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Light Water Reactor Sustainability Program

Guidance for Domestic Content Requirement Under the Internal Revenue Code as Applicable to Nuclear Power Uprates

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Guidance for Domestic Content Requirement Under the Internal Revenue Code as Applicable to Nuclear Power Uprates

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EXECUTIVE SUMMARY

The executive order, "Reinvigorating the Nuclear Industrial Base," signed on May 23, 2025[a] is focused on establishing the nation's path to nuclear energy dominance where the administration has set an ambitious goal to (1) facilitate 5 GW of power uprates from existing plants and (2) start the construction of 10 new large reactors by 2030. This executive order highlights the urgency of "Swift and decisive action… to jumpstart America's nuclear energy industrial base…," which directly translates to the need to expedite already planned power uprates and facilitate the decision-making for additional power uprates.

This report proposes a safe harbor implementation model, or concept, for meeting the domestic content requirements of the Clean Electricity Tax Credits as applicable to nuclear plant power uprates.[b] Ensuring nuclear plants can meet the domestic content requirements is crucial in establishing America's energy dominance and accelerating our path toward a more secure and independent future. Specifically, developing a feasible model for nuclear plants to meet the domestic content requirements may further incentivize the nuclear industry to implement power uprates at existing nuclear plants, adding needed generation capacity to the electric grid.

To utilize the domestic content bonus, the taxpayer is required to ensure a certain percentage of new components procured are manufactured domestically (i.e., the Adjusted Percentage Rule), resulting in an increase in the value of the tax credit. The Adjusted Percentage Rule may be challenging to satisfy as it requires detailed direct cost breakdowns from every component vendor. Recognizing this, the Internal Revenue Service has developed a "safe harbor" approach for several, non-nuclear technologies. The safe harbor approach greatly simplifies the amount of information needed from equipment vendors to satisfy the requirement. The safe harbors are technology-specific tables that assign "weights" to each component typically used in the energy technology installation. If the taxpayer can demonstrate that a certain number of procured components (referred to as "Manufactured Products") are domestically manufactured and result in a cumulative weight above the required threshold, they satisfy the Adjusted Percentage Rule and, thus, the domestic content requirement and are eligible to increase the value of the tax credit.

There is currently no safe harbor model for nuclear technologies. The challenges associated with creating a safe harbor model for nuclear plant power uprates are (1) the list of components in a nuclear plant is more exhaustive than those for other generation technologies and (2) each nuclear plant power uprate requires a plant-specific combination of component procurements to increase electrical output[c]. To address the first challenge, this report investigates the components expected to be procured for future nuclear plant power uprates by surveying nuclear utilities. The components identified in these surveys are also benchmarked against historical power uprate data. The result of this effort is a reasonable list of components expected to be required for power uprates and to be used in a typical safe harbor model. This list is comprised of components such as generators, turbines, isophase bus ducts, pumps, heat exchangers, and valves.

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[a] https://www.whitehouse.gov/presidential-actions/2025/05/reinvigorating-the-nuclear-industrial-base/

[b] The tables in this report could also be leveraged for purposes of the material assistance rules under Section 45Y(b)(1)(E) and Section 48E(b)(6).

[c] This report does not address the application of the domestic content requirements for new build nuclear plants.

With an identified list of power uprate components, a safe harbor model is proposed in this report that could be used for evaluating domestic content requirement compliance for nuclear plant power uprates. The proposed power uprate safe harbor model was developed to reflect historical precedents for other technologies as much as reasonably possible noting that no precedents for nuclear power or additions of capacity currently exist.[d] The key aspect of the proposed safe harbor concept is the assignment of a generic "Weight" for each manufactured product component based on typical component cost ranges. Each taxpayer could construct a plant-specific table based on the type and quantity of components procured for their specific power uprate using this approach. The "plant-specific" safe harbor uprate table thus produces the same result as the safe harbor tables developed for non-nuclear technologies.

A public literature search was conducted to determine if prior research could provide the generic cost inputs used in the proposed safe harbor concept. Several references were found that document efforts to categorize costs of nuclear power plants; however, cost data in these references was found to be insufficient (e.g., outdated, only at the system level, or inadequate detail). Thus, this report identifies an industry gap for current publicly available cost estimates for nuclear plant component replacements. It is recommended a subsequent effort be initiated to fill this gap. This research would not only be helpful for domestic content purposes but may also assist the nuclear industry in reasonably estimating component replacement projects, which could support strategic capital planning and help prevent unexpected cost-overruns.

