Analyzing the Inflation Reduction Act and the Bipartisan Infrastructure Law for Their Effects on Nuclear Cost Data

Nuclear Fuel Cycle and Supply Chain

Prepared for
U.S. Department of Energy
Systems Analysis & Integration Campaign
Nahuel Guaita, Jason Hansen (INL)
April 2024
INL/RPT-23-72925

Page intentionally left blank

SUMMARY

Decarbonizing to meet aggressive climate change mitigation targets requires energy transition within all sectors. In the industrial sector, emissions will need to decrease by 65–90% by 2050 to avert global warming greater than 1.5°C (IPCC 2022). The Inflation Reduction Act, and Bipartisan Infrastructure Law have clean energy requirements and provide financial incentives to accelerate the use of clean energy technologies in the industrial sector. It is important to note that the Inflation Reduction Act is the most extensive action ever taken by Congress and the U.S. government to combat climate change (U.S. CBO 2022). The energy system provisions comprise most of the estimated climate and energy support. A better understanding of those provisions in the above-mentioned acts and laws is crucial to assessing their impact on the equivalent energy costs to the power plant owners (impact on net revenue in $/MWh) across different energy technologies, market deployment potential offered to different energy technologies applications, and energy system research modeling. The purpose of the report is to shed light on the Inflation Reduction Act and Bipartisan Infrastructure Law provisions with particular attention to impacts on the nuclear industry. The report also seeks to understand potential equivalent energy cost savings for nuclear energy technologies from other laws and programs in conjunction with Inflation Reduction Act, Bipartisan Infrastructure Law, loan program guarantees, and Defense Production Act. The report reviews recent legislation on energy policy and translates that policy to impacts on equivalent nuclear costs for the purpose of modeling policy in energy scenarios.

Page intentionally left blank

CONTENTS

FIGURES

TABLES

ACRONYMS

BIL	Bipartisan Infrastructure Law
CAA	Consolidated Appropriations Act
CCS	Carbon capture and storage
CF	Construction factor
CO_2	Carbon Dioxide
CRF	Capital recovery factor
DAC	Direct air capture
DoD	Department of Defense
DOE	Department of Energy
DPA	Defense Production Act
FM	Financial multiplier
GDP	Gross domestic product
GHG	Greenhouse gases
IAF	Inflation Adjustment Factor
IRA	Inflation Reduction Act
IRS	Internal Revenue Service
ITC	Investment Tax Credit
LCOE	Levelized cost of electricity
LPO	Loan Programs Office
MACRS	Modified Accelerated Cost Recovery System
MESC	Office of Manufacturing and Energy Supply Chains
MR	Microreactor
MW	Megawatt
NOI	Notice of intent
O&M	Operations and maintenance
PTC	Production Tax Credit
ReEDS	Regional Energy Deployment System
RFI	Request for information
SMR	Small modular reactors
TELGP	Tribal Energy Loan Guarantee Program
TR	Tax rate
TWh	Terawatt-hours
WACC	Weighted average cost of capital

Page intentionally left blank

ANALYZING THE INFLATION REDUCTION ACT AND THE BIPARTISAN INFRASTRUCTURE LAW FOR THEIR EFFECTS ON NUCLEAR COST DATA

1. INTRODUCTION

The U.S. Congress recently enacted two laws with implications for the nation's energy system: the Inflation Reduction Act of 2022 (IRA) and the Infrastructure Investment and Jobs Act of 2021, also called the Bipartisan Infrastructure Law (BIL). The IRA contains an array of programs, tax credits, and fees that, in combination, seek to create a game-changer policy effect to decarbonize the U.S. economy. These incentives aim at reducing harmful emissions by advancing clean energy while at the same time increasing U.S. energy security. This set of incentives is sufficiently vast that understanding its different provisions can seem like a fog of information. This can be problematic for analysts tasked with modeling energy scenarios impacted by these provisions. Consequently, the purpose of this report is to shed light on IRA and BIL provisions with particular attention to impacts on the nuclear industry. That is, the content is presented to provide a better understanding of how to adjust nuclear cost data for modeling purposes. Specifically, the report describes how an analyst can take base nuclear cost data available to them and adjust that data for the impacts of policy to obtain "policy adjusted" nuclear cost data. The report does not investigate lifetime policy effectiveness or duration.

The BIL has several provisions in it, but because the focus of this report is on the nuclear industry, the relevant BIL provision is the Civil Nuclear Credit (CNC) Program, which creates policy to buttress economically distressed nuclear power plants. Though much of the guidance and implementation from the Department of the Treasure for the IRA provisions is still pending (U.S. IRS 2023b), the following report seeks to strengthen the understanding of IRA's direct effects and some BIL provisions on the cost of different energy technologies. This will improve the modeling calibration of policy effects arising from these provisions.

The IRA builds on the BIL and other previous laws such as the Infrastructure Investment and Jobs Act, signed in November 2021. The IRA incentivizes the commercial scale of clean technologies like solar, wind, carbon capture and direct air capture (DAC), clean fuels, clean hydrogen, advanced nuclear, existing nuclear, and other cutting-edge technologies. Given this focus on technologies, modeling the micro- and macro-energy system implications is sensitive to how the provisions across energy technologies are represented. For instance, examples of modeling the IRA have been recently published by Steinberg et al. (2023), Jenkins (2016), Jenkins et al. (2022), Rennert, Roy, and Burtraw (2022), and Larsen et al. (2024). However, the models in these studies are designed with different purposes, scopes, and aims. Hence, this report seeks to describe the primary effect of IRA and BIL on nuclear technologies and the secondary effects on nuclear by way of provisions that affect non-nuclear energy technologies. This report builds on previous reports in this research space (Kozeracki et al. 2023; Shropshire et al. 2023).

At the same time, these provisions and incentives generate heterogeneous growth effects (U.S. DOE 2022b; Gagnon et al. 2022; Steinberg et al. 2023) among the different technologies, creating an unclear net impact across the share of energy technologies in the energy system. For instance, Gagnon et al. (2022) find that the IRA decreases generation from non-CCS (carbon capture and storage) natural gas and non-CCS coal while increasing generation from solar and wind. Also, CCS natural gas and CCS coal show an increase in deployment. Given this, the report describes how the recent legislation supports or includes different technologies to allow better modeling calibrations and policy evaluations for the other energy sources.

This report finds that some provisions' direct effects are specific to technology type while others are geared toward energy outcomes, and still others remain ambiguous; therefore, clear-cut outcomes cannot be described herein. While anticipated IRA outcomes are expected to have profound implications for carbon dioxide (CO_2) and greenhouse gases (GHG) emissions in the long run, the potential delays in the harnessing of benefits from society could arise from a lack of understanding of the law. The remainder of this section describes energy incentives granted by policy prior to BIL and IRA and the modeling efforts used to reflect these in energy systems. Then Section 2 sheds light on the main provisions, such as tax credits, loan guarantees, and funding for different energy technologies. It continues with a policy overview and deep dive into the provisions contained in IRA and BIL. Analysts who wish to see directly how to adjust nuclear cost data can find in Section 2.2 a set of equations and a table of parameters to perform the adjustments. However, it is critical to mention that the tax credits are not affecting the cost of the physical inputs used in any energy technology, on the contrary, they are affecting the income after tax and the financial result of the company. In other words, the stakeholders, at the moment of construction, still need to pay for the total cost of physical inputs without any tax credit deduction. Taxes will be refunded later. Then Section 3 provides a tradeoff analysis that shows a potential breakeven point between the provisions in the IRA: the production tax credit (PTC) and the investment tax credit (ITC) because of the requirement that one or the other can be applied, not both. Section 4 summarizes and concludes.

1.1 Tax Credits Before IRA

The use of tax credits as a driver for energy investments has been a pattern in the last 40 years. For instance, there is consensus in the literature that in the past decades, renewable energy PTCs and ITCs have driven wind, solar farms, and energy storage deployment.

Multiple U.S. laws since the 1970s have supported renewable energy through PTCs and ITCs. Each law has specified the eligible forms of renewable energy and their applicable tax credit values. The PTC has become the main tax credit for wind projects, and the ITC has become the main tax credit for solar projects (U.S. CRS 2019; U.S. CRS 2021). Also, series of legislative actions have amended and extended federal wind and solar energy tax credits since establishing the wind PTC in the Energy Policy Act of 1992 (U.S. Congress 1992) and the solar tax credit in the Energy Tax Act of 1978. Since their inception, federal renewable tax credits have expired, been extended, modified, and renewed. These federal tax credits have served as one of the primary financial incentives for renewable energy deployment in the past. Previous studies found that one of the significant drivers for renewable energy growth in the United States is the federal tax policies, particularly for wind, where the U.S. wind and solar installations have experienced growth cycles coinciding with PTC expirations and renewals (Leon 2015; Wiser et al. 2016; Mai 2016; Mai et al. 2015). Moreover, these tax credits contributed to the significant electricity capacity additions over the last decades. For instance, wind electricity generation reached 191 terawatt-hours (TWh) in 2015, and photovoltaic (PV) electricity generation rose from near zero in 2005 to 36 TWh in 2015 (U.S. DOE 2016; Mai et al. 2016). Table 1 provides a summary overview of these credits.

Table 1. PTC and ITC before IRA for wind and solar technologies. Adapted from Mai et al. 2016.

		2015	2016	2017	2018	2019	2022	2021
Wind PTC ($/MWh)		23	23	18.4	13.8	9.2	13.8	0
Solar ITC (%)	Utility	30	30	30	30	30	26	22
	Commercial	30	30	30	30	30	26	22
	Residential	30	30	30	30	30	26	22

The PTC and ITC were originally designed to incentivize developing and deploying renewable energy technologies, such as wind, solar, geothermal, and biomass. As such, they did not apply to nuclear energy. The IRA modifies and extends the former PTC and ITC through 2023 and 2024. After that date, they become technology neutral (i.e., for zero or negative GHG emission rate-based credits, the clean electricity PTC, and Clean Electricity ITC) instead of renewables only. They start to phase out after 2032. More specifics on these are in Section 2.1.1.2.

1.2 Previous Modeling Methods

Modeling taxes is not easy. It requires reflecting the impacts of policy with financial and accounting issues. For example, in some cases, there will be instances where the taxes owed are less than the tax credit amount, thus preventing an applicant from receiving the tax credit. (Such a situation is addressed in the current IRA through the provision on monetization.) In other cases, correctly applying tax credits in an analysis requires caution because tax credits typically apply only to specific costs, not the project's total cost. This section describes how models address these issues and have been used to estimate the effect of PTC and ITC historically.

The Regional Energy Deployment System (ReEDS) model from National Renewable Energy Laboratory is one model often used to analyze the evolution of the U.S. power sector in response to policies and technological change (Ho et al. 2021). ReEDS is a model used to simulate the deployment of electricity generation and transmission technologies across the United States, considering a range of factors such as costs, policies, and resource availability. The model evaluates the impacts of different policy scenarios on the electricity system, including deploying renewable energy technologies (Ho et al. 2021; Steinberg et al. 2023). It has also been used to examine the implications of PTC for wind (Lantz et al. 2014) and to simulate ITC for solar (Mai et al. 2015).

