar	WV	Solar	8.4	$13	$2	$3	$6	PTC
Davis Solar (WV)	WV	Solar	11.5	$17	$3	$4	$9	PTC
Beddington Energy Facility, LLC	WV	Solar	50	$76	$11	$18	$36	PTC
Total			2904	$5,099	$774	$1,250	$2,517	

Adding Operations and Maintenance Costs (Solar and Wind)

To receive the full rate of the PTC and ITC, some workers involved in maintenance and repair would also have to be paid prevailing wage rates. Table 7A includes estimated Operations and Maintenance (O&M) costs over ten years along with the share of labor costs for utility solar. The labor cost share for O&M was derived using estimates from Mayfield/Jenkins (2021) of 31.7% ($5.17/$16.32 per kW year) for utility solar. O&M labor cost data for hydroelectric and batteries was not available. The O&M cost estimates are based on US EIA data for 2023 O&M costs for utility solar. Capital cost and O&M estimates are based on 2.5% inflation rate over 10 years.

Table 7A shows that if labor costs are 30% higher for all capital and O&M costs over ten years—the life of the PTC and ITC credit—total project and O&M costs rise approximately 5.2% for solar. These estimates assume no gains from productivity.

Table 7A: Estimated Capital and O&M Costs

	Solar (33)
O&M Cost (MW)	$20,030
MW Capacity	2471.4
O&M Cost	$49,502,142
Labor % of O&M Cost	31.7%
Labor Cost	$15,682,279
10-Year O&M Cost	$553,591,395
10-Year Labor O&M Cost	$175,694,554
Total Capital Costs	$3,704,297,300
Total Labor Capital Costs	$536,382,249
Total Capital and O&M Costs	$3,879,991,854
Total Labor Cost of Capital and O&M (10 Years)	$712,076,803
Total Labor Costs of Capital and O&M (30% Higher)	$925,699,844
Capital and O&M Cost (30% Higher Labor Costs)	$4,093,614,895
Increase in Project Costs w/ 30% Higher Labor Costs	5.2%

Source: Mayfield and Jenkins, "Influence of high road labor policies and practices on renewable energy costs, decarbonization pathways, and labor outcomes," Environmental Research, November 2021, Supplementary Data. Link; "Capital Cost and Performance Characteristics for Utility-Scale Electric Power Generating Technologies," U.S. Energy Information Administration, Appendix A: Labor Location-Based Cost Adjustments, January 2024. Link

Appendix B: Various Estimates for Capital and Labor Costs for Renewable Electricity

The following table is from a recent study by Pinnacle Economic using the estimated installed labor costs per watt from the National Renewable Energy Laboratory (NREL) for solar, battery storage and onshore wind for 2020 and 2019, and estimates from Mayfield and Jenkins (2021). Data on geothermal is from the Electric Power Research Institute (EBRI).

Table 1B: Pinnacle Economics Estimates of Labor Cost Share of Renewable Energy

Resource / Technology	Install Labor Costs as % of Total Capital Costs	Percent % in Project Costs Associated with the Following % Changes in Labor Costs			
		1%	10%	20%	30%
Solar: Utility-Scale Fixed-Tilt (Low - 5 MW)	9.68%	0.10%	0.97%	1.94%	2.90%
Solar: Utility-Scale Fixed-Tilt (High - 100 MW)	10.64%	0.11%	1.06%	2.13%	3.19%
Solar: Utility-Scale One-Axis (Low - 5 MW)	9.70%	0.10%	0.97%	1.94%	2.91%
Solar: Utility-Scale One-Axis Solar (High - 100 MW)	10.89%	0.11%	1.09%	2.18%	3.27%
Solar: Commercial Rooftop (2 MW)	6.96%	0.07%	0.70%	1.39%	2.09%
Solar: Commercial Ground (2MW)	9.15%	0.09%	0.92%	1.83%	2.75%
Wind: Land-Based (2.6 MW Turbines)	6.21%	0.06%	0.62%	1.24%	1.86%
Wind: Fixed-Bottom Offshore (6.1 MW Turbines)	9.34%	0.09%	0.93%	1.87%	2.80%
Wind: Floating Offshore (6.1 MW Turbines)	10.32%	0.10%	1.03%	2.06%	3.09%
Battery Storage: Utility-Scale 60 MW Lithium-ion	5.67%	0.06%	0.57%	1.13%	1.70%
Geothermal: 50 MW Flash Plant (bottom exhaust)	8.03%	NA	NA	NA	NA
Geothermal: 40 MW Flash Plant (top exhaust)	7.58%	NA	NA	NA	NA
Geothermal: 50 MW Binary Plant	3.02%	NA	NA	NA	NA

Note: Changes in total project costs for geothermal projects not estimated because install labor costs are based on union workers receiving prevailing wages and benefits. Offshore wind energy included for context.
Sources: Pinnacle Economics using detailed NREL and EPRI project cost data.

Table 2B includes estimates of capital costs and installation costs as a percentage of total capital costs for renewable energy technologies from EIA (2024), NREL (2020, 2023, 2024), and Mayfield and Jenkins (2021). Installation costs often include equipment costs as well as occupations that may not be subject to prevailing wage requirements.

Table 2B: Various Estimates of Capital Costs and Labor Cost Share of Renewable Energy

	Installation Cost as a Percentage of Total Project Cost	**Project Cost ($kW)**
EIA (2024)		
Battery (BESS): 150 MW, 600MWh (4hr)	3.31%	$1,744
Solar PV, Single Axis, 150 MW	11.70%	$1,502
Solar PV + Battery, Single Axis, 150 MW, 200MWh (4hrs)	8.43%	$2,175
Hydroelectric: 100 MW Net (New Stream)	n/a	$7,073
Offshore Wind: Fixed Bottom 900 MW 15MW Turbine	n/a	$3,689
Onshore Wind: 200 MW 2.8 Turbine	n/a	$1,489
NREL (2020Q1)		
Solar PV, Single Axis, 100 MW	10.89%	$1,010
Solar PV, Single Axis, 50 MW	10.90%	$1,100
Battery: 60MW (4hr) 240-MWh	5.67%	$1,380
Solar PV + Battery: Single Axis, 100 MW, 60MW, 240 Mwh (4hr)	8.99%	$1,730
NREL (2023Q1)		
Solar PV: Single Axis, 100MW	n/a	$1,161

	Installation Cost as a Percentage of Total Project Cost	Project Cost ($kW)
Solar PV + Battery: Single Axis, 100 MW, 60MW, 240 Mwh (4hr)	n/a	$2,130
NREL (2024)		
Solar PV: Single Axis, 100MW (2023)	19.20%	$1,560
Onshore Wind: 200 MW 3.2 Turbine (2023)	n/a	$1,810
Offshore Wind: Fixed Bottom 1,008 MW 12 MW Turbine (2023)	n/a	$4,639
Hydroelectric: 2 MW Net (NPD) (2020)	n/a	$6,580
Battery: 60MW (4hr) 240-MWh (2023)	2.59%	$1,907
Solar PV + Battery: Single Axis, 133 MW, 60MW, 240 Mwh (4hr)	n/a	$2,560
Oak Ridge Lab (2020)		
Hydroelectric: 2.7 MW (Lake)	n/a	$12,097
Hydroelectric: 24.2 (Lock)	n/a	$10,846
Mayfield/Jenkins (2021)		
Solar	11.70%	$1,200
Land-based Wind	6.92%	$1,300
Offshore Wind	9.13%	$4,080

Source: EIA, NREL, Mayfield and Jenkins

Endnotes

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