In the absence of referenceable component cost data, this report assigns a Weighting Factor to each identified component using hypothetical cost estimates informed by engineering judgement and industry input (e.g., supplier and utility feedback). The validity of the proposed concept was then evaluated using case studies for power uprates informed by utility surveys. These evaluations conclude that the proposed concept produces reasonable combinations of components needed to meet the domestic content requirements and would encourage procurement of U.S.-based manufacturing products.

The feasibility of manufacturing the identified power uprate components domestically was also investigated by interviewing nuclear component suppliers. The interviews indicate significant potential gaps in domestic manufacturing capabilities associated with raw material procurement and forged parts for certain higher cost components, such as turbines, generators, and large pumps. The higher cost components are inherently weighted more heavily, which may result in utilities having difficulty meeting the domestic content requirement. Additionally, suppliers indicate some portions of the manufacturing process for these components is limited or does not currently exist domestically. Finally, domestic content feasibility is further challenged by components that can be manufactured in the U.S. but are expected to have high demand in coming years. Based on utility surveys and supplier interviews, long lead times are anticipated for turbines, main generators, large pumps, feedwater heaters, and moisture separator reheaters. The lead times could be improved with a strategic ramp up of manufacturing capabilities for these select critical components, which would expedite implementation of power uprates and deployment of new reactors.

[d] *See* IRS Notice 2024-41, IRS Notice 2025-08.

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ACRONYMS

AC	alternating current
APC	applicable project component
BOP	balance of plant
BWR	boiling-water reactor
CFD	condensate filter demineralizer
CFR	Code of Federal Regulations
DOE	(U.S.) Department of Energy
EOY	end of year
EPRI	Electric Power Research Institute
EPU	extended power uprate
FWH	feedwater heater
HP	high pressure
HVAC	heating, ventilation, and air conditioning
IAEA	International Atomic Energy Agency
INL	Idaho National Laboratory
IRA	Inflation Reduction Act
IRC	Internal Revenue Code
IRS	(U.S.) Internal Revenue Service
ITC	investment tax credit
LEFM	leading edge flow meter
LP	low pressure
LWRS	Light Water Reactor Sustainability
MPC	manufactured product component
MSIV	main steam isolation valve
MSR	moisture separator reheater
MUR	measurement uncertainty recapture
MVA	megavolt-ampere
NEI	Nuclear Energy Institute
NRC	(U.S.) Nuclear Regulatory Commission
OE	operating experience
OLTP	original licensed thermal power
PTC	production tax credit
PWR	pressurized-water reactor

SAT	site acceptance testing
SPU	stretch power uprate

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Guidance for Domestic Content Requirement Under the Internal Revenue Code as Applicable to Nuclear Power Uprates

1. INTRODUCTION

1.1 Purpose

This report proposes a safe harbor model for nuclear plant power uprates to meet the domestic content requirements of select federal tax credits. The proposed safe harbor model leverages accepted models for other electricity generating technologies developed by the Internal Revenue Service (IRS) as much as reasonably possible to maximize the value of federal tax credits for nuclear power plant uprates.

1.2 Background

To help secure America's energy dominance, the Internal Revenue Code (IRC) contains tax credits that existing utilities may leverage to implement power uprates at nuclear power plants. Specifically, the IRC contains a production tax credit (PTC; IRC Section 45Y) and an investment tax credit (ITC; IRC Section 48E), which utilities may leverage to offset the costs of power uprates [7] [16]. The PTC provides an annual credit based on the incremental uprate generation for up to 10 years, while the ITC offers a lump-sum credit for a portion of the capital investment required for the uprate. Both tax credits contain a potential adder if the taxpayer (i.e., utility) can demonstrate that it meets prescribed domestic procurement (i.e., "domestic content") requirements for new materials (additional details provided in Section 2.2). The current proposed guidance developed by the IRS contains safe harbors (i.e., simplified approaches) for meeting the domestic content requirements for non-nuclear technologies, such as solar and wind, but no equivalent safe harbor method currently exists for nuclear power technologies. As a result, the Light Water Reactor Sustainability (LWRS) Program initiated this project to investigate the feasibility of, and propose an implementation approach for, meeting the domestic content requirements for nuclear plant power uprates.