ReEDS models the ITC by assuming that a certain percentage of the total cost of installing qualifying renewable energy systems will be eligible for a tax credit. The tax credits affect the financial parameters specific to these technologies. Understanding how the ITC is modeled requires understanding Equation (1) below, which represents the present value of revenue requirements necessary to finance new investment, including the construction financing, return to equity holders, and interest on debt, taxes, and depreciation (Ho et al. 2021). The numerator captures the present value of the revenue flows needed to recover a capital investment. The denominator grosses that revenue stream up by (1-TR), which gives the additional revenues required to pay taxes, where TR is the prevailing tax rate. The ITC also affects the financial multiplier (fin_{mult}), which reflects the total present value of a stream of higher (or lower) payments to capital relative to what the payments would be at the system's average cost of capital (Ho et al. 2021). The ITC reduces the amount of the financial multiplier. Furthermore, the ITC reduces the flow of annual streams needed to recover capital. That is why the capital expenditure will not decrease by exactly the amount of the ITC.

$$FM = CC_{mult} * fin_{mult} * \frac{1-TR*PV_{depr}*\left(1-\frac{ITC_{eff}}{2}\right)-ITC_{eff}}{1-TR} \quad (1)$$

In Equation (1), FM is the financial multiplier, CC_{mult} is the construction cost multiplier expressing the additional cost for finance construction, fin_{mult} is the financing multiplier which expresses the adjusted required returns for diversifiable risk, and $TR * PV_{depr}$ is the depreciation expense. Note that it reduces the taxable income by the depreciation expense. Here $(1-\frac{ITC_{eff}}{2})$ represents the depreciable basis, and ITC reduces the depreciable basis. ITC_{eff} is the ITC, which reduces the tax liability by the ITC rate, and $1-TR$ is the adjustment for prevailing tax rates. When the ITC is available, it first reduces the fraction at the right side of Equation (1). This means that the rate at which the investors will need to recover the capital investment for their renewable energy projects is reduced; furthermore, it reduces the financial multiplier (FM). For instance, the ITC for solar affects the present value of the revenue required to pay for the capital cost of one MW of solar capacity ($/MW), including interest during construction, finance, and taxes. Finally, the ITC taxable basis (i.e., the capitalized project costs that are used to calculate the tax depreciation expense) amount must be reduced by 50% if the ITC has been requested. The tax code mandates that when an energy tax credit is taken, the depreciable base (capital sum to be recovered by depreciation) of the property for which the credit was taken must be reduced by 50% of the amount of the tax credit (U.S. IRS 2023a).

To model the impact of the PTC, ReEDS uses a set of assumptions about the availability and value of the tax credit over time. The model assumes that the PTC will be available for a set time, with a specific value per kWh of electricity generated. The value of the PTC is then factored into the overall cost of generating electricity from renewable sources, making it more cost-competitive with other energy sources. It is important to note that ReEDS accounts for the tax credits received by facilities as the value of the tax credits at the time the plant would typically start construction. For instance, a plant coming online in 2022 where construction started in 2018 will receive the value of the tax credit from 2018 (Ho et al. 2021). Though, the renewable project developer only really receives the PTC while the renewable project is generating electricity (H.R.6 2005).

The Internal Revenue Service (IRS) has issued guidance that the definition of commenced construction in the context of the new IRA provision is the same as that issued before IRA. The IRS mandates that once construction has commenced, the project should make steady progress toward completion, which is deemed to be automatically fulfilled if the project is commissioned no later than 4 calendar years (or 10 years for projects constructed on federal land) from the calendar year in which construction commenced (U.S. IRS 2022b). This requirement may unintentionally burden facilities where construction exceeds 4 years.

Modeling the impact of the PTC in the ReEDS model takes place according to Equation (2).

$$CWOM_c = WOMF_c * PVA_{d,E} + 8760 * CF_c * (WOMV_c * PVA_{d,E} - \frac{WPTC}{1-TR} * PVA_{d,PTCP}) \quad (2)$$

Here the parameters of the equation are $CWOM_c$, which is the present value of E years of operating costs, including property taxes, insurance, and PTC ($/MW), $WOMF_c$ is the fixed annual operations and maintenance (O&M) cost of class c wind ($/MW-yr), PVA is the present value of annual $1 payments for L years, CF_c is the capacity factor by time-slice for new wind at a class c, TR is the combined federal and state marginal income tax rate, $WOMV_c$ is the variable O&M cost of class c wind ($/MWh), $WPTC$ is the PTC for wind ($/MWh), and $PTCP$ is the period over which the PTC is received (years).

Specifically, the PTC decreases the present value of the variable O&M cost. The PTC ($/MWh) affects the current value of the variable operating expenses—the greater the production tax credit, the more minor the operating cost. Furthermore, this tax credit reduces the overall cost of generating electricity from these technologies, reducing the levelized cost of electricity (LCOE), which contains the O&M and capital cost.

The numerator ($WPTC$) on the right side of the equation represents the value of the PTC and the extent to which it reduces O&M costs. The denominator weights the reduction by an amount (1-TR), which is the additional revenues required to pay federal and state taxes. That is why the *CWOMc* does not decrease by the exact amount of the PTC.

2. METHODS AND APPROACH

This section provides an overview of provisions in the IRA and BIL. Then it goes into detail on each provision. The section concludes with a set of equations that can be used to adjust nuclear cost data for the effects of recent policy. It also provides parameters that analysts can use to adjust data to facilitate adjustment instead of applying the set of equations.

2.1 Policy Review

Here the report provides an overview of the policies evaluated in this study. The newly introduced technology-neutral tax credits (for both the ITC and PTC) can be applied to any facility of any energy technology so long as the greenhouse gas emissions from said facility are net zero or net negative. Figure 1 shows how different technologies may be impacted by IRA and BIL provisions. Figure 1 is a result of a subjective and qualitative analysis made by the authors' subjective and qualitative analyses following and interpreting public document following and interpreting public documents, and it is important to note that the U.S. Department of the Treasury is still working on many implementations of the different sections. Furthermore, Figure 1 is not definite, and it can change in the future. Here green represents those provisions where the support is clearly granted, yellow shows when it is unclear but probably yes, orange also represents ambiguity but probably not supportive, and red shows where there is no support from the listed provision to the correspondent technology.

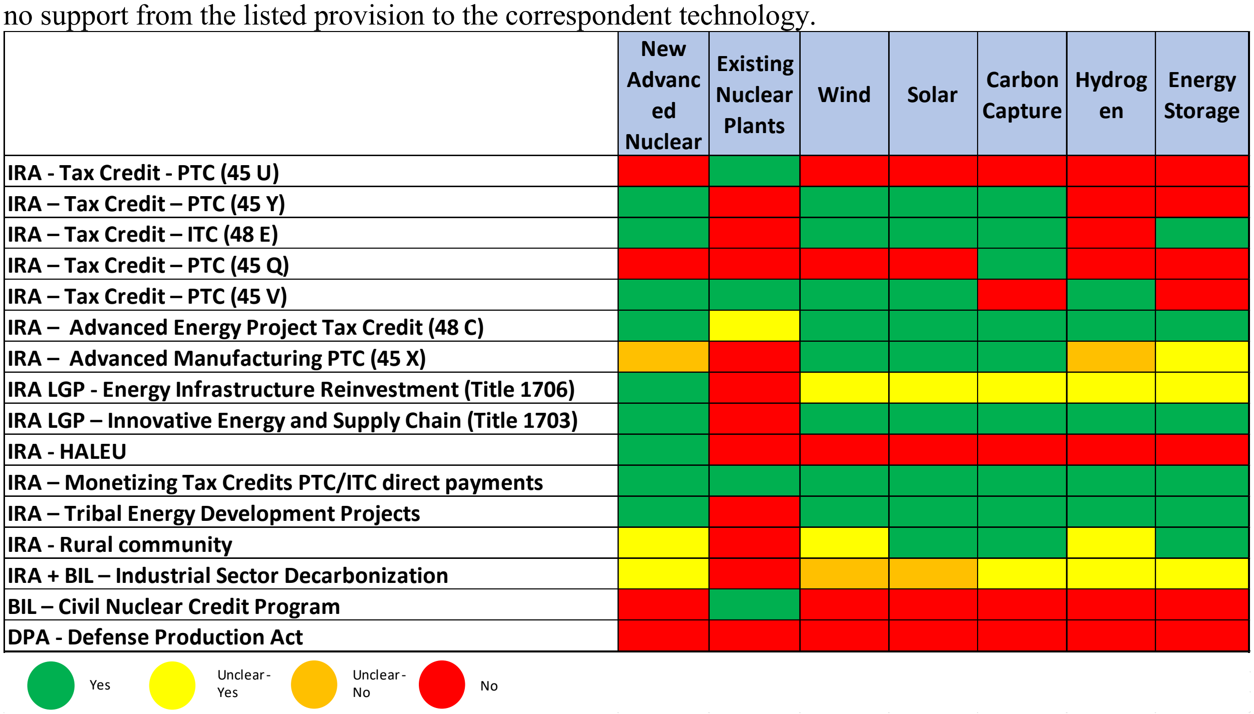

Figure 1. Stoplight chart summarizing evaluated policy provisions.

Note that fossil fuel plants with CCS could have zero emissions rates; furthermore, they theoretically could qualify for the credits 45Y and 48E. That is why the cells for carbon capture are green for the rows of PTC 45Y and ITC 48E.

Coupled with the stoplight chart, Table 1 summarizes the policy provisions and provides the important summary details for each. Section 2.2 provides additional detail for each provision, but Table 2 is for an at-a-glance review. The table arranges the policy provisions by primary and secondary impacts on the nuclear industry. Primary effects are those which specifically aim at nuclear technologies. Secondary effects are those, which, although not aimed directly at nuclear, are likely to have secondary effects on the nuclear industry.

Table 2. Summary of policy provisions.

Policy Provision	Credit Amount	Terms	Expiration
Policy with Primary Impact on Nuclear Industry			
IRA PTC 45U Zero Emission Nuclear Power Production Tax	• Between $3/MWh if wage/labor provisions are not met, and up to $15/MWh if wage/ labor provisions are met. See Figure 2 to see how the PTC is adjusted according to the gross receipts.	• Existing nuclear fleet • Subject to wage/labor provision • Sliding scale above gross receipts of $25/MWh up to $43.75/MWh • Can be monetized	• Available in 2024 and expires in 2032
IRA PTC 45Y Clean Energy Production Tax Credit	• (1) Two levels depending on wage/labor provisions: $5.50/MWh$27.5/MWh* • (2) +10% adders	• Technology neutral, clean energy, new projects • Subject to wage/labor provision • (1) Domestic sourcing • (2) Energy community • Not eligible for stacking with 45, 45E, 45J, 45Q, 45U, 48, 48E • Can be monetized	Later of: • GHG <= 25% of 2022-GHG • 2032
IRA ITC 48E Clean Energy Investment Tax Credit	• (1) Two levels depending on wage/labor provisions: 6% and30% of CAPEX • (2) +10% points adders	• Technology neutral, clean energy • Subject to wage/labor provision • (1) Domestic sourcing • (2) Energy community • Not eligible for stacking with 45, 45J, 45Q, 45U, 45Y, 48, 48A • Can be monetized	• ITC starts to phase out in 2033.
CNC Civil Nuclear Credit Program	• $6 billion dollars for the full program.	• 2022 to 2026	• Until spent or until September 30, 2031

*IRA language described in 1992 USD. Inflation adjusted here as prescribed by IRS.

Policy with Secondary Effects on Nuclear Industry			
IRA 45Q Tax Credit for Carbon Capture	• \$60/ton of CO_2–\$180/ton of CO_2	• Available for DAC • Can be monetized	• For-profit, tax-paying, available for up to 5 years after install of equipment • Tax-exempt, available for 12 years after install of equipment
IRA PTC 45V Clean Hydrogen Production Tax Credit	• Up to \$3/kg H_2	• Subject to wage/labor provision • Life-cycle GHG $<$ 0.45 kg CO_2 • Stacking allowed with 45Y and 48E	• 10 years after placement.
IRA 48C Extension of the Advanced Energy Project Credit	• 6%–30% of CAPEX investment	• Start Date: 2023	• Until funds are depleted
IRA Title 1706 Energy Infrastructure Reinvestment Program	• Percentage of the cost. To be defined.	• Start Date: 2023	• Dec-2026
IRA Title1703 Innovative Clean Energy Loan Guarantee Program	• 80% of the project investment cost	• Start Date: 2023	• Dec-2026

2.1.1 Inflation Reduction Act

The IRA will provide \$370 billion in investments to incentivize clean energy. The goal is "to reduce CO_2 emissions, accelerate private investments in clean energy solutions in every sector of the economy across the country, strengthen supply chains from critical minerals to efficient electric appliances, and create good-paying jobs and new economic opportunities for workers" (WhiteHouse 2023). The IRA supports the Biden-Harris Administration's goals to reduce U.S. emissions by 50–52% from 2005 levels by 2030, create a 100% carbon pollution-free power sector by 2035, and achieve a net-zero economy by 2050.

The climate and energy provisions are substantial, but this summary focuses on the impact the provisions will have on energy technology costs, particularly nuclear costs. It is noteworthy that the extent to which clean electricity projects will qualify for provisions of the IRA is uncertain. In some sections, the IRA is not clear cut, creating uncertainty about what technologies could receive credits because the Department of the Treasury has not defined how to implement all the provisions in practice.

The IRA summary that follows describes the adjustment provisions followed by the IRA sections where individual credits are summarized to describe how they apply to energy technologies.

2.1.1.1 Adjustment Provision Descriptions

While the next section describes the IRA's tax credits and incentives, each of them begins with a base rate that can be adjusted for different bonuses if requirements are met. For instance, a project or facility can earn bonus credits if it meets prevailing wage and registered apprenticeship requirements, meets certain domestic content requirements, and is in an energy community. This section describes provisions that must be met to qualify for adjustments to the base rates. See IRA of 2022 (U.S. Congress 2022), Internal Revenue Code: 26 C.F.R. (Code of Federal Regulations), part 1 for detailed definitions.

Wage and Apprenticeship Requirements

To qualify for higher credit amounts, new energy projects must meet requirements regarding wages and employment. The provision requires that project workers be paid wages at rates not less than the prevailing rates for construction, alteration, or repair of a similar character in the locality in which such a facility is located as most recently determined by the U.S. Secretary of Labor. The provision also requires employing individuals from registered apprentice programs. Meeting the wage and apprenticeship requirements can add up to five times the credit amount.

Domestic Content

The base rate credit is increased if the energy project meets domestic sourcing of content requirements for steel, iron, and manufactured products.

Energy Communities

Adjustments to the base rate of credits are available for projects located within an energy community, which is defined as regions that have historically relied on coal, oil, or natural gas extraction, processing, transport, or storage as the economic base. The IRA aims to incentivize projects in these communities to support a transition to a clean energy economy.

Low-Income Communities

Projects located in low-income communities qualify for an additional adjustment if the projects are for solar and wind, are on Indian land, or are part of a qualified, low-income residential building project.

Monetization

Energy projects may qualify for tax credits that exceed their tax liability. Under the IRA, investors and owners can now monetize tax credits through two new mechanisms: direct pay (Section 6417) and transferability (Section 6418). These options come with their own rules but are valuable tools for monetizing tax credits. The new rules should also simplify transaction structures, potentially creating a wider market for investors interested in acquiring tax credits.

Section 6417 of the IRA provides a new mechanism, called elective payment option or direct pay for investors without tax liability sufficient to benefit from the tax credits. The credits that can qualify for direct pay are 30C, 45, 45Q, 45U, 45V, 45W, 45X, 45Y, 45Z, 48, 48C, and 48E. Only applicable entities such as organizations exempted from income tax and selected state and government authorities qualify for the direct pay option on applicable credits.

Section 6418 offers an alternative monetization method for entities not qualifying for the direct pay election under Section 6417. This section allows for a one-time transfer of tax credits between taxpayers, allowing for a direct sale of the tax benefit. Only eligible entities may elect transfer treatment, which includes taxpayers subject to income taxes that do not qualify for Section 6417. Eligible credits include all those available for Section 6417, except for Section 45W credits which are not transferable. It is important to note that to transfer IRA energy tax credits between taxpayers, payments must be made in cash, cannot be considered gross income for the transferor or a deduction for the transferee, and can only be made once. An election is also required by any taxpayer making a transfer, and partnerships and corporations must make transfer elections on behalf of their partners or shareholders. Also, it is critical to note that excessive credit transfers are calculated and penalized.

2.1.1.2 IRA Provisions

This section describes the IRA provisions where credits are enumerated. It also describes the credit rates. All values listed are in dollar year 2023, except for those listed under 45Y, but that exception will be discussed in the corresponding section.

IRA 45U – Zero-Emission Nuclear Power Production Tax Credit

The PTC 45U supports the existing fleet of nuclear reactors. The zero-emission nuclear power production credit is a per kWh tax credit included under Section 45 for electricity that a qualified nuclear facility generates (U.S. Congress 2022). The term "qualified nuclear power facility" means any nuclear facility "(A) which is owned by the taxpayer, and which uses nuclear energy to produce electricity," "(B) which is not an advanced nuclear power facility as defined in subsection (d)(1) of Section 45J," and "(C) which is placed in service before the date of the enactment of this section" (U.S. Congress 2022).

The PTC 45U provides a corporate tax credit of up to 1.5 cents/kWh ($15/MWh) if the wage and apprenticeship requirements are met, but if requirements are not met, then the credit is 0.3 cents/kWh ($3/MWh). Also, 45U reduces the values of gross receipts that exceed $25/MWh. Then, it decreases linearly to the point where gross receipts are $43.75/MWh, after which the credit exhausts. The credit is available for facilities beginning in 2024 and lasts through 2032.

Receipt of 45U can be accomplished either by tax credit or through the provision on monetization. If monetized, then a direct payment can be made to tax-exempt organizations, including state and local agencies, rural co-ops, and the Tennessee Valley Authority.

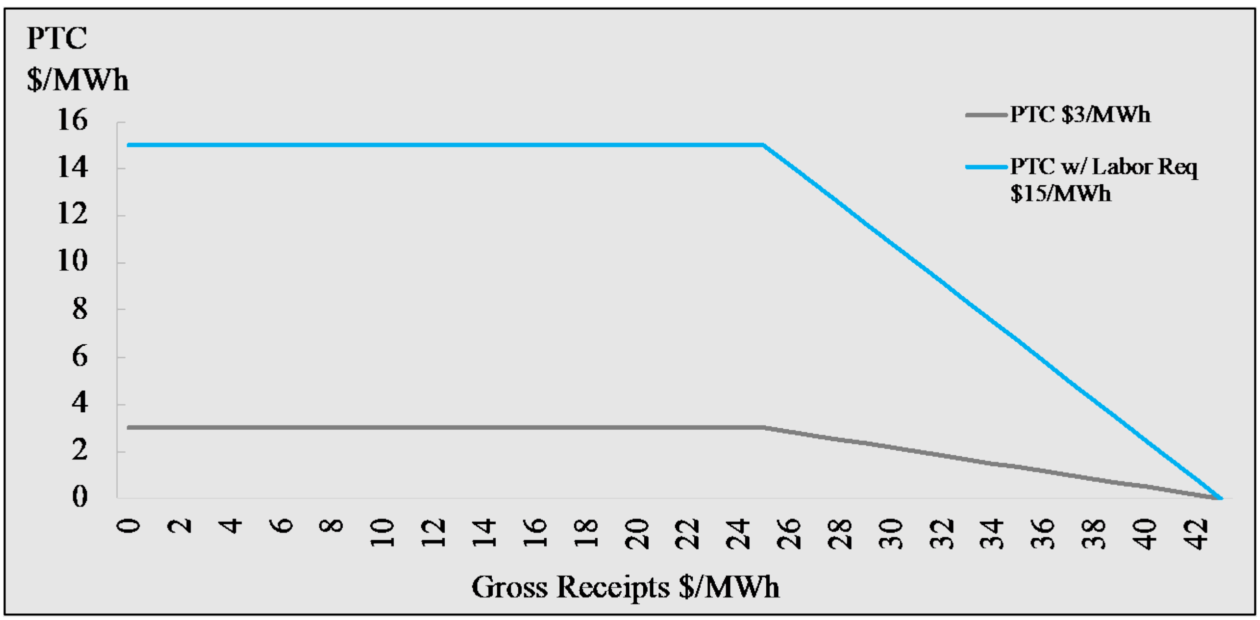

Figure 2. Graphical representation of IRA 45U – zero-emission nuclear power PTC.

IRA 45Y – Clean Electricity Production Tax Credit

The Clean Electricity Production Tax Credit (45Y) establishes a technology-neutral PTC of 1.5 cents per kWh ($15/MWh) of electricity produced, sold, or stored at facilities placed into service after 2024 with zero or negative GHG emissions. The IRA sets this credit based on the dollar year 1992. Once adjusted to 2022 dollars, the credit becomes $27.5/MWh. The IRA requires the adjustment to be made using the gross domestic product (GDP) implicit price deflator. The deflator to convert 1992 dollars to 2022 dollars is 1.89. The IRS describes the adjustment to 2022 dollars (U.S. IRS 2023b). In addition, 45Y is subject to adjustment adders. It can increase by 10% for meeting domestic content requirements and an additional 10% for projects located in energy communities.