The executive order, "Reinvigorating the Nuclear Industrial Base," signed on May 23, 2025 [2] is focused on establishing the nation's path to nuclear energy dominance. The administration has set an ambitious goal to facilitate 5 GW of power uprates from existing reactors and start the construction of 10 new large reactors by 2030. This executive order highlights the urgency of "Swift and decisive action… to jumpstart America's nuclear energy industrial base…," which directly translates to the need to expedite planned power uprates and facilitate the decision-making for additional power uprates. Given the importance of the economic feasibility of power uprates, the domestic content bonus for the tax credits increases the economic viability of power uprates.

1.3 Scope and Approach

To achieve the project objectives, the following three interrelated tasks were performed:

1. Generate a list of the components expected to be procured for future nuclear plant power uprates through a survey of nuclear utilities.
2. Interview component suppliers to determine their capabilities to manufacture the expected uprate components domestically.
3. Develop a safe harbor model, or concept, for utilities performing nuclear plant power uprates to simplify the process of meeting the domestic content requirements.

This report includes:

- An overview of the relevant tax credits and an explanation of the specific requirements for meeting the domestic content adder.
- An overview of nuclear plant components that may be impacted by a power uprate based on industry operating experience (OE) and utility feedback, including results of the utility survey to gauge the expected components that may be procured for future nuclear power uprates throughout the domestic fleet.
- A proposed safe harbor model for nuclear plant power uprates to meet the domestic content requirements.
- An overview of current domestic manufacturing capabilities to support power uprates based on input from interviews with component suppliers.

2. TAX CREDITS AND DOMESTIC CONTENT OVERVIEW

2.1 Tax Credit Overview

The IRC provides for a PTC (Section 45Y) and an ITC (Section 48E), which nuclear power plants may leverage to offset the costs of power uprates [7] [16]. These tax provisions recognize nuclear energy's essential role in establishing America's energy dominance and accelerating the nation's path toward a more secure and independent energy future. Further, they help incentivize the nuclear energy industry to implement power uprates at existing nuclear plants, adding needed generation capacity. Importantly, taxpayers may only select either the PTC or the ITC for the increased generation from any single power uprate.

The PTC provides an annual credit based on the incremental uprate generation for up to 10 years. The base value of the PTC is $0.003/kWh, adjusted annually for inflation [16]. Alternatively, the ITC offers a lump-sum credit for a portion of the capital investment required for the uprate. The base ITC value is 6% of eligible construction costs [7].

Each credit is subject to three additional requirements, which can increase the value of the credits as follows [7] [16]:

- A Prevailing Wage & Apprenticeship requirement, which would multiply the value of the credit by five (e.g., increasing the ITC value from 6% to 30% of eligible construction costs).
- An Energy Community requirement, which would increase the value of the PTC by a factor of 1.1 or the value of the ITC by 10 percentage points (e.g., from 30% to 40% if the Prevailing Wage Requirement is also met).
- A Domestic Content requirement, which would increase the value of the PTC by a factor of 1.1 or the value of the ITC by 10 percentage points.

The focus of this report is the Domestic Content requirement, which is discussed in detail in Section 2.2.

2.2 Domestic Content Overview

The domestic content requirements for the applicable tax credits are detailed in IRC Sections 45(b)(9) and 48(a)(12) and IRS Notices 2023-38 [3], 2024-41 [4], and 2025-08 [17]. Taxpayers are eligible for the bonus if it can be shown that a certain percentage of components procured are manufactured domestically. For cases involving adding additional capacity to existing facilities (i.e., nuclear power uprates), the domestic content requirements apply only to the "new" materials required for the additional capacity (i.e., not the existing plant equipment or materials).

Additional information and specific requirements for the domestic content adder are summarized in Sections 2.2.1 through 2.2.5.