The 45Y credit can be received for 10 years, starting the year the facility starts operations between 2024 and 2032. It starts to expire when the annual GHG emissions from electricity production are less than or equal to 25% of GHG emissions in 2022 or by the year 2032, whichever is realized later. If 45Y is the chosen credit for an energy project, then the project is not eligible for ITC (48E) (discussed next). Further, 45Y cannot be coupled with credits 45, 45J, 45Q, 45U, and 48.

Receipt of 45Y can be accomplished either by tax credit or through the provision on monetization. If monetized then a direct payment can be made to tax-exempt organizations, states, political subdivisions, the Tennessee Valley Authority, Indian Tribal governments, Alaska Native Corporations, and rural electric co-ops.

Table 3. Summary of IRA 45Y – clean electricity PTC ($/MWh).

Base Rate	+10%, Domestic Content	+10%, Energy Community	Total
Does Not Meet Wage/Labor Requirements			
5.5	0.55	0.55	6.60
Meets Wage/Labor Requirements			
27.50	2.75	2.75	33.00

IRA 48E – Clean Electricity Investment Tax Credit

This technology-neutral ITC (48E) is an emissions-based incentive. It can be applied in the year the facility is placed in service. The IRA creates this ITC with a base rate of 6% of the qualified capital expenditure (CAPEX) that can increase to 30% of the CAPEX if the wage and apprenticeships requirements are met.

An additional adjustment of 10% can be applied to the ITC 48E to meet domestic sourcing requirements. The adjustment for energy communities can also be applied for an additional 10%. It is important to note that the adjustments for domestic content and energy communities can be reduced to only 2% if the project does not meet labor requirements. A bonus adjustment is available for 48E for low-income communities. If the energy project is one of either wind or solar and located in a low-income community or on tribal lands, then the bonus adjustment of 10% applies. Additionally, another 20% adjustment is available if the project is for a residential building.

The credit indicates that for electricity projects smaller than 5 MWe, the costs for interconnection can be claimed under 48E. The 48E credit is set to expire in the later of: 2032 or when emission targets are achieved (i.e., the electric power sector emits 75% less carbon than 2022 levels). The 48E cannot be claimed if one of following credits are also claimed: 45, 45J, 45Q, 45U, 45Y, 48, coal project under 48A, or 38.

Receipt of 48E can be accomplished either by tax credit or through the provision on monetization. If monetized, then a direct payment can be made to tax-exempt organizations, states, political subdivisions, the Tennessee Valley Authority, Indian Tribal governments, Alaska Native Corporations, and rural electric co-ops.

Table 4. Summary of IRA 48E – clean electricity ITC (%CAPEX).

Base Rate	Adder for Domestic Content	Adder for Energy Community	Total
Does Not Meet Wage/Labor Requirements			
6	2	2	10
Meets Wage/Labor Requirements			
30	10	10	50

45U, 45Y and 48E Tax Credits Phase Out

According to IRA sections 45U, 45Y, and 48E (U.S. Congress 2022), the PTC and ITC have different phase out timelines. The 45U production tax credit shall not apply to taxable years beginning after December 31, 2032. The 45Y production tax credit and 48E investment tax credit phase-out will begin following the next schedule:

- For a facility (or any storage technology in the ITC) the construction of which begins during the first calendar year following the applicable year (see definition below), 100 percent
- For a facility (or any storage technology in the ITC) the construction of which begins during the second calendar year following the applicable year, 75 percent
- For a facility (or any storage technology in the ITC) the construction of which begins during the third calendar year following the applicable year, 50 percent
- For a facility (or any storage technology in the ITC) the construction of which begins during any calendar year after the calendar year described in (iii), 0 percent.

According to the U.S. Congress (2022) the term “applicable year” means the later of:

- The calendar year in which the Secretary determines that the annual greenhouse gas emissions from the production of electricity in the United States are equal to or less than 25 percent of the annual greenhouse gas emissions from the production of electricity in the United States for calendar year 2022
- Calendar year 2032.

IRA 45Q – Tax Credit for Carbon Capture

The IRA introduced revisions to the 45Q tax credit, to encourage the utilization of CCS. Broadening the scope of 45Q makes it more accessible to a wide range of investors and developers. The broader scope means that DAC technology, which had limited potential under a $50/ton CO_2, now has rates as follows:

- $60/ton of CO_2 for utilization from industrial and power generation carbon capture
- $85/ton for storage in saline geologic formations from carbon capture on industrial and power generation facilities
- $130/ton for utilization from DAC
- $180/ton for storage in saline geologic formations from DAC.

For qualified facilities, the carbon capture threshold is now up to 18,750 tons of CO_2 per year. For industrial facilities, it is now 12,500 tons of CO_2 per year, and for DAC facilities, it is 1,000 tons of CO_2 per year. Power generation facilities that wish to be eligible for the credit must ensure that their capture design capacity is no less than 75% of the CO_2 emitted from the electricity generating unit that will have the capture equipment installed.

Developers of carbon capture projects can receive 45Q as a direct payment that is fully refundable, as if it were a tax overpayment. However, this direct pay option is only available to for-profit, tax-paying entities for a period of 5 years after the installation of carbon capture equipment. On the other hand, tax-exempt entities such as states, municipalities, tribes, and cooperatives can benefit from the direct pay option for the entire 12-year period following the installation of the carbon capture equipment.

The 45Q tax credit beneficiaries have the option to transfer the entire credit value or a part of it to any third-party tax-paying entity for a cash payment during the 12-year credit period. The cash payment received by the initial 45Q recipient will not be subject to taxation.

Table 5. Summary of IRA 45Q – tax credit for carbon capture (\$/metric ton CO_2).

Base Rate Injection or Utilization	Base Rate Disposal	Direct Air Capture
Does Not Meet Wage/Labor Requirements		
12	17	
Meets Wage/Labor Requirements		
60	85	180

IRA 45V – Clean Hydrogen Production Tax Credit

The new clean hydrogen PTC (45V) creates a 10-year incentive for clean hydrogen production that will support new renewables, and existing renewables parallel with existing nuclear. The maximum credit can be reached if the hydrogen is made with less than 0.45 kilograms of CO_2 equivalent (CO2e) per kilogram of hydrogen (i.e., H_2).
Qualifying projects must begin construction before January 1, 2033, and eligibility includes retrofit facilities. When a hydrogen project sources electricity generated from non-emitting resources to operate a qualified clean hydrogen production facility, the project may be eligible to receive both the clean hydrogen PTC (45V discussed here) and either of the clean energy tax credits for clean electricity generation (45Y-PTC or 48E-ITC). However, it is vital to mention that the IRS has not yet defined the total amount that PTC 45U could be stacked with the 45V. The December 2023 IRS Notice of Proposed Rulemaking says 45U can be stacked with 45V, but the electricity must be incremental (U.S. Federal Register 2023). Finally, it cannot stack with the carbon capture and sequestration tax credit (45Q).

Electricity input for producing hydrogen through electrolysis of water molecules raises complicated issues regarding the life-cycle emissions of this hydrogen production pathway because the demand for electricity input may affect other power plant operations on the grid. Ricks, Xu, and Jenkins (2023) describe these as additionality, regionality, and time matching. The full set of potential, unintended consequences is beyond the scope of this paper. However, briefly, additionality (also called incrementality) is the problem that arises when capacity allocated to produce hydrogen is filled on the grid with a fossil-based source. Regionality is when the hydrogen is produced with contracted, clean electricity that is not in the same nodal network where the hydrogen is produced. And related, the time matching problem is when contracted, clean energy used for hydrogen in not produced at the same time-step as when hydrogen production needs it. The Department of Treasury has not provided final guidance on these issues, but it proposed rules in the notice from December 26, 2023 (U.S. Federal Register 2023).

Receipt of 45V can be accomplished either by tax credit or through the provision on monetization. If monetized, then a direct payment can be made to tax-exempt organizations, states, political subdivisions, the Tennessee Valley Authority, Indian Tribal governments, Alaska Native Corporations, and rural electric. Finally, projects can also elect to claim up to a 30% investment tax credit under Section 48 (U.S. DOE 2024).

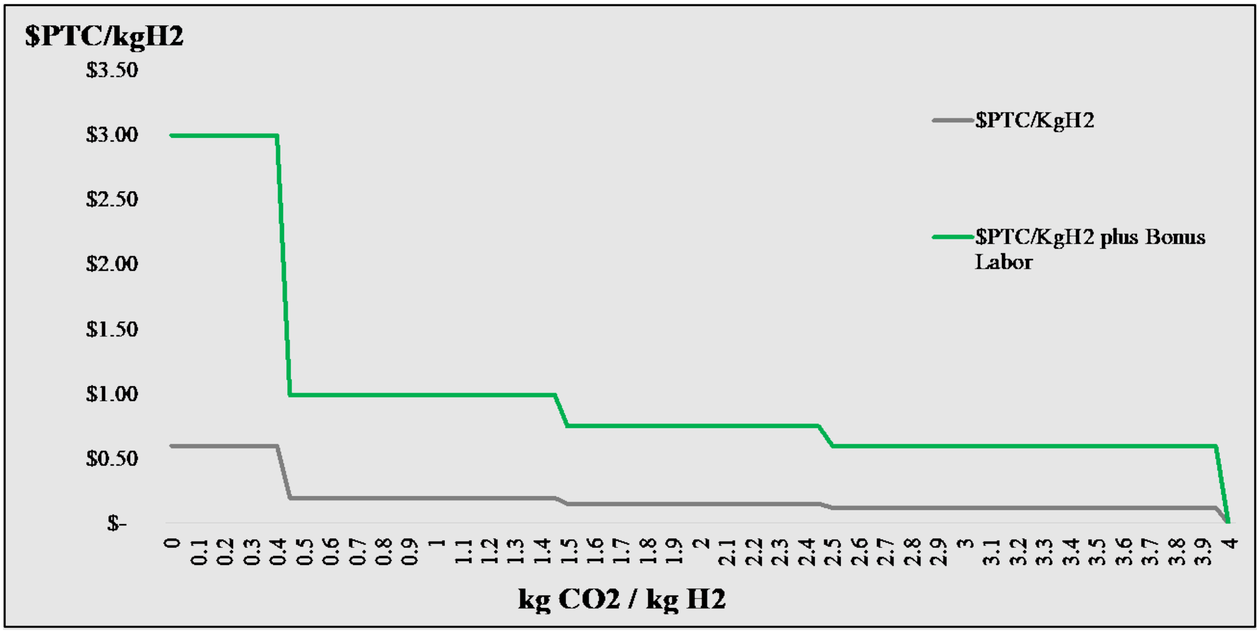

Figure 3. Graphical representation of IRA 45V – clean hydrogen PTC.

Table 6. Summary of IRA 45V – life-cycle emissions requirements for hydrogen production ($/kg H_2).