2.2.1 Key Definitions

Key terms used in the domestic content requirement notices are provided here for context, and Notices 2023-38 [3], 2024-41 [4], and 2025-08 [17] contain more in-depth information and formal definitions of the **bolded** terms:

- In the context of this report, the **Applicable Project** refers to the nuclear power plant power uprate project.
- An **Applicable Project Component (APC)** is any component used as a part of the Applicable Project and are categorized as steel and iron products or Manufactured Products.
- A **Manufactured Product** is an item produced by changing the form or function of materials or of elements of a product in a manner adding value and transforming those materials or elements so that they represent a new item functionally different from that which would result from mere assembly of the elements or materials.
- A **Manufactured Product Component (MPC)** is a subcomponent of a Manufactured Product and is any article, material, or supply whether manufactured or unmanufactured that is directly incorporated into an APC that is a Manufactured Product.
- A **U.S. Manufactured Product** is a Manufactured Product in which all manufacturing processes for its MPCs took place in the U.S. Note that the subcomponent origin of the MPCs themselves does not impact the U.S. Manufactured Product determination.
- A **Non-U.S. Manufactured Product** is a Manufactured Product in which some or all MPC manufacturing did not take place in the U.S. The Non-U.S. Manufactured Product may consist of MPCs of both U.S. and non-U.S. origin.

2.2.2 Steel and Iron Rule

All APCs that are primarily comprised of steel and iron and are structural in function must be manufactured in the U.S. (except metallurgical processes involving refinement of steel additives). This rule excludes steel or iron that are used in subcomponents of MPCs (e.g., nuts, bolts, and screws) as described in Notice 2023-38 [3].

2.2.3 Adjusted Percentage Rule

The Adjusted Percentage Rule applies to Manufactured Products. All Manufactured Products shall be deemed to have been produced in the U.S. if [1]:

$$\frac{\text{U.S. Manufactured Products} + \text{U.S.MPCs of Non}-\text{U.S. Manufactured Products}}{\text{Total Costs of All (US+Non}-\text{US) Manufactured Products}} > Adjusted\ Percentage \quad (1)$$

Manufacturing is broken down into four activities as follows:

- Procuring raw materials (note this refers to the materials or elements <u>before</u> they are transformed in the manufacturing process step)
- Processing raw materials, including forgings and castings
- Assembling the processed components into a final product
- Testing the final product prior to delivery to the end user

IRS guidance indicates that, for the application of the Adjusted Percentage Rule for the domestic content requirement applicable to tax credits, manufacturing begins when the raw materials or elements of a product enter the processing stage in which they are altered or transformed [3]. With this context, procurement of raw materials and manufacturing of subcomponents may not be considered in qualifying a product or component in the context of the Adjusted Percentage Rule. For completeness, this report investigates the domestic manufacturing capabilities of all four activities listed above for information purposes.

Further, only direct material and labor costs are includable in the cost of a U.S. Manufactured Product or U.S. MPC in Equation 1 [3]. This includes direct labor costs associated with processing, assembling, and testing the product prior to delivery, but does not include direct costs incorporating the APCs into the Applicable Project. Accordingly, costs that are not incorporated into the Adjusted Percentage Rule include:

- Engineering and design, project management, and administrative labor
- Installation in the plant
- Onsite testing after installation (e.g., Site Acceptance Testing [SAT])

Note that labor costs may only be included in the numerator of Equation 1 for U.S. Manufactured Products and may not be included in the numerator for Non-U.S. Manufactured Products. All direct costs (whether U.S. or non-U.S.) are included in the denominator of Equation 1.

The adjusted percentage to qualify for a domestic content bonus is dependent upon the year in which Applicable Project construction begins, as noted in Table 1 [7] [16]:

Table 1. Adjusted percentage rule for manufactured products as applicable to nuclear uprates.

Construction Begins	Adjusted Percentage
Before 2025	40%
In 2025	45%
In 2026	50%
After 2026	55%

2.2.4 Direct Payment Ramifications

Tax-exempt utilities (such as those funded by municipalities) or cooperatives may use a direct payment method rather than receive a tax credit. If the utility elects to utilize the direct payment method, the utility must meet domestic content requirements or obtain a domestic content exemption (see Section 2.2.5). If neither of these occur, then the value of the direct payment is reduced from 100% to 0% of the full value depending on when project construction begins, as noted in Table 2. Current guidance applicable to nuclear electric generation projects indicates that the start of construction can be demonstrated by either a "Physical Work Test" or a "Five Percent" safe harbor that stipulates when 5% of the total project costs have been spent, the project is deemed to have started construction [14].

Table 2. Direct payment value ramifications.