2.5kg<CO_2<4kg per kgH_2	1.5kg<CO_2<2.5kg per kgH_2	0.45kg<CO_2<1.5kg per kgH_2	CO_2<0.45kg per kgH_2
Without Labor Requirements			
0.12	0.15	0.20	0.60
With Labor Requirements			
0.6	0.9	1.0	3.0

IRA 48C – Extension of the Advanced Energy Project Credit

The IRA reinstated an advanced energy project credit, a 30% advanced manufacturing ITC, in Section 48C of the Internal Revenue Code. Originally, the American Recovery and Reinvestment Act of 2009 included a tax credit for investments in manufacturing facilities for producing or recycling clean energy components. The current 48C credit provides $10 billion in credits for qualifying advanced energy projects, $4 billion of which must be allocated to projects located in energy communities. The complete credit is subject to the wage provisions. However, components manufactured in facilities that obtained the manufacturing ITC are ineligible for the advanced manufacturing production credits.

The credit begins with a base rate of 6% of investment costs, increasing up to 30% if wage and apprenticeship requirements are met. The credit is aimed at projects which establish, equip, or expand manufacturing or industrial facilities that produce specified clean energy equipment. It also includes facilities that manufacture, among other items, energy storage systems and components, electric grid modernization equipment or components, electric and hybrid vehicles (and components thereof), and associated charging and refueling infrastructure, property used to produce energy conservation technologies, and equipment which reequips a manufacturing facility with equipment designed to reduce greenhouse emissions by at least 20%.

It is important to clarify that the 48C credit provides upstream supply chain support; a CCS "vacuum" equipment manufacturer might get 48C to help the stakeholder manufacturer lots of vacuums. Then if a coal plant installs the CCS vacuum to put all CO_2 into the ground instead of air, the coal plant owner gets 45Y or 48E. For a detailed description of what facility is eligible for the credit, see the Internal Revenue Service Common Themes and Issues Seen in Concept Papers Submitted § 48C(e) Round 1.

Projects are not eligible for Section 48C if they received prior credits under Sections 48B, 48E, 45Q, or 45V. Existing and modified industrial or manufacturing facilities may be eligible for the credit.

IRA 45X – Advanced Manufacturing Production Credit

The Advanced Manufacturing Project Credit, 45X, under the IRA is geared toward companies that manufacture and sell clean energy equipment domestically between December 31, 2022, and December 31, 2032. The manufacturing components covered are for wind energy components, critical minerals, distributed wind inverters, and offshore wind vessels. The credits begin to phase out in 2030.

Receipt of 45X can be accomplished either by tax credit or through the provision on monetization. If monetized, then a direct payment can be made to tax-exempt organizations, states, political subdivisions, the Tennessee Valley Authority, Indian Tribal governments, Alaska Native Corporations, and rural electric.

Projects cannot claim 45X credit for property produced at facilities that received the 48C credit.

IRA Loan Guarantee Programs

The IRA expands loan guarantee programs administered by the Department of Energy's Loan Programs Office (LPO). Under the Title 17 Innovative Clean Energy Loan Guarantee Program (Title 17) and authorized by the Energy Policy Act of 2005 (Act 2005), Title 17 supports energy projects that utilize innovative technology to reduce, avoid, or sequester GHG. Some of the projects the LPO could accept under Title 17 are as follows (42 U.S. Code § 16513; U.S. Congress 2022):

- Conditional Commitment to Holtec Palisades to Finance the Restoration and Resumption of Service of 800-MW Nuclear Generating Station
- Advanced nuclear energy facilities
- Renewable energy systems
- Advanced fossil energy technology (including coal gasification meeting the criteria in subsection)
- Hydrogen fuel cell technology for residential, industrial, or transportation applications
- Carbon capture and sequestration practices and technologies, including agricultural and forestry practices, that store and sequester carbon
- Efficient electrical generation, transmission, and distribution technologies
- Efficient end-use energy technologies
- Production facilities for fuel-efficient vehicles, including hybrid and advanced diesel vehicles
- Pollution control equipment
- Refineries, meaning facilities at which crude oil is refined into gasoline.

Title 17 (1703) Innovative Clean Energy Loan Guarantee Program

Under this program in the LPO, up to $62 billion in loan guarantee is authorized for use in nuclear projects that use innovative technologies. This section also can provide funding for manufacturing materials and components of the nuclear supply chain. This guarantee can cover up to 80% of the project costs. This funding is available through the end of fiscal year 2026. This funding is currently active and to date has been committed to two projects (LPO 2023a).

Title 17 (1706) Energy Infrastructure Reinvestment Program

This section of the program provides LPO with lending authority up to $250 billion. This funding can be used to retool, repower, repurpose, or replace energy infrastructure that has reached the end of its useful life or enable new infrastructure to avoid, reduce, utilize, or sequester air pollutants or other GHGs. This might include projects such as converting retiring coal assets into nuclear power plants. The loans must be initiated by the end of 2026. As defined in the bill, energy infrastructure would include electricity generation and transmission or production, processing, and delivery of fossil fuels, petroleum-derived fuels, or petrochemical feedstocks (LPO 2023b).

Tribal Energy Loan Guarantee Program (TELGP)

The Tribal Energy Loan Guarantee Program (TELGP) was established in 2005 (Act 2005). Federally recognized tribes and qualified tribal energy development organizations can access up to $20 billion in loans or partial loan guarantees from LPO for projects utilizing commercially available nuclear technologies without an innovation requirement. It is important to note that as of August 5, 2022, no projects have received funding commitments under TELGP authority.

2.1.2 Bipartisan Infrastructure Law

BIL CNC – Civil Nuclear Credit Program

The BIL represents a long-term investment in U.S. infrastructure (U.S. DOT 2023). Providing more than $550 billion in infrastructure investment, a portion of BIL that can directly impact the nuclear industry is the CNC Program which repurposed more than $3 billion from the original $6 billion of investment funds aimed at preserving the current U.S. reactor fleet (U.S. Congress 2024). The program allows owners or operators of commercial U.S. reactors to seek certification, which will enable them to bid on credits to sustain their ongoing operations. Selected certified reactors will receive credits over 4 years in each round of CNC awards, commencing from the selection date, and these credits can be granted until September 30, 2031.

A point that remains unclear is the interaction of the CNC Program with IRA 45U credits. It is important to note the IRA 45U(B) section which describes some details about the treatment of certain receipts. The amount of the 45U production tax credit received by the taxpayer in the taxable year from a zero-emission credit program for the qualified nuclear power facility is calculated based on the gross receipts of the nuclear power plant. Furthermore, any other zero-emission program received by the plant should be included in the annual gross receipt's estimations. The term “zero-emission credit program” refers to payments related to a qualified nuclear power facility from a government program at the federal, state, or local level that recognizes the zero-emission, zero-carbon, or air quality attributes of the electricity produced by the facility:

> For purposes of clause (i), any amount received by the taxpayer from a zero-emission credit program shall be excluded from the amount determined under subparagraph (A)(ii)(I) if the full amount of the credit calculated pursuant to subsection (a) (determined

> without regard to this subparagraph) is used to reduce payments from such zero-emission credit program (U.S. IRS 2022b).

This language appears to allow existing nuclear power plants to potentially receive both CNC credits and 45U PTCs, but any CNC credits would count toward gross receipts, thus possibly reducing the value of 45U PTCs. The intent of the CNC Program is to be a "lifeline" to nuclear facilities that would otherwise retire prematurely based on economics. Once an existing nuclear facility qualifies for 45U PTC for existing nuclear, then the utility is likely no longer "underwater," in which case the CNC Program may no longer be needed. But the interaction between these two programs remains to be worked out at the time of this writing.

2.1.3 Defense Production Act

The Defense Production Act (DPA) of 1950 is the primary source of presidential authorities to expedite and expand the supply of materials and services from the U.S. industrial base needed to promote the national defense, respond to military conflicts, natural or human-caused disasters, or acts of terrorism, minimize disruption to normal activities. See 50 U.S.C. § 4501 et seq. in U.S. Congress (2022).

The DPA's definition of "national defense" includes programs for energy production regarding energy production and construction, distribution, and use and directly related activities. See update to the DPA in the Executive Order from President Obama (2012). For instance, the DPA Title III authorizes in 2022 enhancing the U.S. industrial base for large-capacity batteries. This decision empowers the Department of Defense (DoD) to augment domestic mining and processing of critical materials required to produce large-capacity batteries. With the implementation of DPA Title III authorities, the DoD can carry out various actions, such as conducting feasibility studies and upgrading mature mining, benefaction, and value-added processing projects to boost productivity, environmental sustainability, and workforce safety. Additionally, it permits the production of by-products and co-products at existing mining sites, mine waste reclamation sites, and other industrial facilities.

Biden's administration has authorized the use of the DPA to accelerate the production of five critical energy technologies and expand U.S. manufacturing for solar panels (photovoltaics modules and module components), building insulation, heat pumps, equipment for making and using clean electricity-generated fuels, and critical power grid infrastructure like transformers. The goal is to incentivize additional domestic solar manufacturing capacity through master supply agreements and by applying "super preferences." They are complemented by other federal benefits such as expediting clean energy project reviews on public lands, facilitating community-based clean energy in urban and rural areas, and supporting a diverse solar workforce with wage requirements (White House 2022).
The following notice of intent (NOI) and request for information (RFI), from November 2022, regarding the establishment of a program to use the DPA to support electric heat pump manufacturing and deployment. It is important to note that the DPA has not defined support for nuclear energy so far, but in the future, it could provide funding. Currently, the DPA is only oriented to specific energy technologies:

> The U.S. Department of Energy (DOE) and the Office of Manufacturing and Energy Supply Chains (MESC) are issuing this NOI to notify interested parties of its intent to support domestic manufacturing of electric heat pumps using Title III of the Defense Production Act (DPA) and to describe the proposed funding approach for participation by eligible entities in the electric heat pumps industry. DOE also seeks comment from all stakeholders through this RFI regarding the application process, examples of eligible projects, potential funding sizes required, and criteria for qualification and selection of eligible projects to participate in the electric heat pumps DPA program. The Inflation Reduction Act (IRA) appropriated $500 million to carry out DPA activities, remaining available until September 2024. DOE will use $250 million of the appropriated DPA

funds to support manufacturing and deployment of electric heat pumps (U.S. DOE 2022c).

2.2 Recommended Cost Adjustment Factor

The previous section describes how to compute the PTC and ITC under various criteria. This section describes how to take PTC and ITC and adjust cost data. Keeping in mind that this report's purpose is to describe how to reflect the impacts of recent energy policies on input cost data used for modeling and simulation, this section focuses on how to adjust O&M and capital expenditure. Under the assumption that the analyst begins with data on the LCOE and the standard formulation of LCOE as follows:

$$LCOE = LCOE_{CAPEX} + LCOE_{O\&M} + LCOE_{fuel} \quad (3)$$

where, as the equation shows, LCOE is the per-unit cost of electricity over the lifetime of the facility, disaggregated by CAPEX, O&M, and fuel costs ($fuel$). Because this report's focus is on adjusting nuclear cost data for the PTC and ITC, the equation development adjusts the portion of the equation for CAPEX, target impact of ITC, and O&M, target impact of PTC. To denote the adjusted cost data, "$adj.$" is added to clarify that the corresponding LCOE metric has had the policy impact (PTC or ITC) considered.

Beginning with the adjustment factor for O&M cost, in units of $/MWh, Equation (4) shows the relatively straightforward method of adjustment. Blair, Sullivan, and Mai (2009) show how to adjust the PTC for the effects of taxes. Here, TR, the tax rate, is the sum of the federal tax rate and the state tax rate. O&M defined in Short, Packey, and Holt (1995) comprises annual operating and maintenance costs as the sum of fixed and variable O&M costs. Short et al. note that taxes should be considered as a component of economic analysis, like labor and material costs, because taxes represent additional expenses that must be factored in when evaluating the feasibility and profitability of a technology or project. Consequently, the PTC should be grossed up by the effects of TR.

$$LCOE_{O\&M-adj.} = LCOE_{O\&M} - \frac{PTC}{(1-TR)} \quad (4)$$

Adjusting CAPEX for the impact of ITC is given in Equation (5). It shows how to adjust the LCOE for the CAPEX and ITC. Following Short, Packey, and Holt (1995) and with additional development, the LCOE adjusted for the impact of *ITC* is by the factor ϕ. To obtain ϕ, it is necessary to know how the value of the capital recovery factor (CRF) changes given the ITC. Equation (6) shows how the *ITC* will translate to the capital expenditure in Equation (5) through ϕ. The present value of an annuity is the current value of future payments from an annuity, given a specified rate of return, or discount rate—the higher the discount rate, the lower the present value of the annuity. The net present value of depreciation (*NPVDep*) expense is computed based on the fraction of the plant value that is depreciable in each year. All investments use a MACRS depreciation schedule which establishes a fraction of the capital good (i.e., nuclear reactor) to be depreciated in each year (U.S. IRS 2023a). Once estimated, the present value of the depreciation annuities, the *NPVDep,* is sheltered from taxes, which is reflected by the term ($1 - TR *$ *PVDep*) in the equation. See Appendix A-1 for derivation of these equations.

$$LCOE_{CAPEX-adj.} = \phi * \left(\frac{CAPEX}{E}\right) \quad (5)$$

$$\phi = 1 - \frac{\partial\, CRF_b}{\partial\, ITC} * ITC \quad (6)$$

$$CRF_b = CRFa * \left\{1 - \left[\left(\frac{NPV_{Dep}*TR}{1-ITC}\right) * \left(1 - \frac{ITC}{2}\right)\right]\right\} * (1 - ITC) \qquad (7)$$

The following example illustrates how to use these equations to adjust nuclear cost data for policy impacts. In it, the following parameters are assumed. *TR* is shown at 28%, assuming a federal tax income of 21% and a state tax of 7% based on data (U.S. EIA 2023). State tax rates differ by state, but for simplicity, 7% is used here consistent with the discussion in Appendix. A methodological distinction exists when evaluating the PTC and ITC as mandated by the Internal Revenue Code (U.S. IRS 2023b) and is illustrated with Equations (4–7). The distinction involves reducing the "depreciable basis" which is the amount subject to depreciation, by half the value of the ITC or equivalent cash grant. In the case of a 30% ITC or cash grant, the depreciable basis is lowered by 15%. The basis reduction does not apply to the PTC as follows:

- CRF_a = 100%
- *TR* = 28%
- *NPVDep* = 61.3%
- *ITC* = 50%.

Given these parameters, ϕ becomes 0.54. Table 7 below shows the results of applying Equations (4) and (5) to the example cost data listed in the table. The example cost data listed in the table is available in the sources listed in the third column. The table also lists the relevant IRA credit and the amount of the credit received when PTC is chosen or when ITC is chosen. Column five shows $LCOE_{O\&M\text{-}adj.}$ and $LCOE_{CAPEX\text{-}adj.}$.

Table 7. Example of adjusting nuclear cost data by impact of relevant IRA provisions.

Nuclear Category	Cost Data	Source	Relevant Credit	Policy-adjusted Cost Data
Existing Fleet O&M	\$29.13/MWh	NEI 2022	45U – \$15/MWh	$LCOE_{O\&M\text{-}adj.}$ = 8.3\$/MWh
New Nuclear O&M	\$20/MWh	Abou-Jaoude et al. 2023	45Y – \$33/MWh	$LCOE_{O\&M\text{-}adj.}$ = -25.83\$/MWh*
New Nuclear CAPEX	\$4,000/kWe	Abou-Jaoude et al. 2023	48E – 50%	$LCOE_{CAPEX\text{-}adj.}$ = \$2,171.64 kWe
*In the case of a negative adjustment such as this, the applicant would seek monetization from the U.S. Treasury since the tax credit is less than the actual cost.				

Based on the equations above, Table 8 shows a set of possible values for the adjustment factor, ϕ. The financial parameters needed to perform the calculations are listed as notes in the table. Although these values can in theory take on a range of values, in practice, the values listed are representative of typical values. Appendix A-2 shows the assumptions to reach the parameters listed in Table 8.

Table 8. Values for adjustment factor.

ITC	ϕ
0%	1.00
6%	0.95
30%	0.73

ITC	ϕ
50%	0.54

Note: CRF_a = 100%; TR = 28%; NPVDep = 61.3%

3. KEY CONSIDERATION: PTC/ITC TRADEOFF

In the summary of the provisions above, there are occurrences where an applicant to an IRA provision must choose between a PTC or ITC, for example 45Y or 48E. Which should the applicant choose, or to the point of this paper, which should the analyst reflect in the model? What are the situations where ITC is the better choice versus PTC? While the final decision could depend on many uncertain and subjective factors, some technological attributes can point to one or the other. Two technical attributes to consider are the capacity factor of the technology and the capital cost (CAPEX) of the investment project.

The decision for eligible project owners is influenced, to some extent, by the comparative net present financial value of each incentive given by the installed project expenses and the projected capacity factor, which is the anticipated production level. There is a crossover point where the ITC is more beneficial than the PTC depending on the CAPEX. For instance, lower-cost projects with a high-capacity factor may find more favorable economic outcomes with the PTC, while higher-cost projects with a low-capacity factor may find better outcomes with the ITC.

Finally, eligibility for bonus provision adjustments could turn the balance in favor of one another. Other factors, such as the risk of congestion and curtailment, should be considered.

The choice to apply for PTC, ITC, or some combination of these with other IRA benefits will depend on many factors considered by each company and each project. However, the tradeoff between the PTC and ITC can be reduced to two quantitative factors: the capacity factor, and the CAPEX of the project. For those projects that have a high CAPEX and a low-capacity factor, the ITC could be preferred, and for those projects where the CAPEX is low and the capacity factor is high, the PTC could be preferred. In other words, a higher capacity factor results in the generation of more megawatt-hours eligible for more PTCs (Bolinger et al. 2009). It is important to note that nuclear energy has both a high-capacity factor and a high CAPEX; furthermore, a more detailed analysis is needed to evaluate the PTC and ITC.

A financial analysis (U.S. DOE 2022a) allows an estimate of the present value of an advanced nuclear project, including parameters of depreciation, the weighted average cost of capital (WACC), and tax rates. For each CAPEX and capacity factor, the net present value of the PTC and ITC can be estimated. For the purposes of this analysis, assume that the applicable ITC is 30% and the PTC is $27.50/MWh. Both ITC and PTC follow the provisions as described in Section 2.1.1.2.

Table 9 shows the results of this calculation. Further details are included in Appendix A-3. These results are consistent with Kozeracki et al. (2023), where the PTC would offer more value when the capital expenditure is below $6,000 per kW, and the ITC returns greater value when the CAPEX is above $6,000 per kW. The selected small modular reactors (SMRs) for this analysis include the molten-salt SMR, water-cooled SMR, gas-cooled SMR, gas-cooled skid, and gas-cooled microreactor. The source data for this comparison is from the sources listed in the table and based on internal INL calculations.

Table 9. Results of comparing ITC to PTC.

	Molten-salt SMR (400 MWt)	Water-cooled SMR (250 MWt)	Gas-cooled SMR (200 MWt)	Gas-cooled skid (50 MWt)	Gas-cooled microreactor (15 MWt)
Source Data	Mignacca and Locatelli 2020a; EFWG 2018	PNNL 2018; EFWG 2018; Black 2018; Ganda et al. 2017	Stewart et al. 2020; PNNL 2018; EFWG 2018	NEI 2019a; PNNL 2018; EFWG 2018	NEI 2019a; PNNL 2018; EFWG 2018
Capacity Factor	$5,934/kWe*	$7,276/kWe*	$8,166/kWe*	$10,497/kWe*	$13,637/kWe*
75%	ITC**	ITC	ITC	ITC	ITC
80%	ITC	ITC	ITC	ITC	ITC
85%	ITC	ITC	ITC	ITC	ITC
90%	PTC	ITC	ITC	ITC	ITC
95%	PTC	ITC	ITC	ITC	ITC
100%	PTC	ITC	ITC	ITC	ITC

*INL internal calculations based on listed source data.

**Cell data show which IRA policy provision returns the largest economic benefit.

Notes: ITC = 30%; PTC = $27.50/MWh; WACC = 10%.

4. SUMMARY

Recent U.S. legislation has created significant policy support to advance clean energy, particularly for all clean energy technologies. How will this impact society? This is a question for researchers and analysts who perform studies using modeling and simulation techniques. This report provides information for that research community on adjusting nuclear cost data for the effects of recent legislation and energy policy.

The report provides a detailed review of the IRA for those provisions aimed at energy or emission reduction technologies and BIL's CNC program. It reviews which policies will impact the nuclear industry directly and separates those from policy provisions likely to have secondary effects on the industry. Then it presents a set of equations that can be used for adjusting nuclear cost data. These equations are supported by theory and described in detail in this report's appendix. But for those analysts interested in numerical adjustment factors, the report provides a set of parameters to do just that.

5. REFERENCES

Abou-Jaoude, Abdalla, Linyu Lin, Chandrakanth Bolisetti, Elizabeth Worsham, Levi M. Larsen, and Aaron Epiney. 2023. *Litterature Review of Advanced Reactor Cost Estimates*. INL/RPT-23-03370 vols. Idaho Falls, ID: Idaho National Laboratory.

Blair, Nathan, Patrick Sullivan, and T. Mai. 2009. *ReEDS Model Documentation: Base Case Data and Model Description*. Golden, CO: National Renewable Energy Laboratory.

Bolinger, Mark, Ryan Wiser, Karlynn Cory, and Ted James. 2009. *PTC, ITC, or Cash Grant? An Analysis of the Choice Facing Renewable Power Projects in the United States*: Lawrence Berkely National Laboratory.