Start of Construction Before	Value
EOY* 2023	100%
EOY 2024	90%
EOY 2025	85%
Afterwards	0%

*End of year

Importantly, if the project does not begin construction before the end of Calendar Year 2025 and is unable to meet the domestic content requirements or obtain an exemption, the direct payment value is zero. The domestic content requirements for the direct pay pathway are equivalent to eligibility for the tax credit bonus.

2.2.5 Direct Payment Domestic Content Exemptions

The IRC currently provides two exemptions expected to be applicable for nuclear plant power uprates to domestic content requirements for the direct payment pathway only (i.e., the exemptions cannot be used to obtain the bonus). Domestic content requirements would be waived if it can be shown that either [6]:

- The inclusion of domestic content would increase the construction costs of the qualified facility by more than 25% or
- The relevant components are not produced domestically in sufficient quantities or satisfactory quality.

These exemptions are not applicable to tax-paying utilities; however, if a taxpayer pursuing the ITC or PTC does not meet domestic content requirements, they may still receive the base ITC or PTC credit without the domestic content bonus.

3. NUCLEAR POWER PLANT COMPONENTS IMPACTED BY POWER UPRATE

This section investigates components that may need to be procured by nuclear power plants to implement power uprates. This information is collected from historical power uprates and via a survey of utilities currently planning to implement power uprates.

3.1 Nuclear Plant Power Uprate Types

Three types of power uprates have historically been implemented in the U.S.: Measurement Uncertainty Recapture (MUR), Stretch Power Uprate (SPU), and Extended Power Uprate (EPU). An overview of the power uprate types is described in INL/RPT-23-74681 [5] and summarized below. Additional publicly available industry guidance on power uprates includes:

- NEI 08-10, "Roadmap for Power Uprate Program Development and Implementation" [8]
- IAEA NP-T-3.9, "Power Uprate in Nuclear Power Plants: Guidelines and Experience" [9]
- EPRI 3002026402, "Facilitating Power Uprates at Nuclear Power Plants: Feasibility Study Guideline" [10]

3.1.1 Measurement Uncertainty Recapture

MURs increase the licensed power level by up to 2% of the original licensed thermal power and are also often referred to as 10 Code of Federal Regulations (CFR) 50.62 Appendix K uprates. To account for uncertainty in measuring feedwater flow, 10 CFR 50.62 Appendix K required utilities to apply a 2% uncertainty factor to thermal power calculations used in safety analyses. Historically, plants have utilized ultrasonic feedwater flow measurement devices that provide more precise measurements of feedwater flow, and in turn allow utilities to claim a portion of the 2% uncertainty factor applied to thermal power calculations. In addition to the traditional hardware-based solution for MUR, there is a current industry effort to utilize data validation and reconciliation as a software-based alternative approach. MURs typically do not require significant component upgrades other than new feedwater flow measurement devices but the level of modification is dependent on available margin. For example, some sites have had to modify significant components such as the high-pressure (HP) turbine and generator due to limited margin from prior power uprates.

3.1.2 Stretch Power Uprate

SPUs typically increase licensed power levels between 2% and 7% of the original licensed thermal power and are typically within the existing design margin of the plant. The achievable value for percentage increase in reactor power is plant-specific and depends on the operating margins included in the design of a particular plant. SPUs typically require changes to instrument setpoints but historically have not involved significant plant modifications beyond potentially the high-pressure turbine (and in some cases the main generator) depending on the existing margin.

3.1.3 Extended Power Uprate

EPUs are greater increases in licensed power than SPUs and have been approved for power increases as high as 20% of the original licensed thermal power in the U.S. To implement EPUs, steam flow is typically substantially increased. The thermal power generated in the reactor core must also be increased, which is accomplished by flattening the core power distribution. The core power distribution is typically adjusted by methods such as changing the radial and axial fuel loading patterns, control rod programs, and the distribution of burnable poisons. Similar methods are utilized to ensure that the core design provides sufficient operational flexibility (i.e., can provide baseload power but also respond to various grid demands) and reactivity characteristics. EPUs typically require significant modifications to the balance of plant (BOP) equipment, such as HP turbines, condensate pumps and motors, main generators, and transformers. In some cases, upgrades to the highest cost components (such as steam generators, main condensers, and low-pressure turbines) may be evaluated on a cost-benefit basis to determine whether to include with the power uprate project.