Gagnon, Pieter , Brown Maxwell, Steinberg Dan, Brown Patrick, Awara Sarah, Carag Vincent, Cohen Stuart, Cole Wesley, Ho Jonathan, Inskeep Sarah, Lee Nate, Mai Trieu, Mowers Matthew, Murphy Caitlin, and Sergi Brian. 2022. 2022 Standard Scenarios Report: A U.S. Electricity Sector Outlook. Golden, CO: National Renewable Energy Laboratory.

H.R.6. 2005. Energy Policy Act of 2005. 109th Congress (2005-2006). August 8, 2005. https://www.congress.gov/bill/109th-congress/house-bill/6.

Ho, Jonathan, Jonathon Becker, Maxwell Brown, Patrick Brown, Ilya Chernyakhovskiy, Stuart Cohen, and Wesley Cole. 2021. Regional Energy Deployment System (ReEDS) Model Documentation: Version 2020. Golden, CO: National Renewable National Laboratory.

Internal Revenue Code. 26 C.F.R. [Code of Federal Regulations], part 1. 26 C.F.R. [Code of Federal Regulations], part 1. https://www.ecfr.gov/current/title-26/chapter-I/subchapter-A/part-1?toc=1

Internal Revenue Service. No date. Common Themes and Issues Seen in Concept Papers Submitted in § 48C(e) Round 1.Jenkins, Bryan. 2016. *Background for the Energy Cost Calculator*. Davis, CA: University of California, Institute of Transportation.

Jenkins, Jesse , Jennifer Larsen, Robbie Orvis Michael, Karen Palmer, and Kevin Rennert. 2022. Inflation Reduction Act of 2022: Modeling Major Climate and Energy Provisions. Washington, DC: Resources for the Future

Kozeracki, Julie, Chris Vlahoplus, Katheryn Scott, Melissa Bates, Billy Valderrama, Erica Bickford, Tim Stuhldreher, Andrew Foss, and Tom Fanning. 2023. Pathways to Commercial Liftoff: Advanced Nuclear. U.S. Department of Energy.

Lantz, Eric, Daniel Steinberg, Michael Mendelsohn, Owen Zinaman, Ted James, Gian Porro, Maureen Hand, Trieu Mai, Jeffrey Logan, Jennie Heeter, and Lori Bird. 2014. *Implications of a PTC Extension on U.S. Wind Deployment*. Golden, CO: National Renewable National Laboratory.

Larsen et al. (2024) [Forthcoming]. Effects of the U.S. Inflation Reduction Act on SMR Economics. Frontiers in Nuclear Engineering.

Leon, Warren. 2015. *Clean Energy Champions: The Importance of State Programs and Policies*. Montpelier, VT: Clean Energy States Alliance.

LPO 2023a. Title 17 Clean Energy Financing. Accessed March 31, 2024. https://www.energy.gov/lpo/title-17-clean-energy-financing.

LPO 2023b. Energy Infrastructure Reinvestment. Accessed March 31, 2024. https://www.energy.gov/lpo/energy-infrastructure-reinvestment

Mai, Trieu, Cole, Wesley, Lantz, Eric, Marcy, Cara, & Sigrin, Benjamin. 2016. Impacts of Federal Tax Credit Extensions on Renewable Deployment and Power Sector Emissions.

Mai, Trieu, Wesley Cole, Eric Lantz, Cara Marcy, and Benjamin Sigrin. 2016. Impacts of Federal Tax Credit Extensions on Renewable Deployment and Power Sector Emissions. National Renewable Energy Laboratory.

Mai, Trieu, Wesley Cole, Venkat Krishnan, and Mark Bolinger. 2015. *Impact of Federal Tax Policy on Utility-Scale Solar Deployment Given Financing Interactions*. Golden, CO: National Renewable Energy Laboratory.

NEI. 2022. *Nuclear Cost in Context*. Washington, DC: Nuclear Energy Institute.

Obama, Barrack. 2012. *National Defense Resources Preparedness*. Vol. Executive Order 13603.

Rennert, Kevin, Nicholas Roy, and Dallas Burtraw. 2022. *Modeled Effects of Inflation Reduction Act of 2022*. Washington, DC: Resources for the Future.

Ricks, Wilson, Qingyu Xu, and Jesse D Jenkins. 2023. "Minimizing emissions from grid-based hydrogen production in the United States." *Environmental Research Letters* 18 (1):014025.

Short, Walter, Daniel J. Packey, and Thomas Holt. 1995. A Manual for the Economic Evaluation of Energy Efficiency and Renewable Energy Technologies National Renewable Energy Laboratory.

Shropshire, David E, Kathleen Araujo, Cassie Koerner, Christi Bell, Richelle Johnson, John Parsons, Selena Gerace, Eugene Holubynak, Tara Righetti, and Steven E Aumeier. 2023. Microreactor Applications in U.S. Markets, Evaluation of State-Level Legal, Regulatory, Economic and Technology Implications.: Idaho National Laboratory.

Statista. 2023. *Empowering People with Data*. Online media.: Subscription login.

Steinberg, Daniel C., Maxwell Brown, Ryan Wiser, Paul Donohoo-Vallett, Pieter Gagnon, Anne Hamilton, Matthew Mowers, Caitlin Murphy, and Ashreeta Prasanna. 2023. Evaluating Impacts of the Inflation Reduction Act and Bipartisan Infrastructure Law on the U.S. Power System. United States: National Renewable National Laboratory.

U.S. CBO. 2021. *Summary of Estimated Budgetary Effects of Senate Amendment 2137 to H.R. 3684, the Infrastructure Investment and Jobs Act*. Washington, DC: United States Congressional Budget Office.

U.S. CBO. 2022. *Estimated budgetary effects of H.R. 5376, the Inflation Reduction Act of 2022*. Washington, DC: U.S. Congressional Budget Office.

U.S. Congress. 1992. *Energy Policy Act of 1992.* Vol. H.R. 776 - 102nd Congress. Washington, DC: United States House of Representatives.

U.S. Congress. 2022. *Inflation Reduction Act of 2022*, *H.R. 5376 117th Congress (2021-2022)*. Washington, DC: United States 117th Congress.

U.S. Congress. 2024. Consolidated Appropriations Act, 2024. https://www.congress.gov/118/bills/hr4366/BILLS-118hr4366enr.pdf. .

U.S. CRS. 2019. *The Energy Credit or Energy Investment Tax Credit (ITC).* Washington, DC: U.S. Congressional Research Service. https://crsreports.congress.gov/product/pdf/IF/IF10479

U.S. CRS. 2021. The Value of Energy Tax Incentives for Different Types of Energy Resources. Washington, DC: U.S. Congressional Research Service. https://crsreports.congress.gov/product/pdf/R/R44852

U.S. DOE. 2016. *Leveraging Federal Renewable Energy Tax Credits*. Washington, DC: United States Department of Energy.

U.S. DOE. 2022a. *Federal Tax Credits for Solar Manufacturers*. Washington, DC: United States Deparment of Energy.

U.S. DOE. 2022b. *The Inflation Reduction Act Drives Significant Emissions Reductions and Positions America to Reach Our Climate Goals*. DOE/OP-0018 vols. Washington, DC: United States Department of Energy, Office of Energy Policy.

U.S. DOE. 2022c. *Notice of Intent and Request for Information regarding establishment of a Program to Use Defense Production Act to Support Electric Heat Pump Manufacturing and Deployment*. Washington, DC: United States Department of Energy, Office of Manufacturing and Energy Supply Chains.

U.S. DOE. 2024. Financial Incentives for Hydrogen and Fuel Cell Projects. Hydrogen and Fuel Cell Technologies Office. Accessed April 2, 2024. https://www.energy.gov/eere/fuelcells/financial-incentives-hydrogen-and-fuel-cell-projects

U.S. DOT. 2023. *Bipartisan Infrastructure Law*.

U.S. EIA. 2023. Assumptions to the Annual Energy Outlook 2023: Electricity Market Module.

U.S. Federal Register. 2023. Section 45V Credit for Production of Clean Hydrogen; Section 48(a)(15) Election To Treat Clean Hydrogen Production Facilities as Energy Property. https://www.federalregister.gov/documents/2023/12/26/2023-28359/section-45v-credit-for-production-of-clean-hydrogen-section-48a15-election-to-treat-clean-hydrogen

U.S. IRS. 2022a. *How to Depreciate Property*. Vol. Publication 946. Washington, DC: The United States Internal Revenue Service.

U.S. IRS. 2022b. Prevailing Wage and Apprenticeship Initial Guidance Under Section 45(b)(6)(B)(ii) and Other Substantially Similar Provisions.

U.S. IRS. 2023a. 26 U.S. Code § 50 - Other special rules.

U.S. IRS. 2023b. Inflation Reduction Act 2022.

White House. 2022. *Fact Sheet: President Bident Takes Bold Executive Action to Spur Domestidc Clean Energy Manufacturing*. Washington, DC: The White House.

White House. 2023. Building a Clean Energy Economy: A Guidebook to the Inflation Reduction Act's Investments in Clean Energy and Climate Action. Washington, DC: The White House.

Wiser, Ryan, Galen Barbose, Jenny Heeter, Trieu Mai, Lori Bird, Mark Bolinger, Alberta Carpenter, Garvin Heath, David Keyser, Jordan Macknick, Andrew Mills, and Dev Millstein. 2016. A Retrospective Analysis of the Benefits and Impacts of U.S. Renewable Portfolio Standards. Lawrence Berkeley National Laboratory and National Renewable Energy Laboratory.

Wisevoter. 2023. *Corporate Tax Rate by State*. Online media.: Wisevoter.

Appendix A

A-1. Derivation for CAPEX Adjustment

The LCOE measures the cost per unit of electricity on a consistent basis and enables the comparison of costs across alternatives energy technologies. This section provides the derivation and underlying assumptions for Equations (5–7) in Section 2.2. The central question is: what is the appropriate adjustment to the LCOE when an ITC is present?

LCOE formula covers total life-cycle costs but since the ITC only applies to CAPEX the O&M costs and Fuel costs are set to zero for this derivation. That is why $LCOE_{CAPEX}$ indicates only the capital component of the levelized cost of energy. Expressed in reduced form and following Short, Packey, and Holt (1995), the LCOE of the capital expenditures can be expressed as:

$$LCOE_{CAPEX} = \left(\frac{CAPEX}{E}\right) * [CRF] \quad (8)$$

where $CAPEX$ equals total capital expenditures; E equals annual energy output; and CRF equals capital recovery factor.

A point to keep in mind is that the IRA's ITC does not affect the cost of resources used to produce electricity, but instead, it affects the CRF because it is a function of the level of ITC and the WACC.

To compute the CRF, the following parameters are assumed, and a series of steps are followed.

Table 10. Parameters used to compute the WACC.

Parameter	Description	Unit	Value	Source
dR	Debt percent	%	60	U.S. EIA 2023
1-dR	Equity percent	%	40	U.S. EIA 2023
IRR	Internal rate of return	%	10.2	U.S. EIA 2023
TR	Total tax rate	%	28	Calculated
TRs	State tax rate	%	7	Wisevoter 2023
TRf	Federal tax rate	%	21	U.S. EIA 2023
T	Plant life	Years	40	U.S. EIA 2023
Construction years	Construction period	Years	7.3	Statista 2023

Step 1: The WACC

Following Rothwell (2016), the nominal WACC after tax can be expressed as:

$$WACC = r = [d * (1 - TR) * dR] + [re * (1 - dR)] \quad (9)$$

where d is pretax interest rate and dR is the debt to total capitalization ratio, $[\frac{d}{d+e}]$, where e is the amount of equity and d is the amount of debt. The debt to total capitalization ratio set exogenously by the investor. In other words, how the investor wants to finance the project is a political decision. The values used in the *CRF* calculations are consistent with the table above. Further, re is the rate of return on equity desired by the company. Also, it is necessary to estimate the construction factor (CF) which expresses the additional cost for finance construction (adapted from Jenkins 2006):

$$CF = (1 + WACC)^{constr.years}. \qquad (10)$$

Once the WACC after tax is computed, the real required IRR_r is a function of the WACC after tax and inflation rate, as follows:

$$IRR_r = \frac{1+WACC}{1+inflation\ rate} - 1. \qquad (11)$$

Step 2: The CRF

The second step allows the estimate of the *CRF* adjusted by taxes. The *CRF* tells the rate at which the capital investment is recovered as follows:

$$CRF = \frac{\left\{IRR_r * \frac{(1+IRR_r)^T}{[(1+IRR_r)^T-1]}\right\}}{(1-TR)}. \qquad (12)$$

The CRF needs adjustment for the effect of taxes. To do so, the numerator is divided by $(1 - TR)$ to obtain the before-tax revenue to cover the costs (Holt 1995).

Step 3: Adjusting the CRF by the Construction Factor

$$CRF_a = CRF * CF \qquad (13)$$

Once here, the CRF_a is adjusted by the depreciation and the ITC.

Step 4: Including the Effect of ITC

Step four includes taxes and different rules from the IRS (2015; 2023). It considers the benefit from tax depreciation the company will receive in a situation with the ITC which results in Equation (13). Here $BDep$ represents the benefit from tax depreciation where the ITC is present.

$$BDep = \frac{NPV_{Dep}*TR}{1-ITC} * \left(1 - \frac{ITC}{2}\right) \qquad (14)$$

NPV_{Dep} is the net present value of the depreciation, and ITC is not taxable.

To obtain NPV_{Dep}, find the sum of the percentage of depreciation corresponding to each year in T of a nuclear reactor depreciation schedule. For instance, in this case, the depreciation time span is 17 years with a declining balance percentage according to the IRS methodology which uses MACRS tables (U.S. IRS 2022a) (see Table 11).

Table 11. Depreciation schedule following MACRS tables.

Year	Depreciation
1	5.0%
2	9.5%
3	8.6%
4	7.7%
5	6.9%
6	6.2%
7	5.9%
8	5.9%
9	5.9%
10	5.9%
11	5.9%
12	5.9%
13	5.9%
14	5.9%
15	5.9%
16	3.0%

To estimate the net present value, a discount rate is needed. It is critical to note here that we use the nominal WACC rather than the real WACC because the tax shield (reduction in the taxable income after claiming an allowable deduction) is the same in nominal terms no matter what happens to inflation.

Also, it is important to note that when the ITC is claimed, accelerated depreciation rules allow the full tax basis minus half the ITC to be depreciated over a 17-year depreciation schedule using a half-year convention that is why we need to adjust our net present value of depreciation by the half of the ITC.

Second, the NPV_{Dep} is adjusted by the total tax rate (TR). Finally, it is necessary to adjust the tax shield value of depreciation by $(1 - ITC)$ to obtain the revenue before taxes.

Step 5: Adjust CRF_a by Depreciation Shield and ITC

Here CRF_a results after including the $Bdep$ and ITC, as in Equation (15).

$$CRF_b = CRF_a * (1 - Bdep) * (1 - ITC). \qquad (15)$$

Consequently, the $LCOE_{CAPEX-adj.}$ can be calculated as follows:

(16) $$LCOE_{CAPEX-adj.} = \frac{CAPEX}{Electricity\ Production} * CRF_b.$$

A-2. Analysis to Generate Adjustment Parameter

To obtain the new LCOE adjusted, starting from Equation (15), the variation of the CRF is going to tell us how much the CAPEX should be adjusted when the ITC is present:

$$LCOE_{capex\ adjusted} = \left(\frac{CAPEX}{E}\right) * \emptyset. \qquad (16)$$

In Equation (17), $\emptyset$ represents the adjustment factor after, which shows that if the ITC is 0%, the CAPEX does not need to be adjusted; otherwise, the capital expenditure needs to be decreased by the amount given by ΔCRF_b.

$$\emptyset = (CRF_{b-ITC0\%} + \Delta CRF_{b-ITCx\%}) \qquad (17)$$

$$\Delta CRF_{b-ITCx\%} = \frac{\partial CRF_b}{\partial ITC} * ITC < 0 \qquad (18)$$

And, as the CRF is the only function that contains the ITC, to obtain the adjustment factor of the capital cost, derive the CRF_b from Equation (15) by the ITC.

$$CRF_b = CRF_a * \left\{1 - \left[\left(\frac{NPV_{Dep} * TR}{1-ITC}\right) * \left(1 - \frac{ITC}{2}\right)\right]\right\} * (1 - ITC) \qquad (19)$$

$$CRF_b = CRF_a * (1 - ITC) * \left\{1 - \left(\frac{NPV_{Dep} * TR}{1-ITC}\right) - \left[-\left(\frac{NPV_{Dep} * TR}{1-ITC}\right) * \frac{ITC}{2}\right]\right\} \qquad (20)$$

$$CRF_b = CRF_a * (1 - ITC) * \left\{1 - \left(\frac{NPV_{Dep} * TR}{1-ITC}\right) + \left[\left(\frac{NPV_{Dep} * TR}{1-ITC}\right) * \frac{ITC}{2}\right]\right\} \qquad (21)$$

$$CRF_b = CRF_a * \left\{(1 - ITC) - \left(NPV_{Dep} * TR\right) + \left[\left(NPV_{Dep} * TR\right) * \frac{ITC}{2}\right]\right\} \qquad (22)$$

$$\frac{\partial CRF_b}{\partial ITC} = CRFa * (NPV_{Dep} * \frac{TR}{2} - 1) \qquad (23)$$

When obtaining the LCOE in kWe units as opposed to units of MWh, the value of the *CRFa* is not important because what is critical is how much the CRF varies when the ITC changes. This assumes that the construction is completed overnight, all capital is recovered in one period, and there is no production over time. In this scenario, the production (E) represents only the maximum electricity that could be produced based on the nameplate capacity of the plant.

Assuming the parameters as *NPVDep* = 61.30%, *CRFa* = 100%, and *TR* = 28%, it is possible to estimate the derivative.

$$\frac{\partial CRF_b}{\partial ITC} = CRFa * \left(NPV_{Dep} * \frac{TR}{2} - 1\right) = -0.91418 \qquad (24)$$

A-3. Analysis Supporting Crossover Points

In the analysis conducted for advanced nuclear technologies, the tradeoff between the PTC and ITC was estimated using a cash flow analysis. A more detailed analysis of the crossover point can be seen in Levi et al. (2024), where the crossover level is around $3,000/kWe.

In the present study, the impact of the PTC was calculated based on the electricity produced, while the impact of the ITC was calculated based on the construction cost of the system.

For this example, the ITC is provided upfront as a tax credit that remains constant regardless of system performance. In contrast, the PTC offers a potentially more favorable cash flow as the tax credits are earned over time. The choice between the ITC and the PTC primarily depends on factors such as the project's cost, capacity factor, and eligibility for any additional tax credits. The final selection of PTC, ITC, or cash grant will depend on a project-specific basis and unique characteristics that are not captured on this analysis; however, the availability of this choice of federal incentives affects the value that can be received by a nuclear project. It allows each project to select the incentive that aligns best with its requirements.

To illustrate how each incentive could be calculated and applied at a nuclear reactor owner, consider a project that commenced construction of an SMR in 2023, placed it in service in 2025, and uses the calendar year as its tax year. Table 12 lists the assumed technology and financial parameters for this example.:

Table 12. Parameters for tradeoff calculation.

Parameter	Value
CAPEX	Range between $5,000/kWe and $13,000/kWe
Nameplate Capacity	6 MW
Depreciation Schedule	MACRS (half-year convention) Recovery period: 17 years 200% declining balance method
Federal Corporate Tax Rate	21%
ITC	30%
PTC	$27.5/MW – [2025-2033] $20.6/MW – 2034 $13.75/MW-2035
PTC Time Span	10 years
WACC	5.5%
Capacity Factor	100%
Inflation Rate	3%

ITC Calculation

In accordance with the methodology outlined in DOE 2023, consider an example using a capital cost of $10,000,000 for an SMR project that started construction in 2023. This project qualifies for a 30% ITC; meaning that when the tax basis is $10,000,000, the 30% ITC reduces the tax liability by $3,000,000.

Depreciation Calculation

Following the IRS (2010), when the business claims the ITC, its depreciable basis for the system after applying the ITC has to be reduced by half (30%/2): depreciable basis = 85% * (CAPEX). Furthermore, the new depreciable basis is: $8,500,000.

Accelerated Depreciation Calculation

The SMR project utilizes accelerated depreciation for determining the annual deduction of depreciation from 2025 to 2035. With a recovery period of 17 years, a half-year convention, and a 200% declining balance method, the depreciation rate for Year 1, according to IRS Publication 946 Table A-1 (U.S. IRS 2022a), is 5.0%. To calculate the accelerated depreciation deduction, the business multiplies the depreciable basis of Year 1 from Table 11 by the depreciation rate:

- 5.0% * ($8,500,000) = $425,000.

The total impact on tax liability assuming the business has a federal corporate TR of 21%:

- 21% * ($425,000) = $89,250.

Therefore, the total reduced tax liability for 2025 from depreciation deductions and the ITC is:

- $3,000,000 + $89,250 = $3,089,250.

The business plans to claim accelerated depreciation deductions in tax years 2026, 2027, 2028, 2029, 2030, 2031, 2032, 2033, 2034, and 2035. However, the depreciation rate for each year will differ.

PTC Calculation

For the PTC, the accelerated depreciation is calculated for each year from 2025 to 2035 following the same steps than before, and we add the PTC tax credit for each year adjusted by inflation:

- PTC = $/MW * 1 Year Generation * Inflation Adjustment Factor (IAF).

$$IAF = (1 + inflation\ rate)^{years\ since\ construction} \quad (25)$$

After all the tax credits have been estimated, the net present value of all the PTC flows between 2025 and 2035 is calculated assuming a WACC of 5.5%.