3.1.4 Thermal Efficiency Upgrade

In addition to thermal power uprates, plants have achieved additional electrical output through thermal efficiency improvements. All currently operating commercial nuclear power plants in the U.S. are light water reactors, which use the Rankine Cycle to generate electricity. The Rankine Cycle: (1) converts water into steam using a heat source (in this case the reactor); (2) passes that steam through a turbine connected to a generator to produce electricity; (3) condenses the resultant steam back into water using a condenser; and (4) returns the water back to the heat source using pumps. The resultant thermal efficiency of the nuclear plant is defined as the ratio of the net power output to the heat input. There are changes that can be made to a plant to increase thermal efficiency, and subsequently electric generating capacity, without altering the reactor's thermal power. These include but are not limited to upgrades or replacements to turbines, heat exchangers, and condensers. Increased electrical output through a thermal efficiency project may be eligible for the tax credits discussed herein and thus included in the report.

3.2 Nuclear Power Uprate History

There is an extensive history of implementing power uprates in the domestic nuclear industry. Since the late 1970s, over 170 thermal power uprates (inclusive of EPUs, SPUs, and MURs) have been implemented in the U.S., with a vast majority (83%) of nuclear reactors operating during this timeframe performing at least one type of power uprate [10] [11] [12]. Figure 1 provides a summary of these uprates with these key takeaways:

- MURs have been the most common uprate type followed by SPU and EPU, in increasing order of technical complexity.
- A majority (i.e., 60%) of the units that have performed power uprates have performed more than one uprate. Given the extensive history of power uprates, many plants will have limited margin for future EPU and SPUs without significant plant modifications.

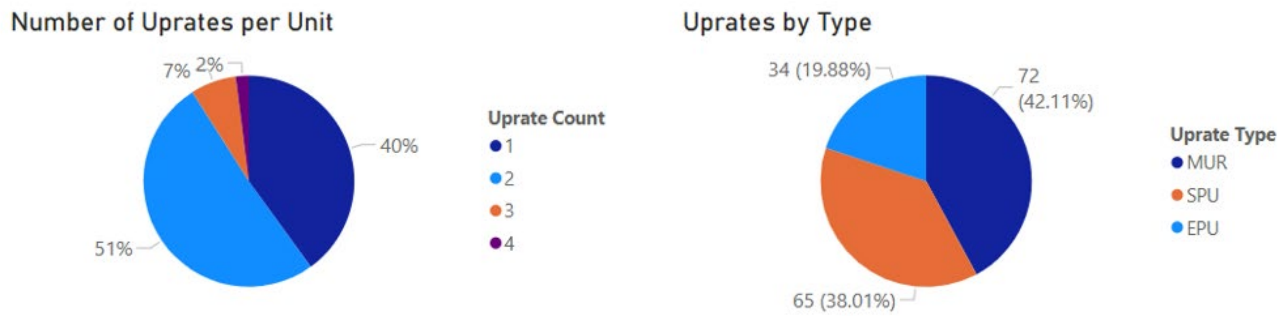

Figure 1. Historical nuclear power uprate summary as of June 2025 [10] [11].

A timeline for historical power uprates organized by uprate type is provided in Figure 2 [10] [11]. Key takeaways are:

- SPUs were the first type of uprate performed across the industry, since they were primarily paper exercises with limited equipment impact.
- Since EPUs are historically more complex and resource intensive than SPUs, they were performed after the industry gained experience in power uprate implementation from the initial SPUs.
- The number of MURs performed spiked in the early 2000s, enabled by advancements in leading edge flow meter (LEFM) technology and regulatory approval for its use in MUR applications [13].

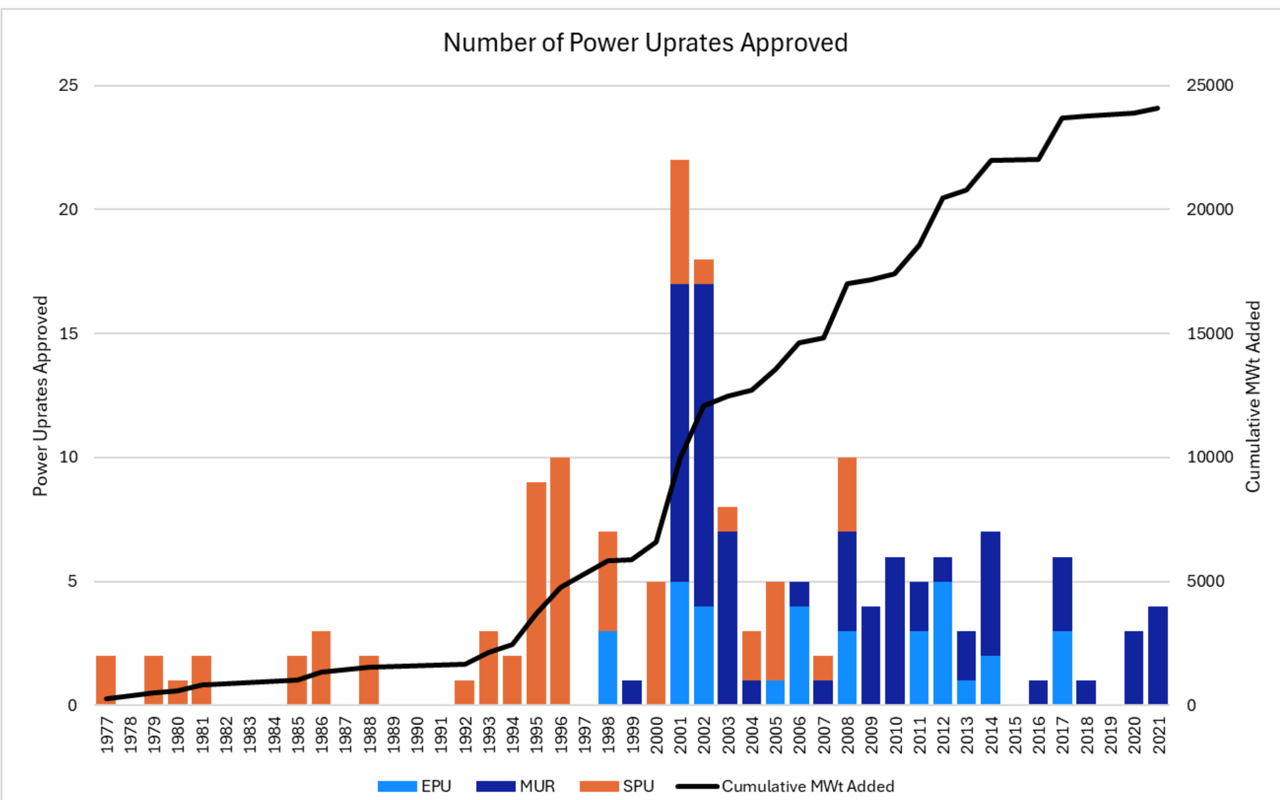

Figure 2. Historical nuclear power uprate timeline [10] [11].

3.3 Historical Uprate Component Impact Summary

The impact of power uprate on nuclear power plant components is well understood. A summary of industry OE from historical power uprates is described in INL/RPT-23-74681 [5] and is summarized below.

There are a number of general plant impacts due to power uprate, including:

- The steam flow from the boiling-water reactor (BWR) pressure vessels or the pressurized-water reactor (PWR) steam generators will increase, resulting in increased pressure drops and greater dynamic loads on various systems. For example, condensate and feedwater flow will experience a corresponding increase, which may increase vibration or degradation of certain components.
- The power plant environment will be subject to larger amounts of waste heat, which could require an upgrade to the cooling water systems.
- The mean value of power density in the core will increase, which could require the utility to invest in improved fuel designs that have larger margins to safety limits.
- Neutron irradiation in the core region will increase, potentially changing requirements for monitoring programs.
- Downstream plant waste streams will contain higher concentrations of radiological materials, placing additional strain on radwaste processing systems.
- Plant decay heat will be increased, requiring additional capacity from safety systems. Energy releases into the primary containment will be greater in the event of an accident.

The extent of the modifications required to implement power uprate and mitigate the impact on plant margins is highly plant-specific and depends on factors such as the desired power level, the capacity of currently installed equipment, original plant design margin, and remaining margin as a result of any prior power uprates.

Table 3 provides a list of common components impacted by power uprates along with details on specific aspects that are typically challenged. Some of the most significant component impacts include:

- HP turbines to increase flow passing capability and maintain required throttle flow margin
- Main generators, including replacements, rewinds, or cooling upgrades to accommodate the increase in power generation
- Internals of the moisture separators and moisture separator reheaters (MSRs) to provide adequate moisture separation at the increased steam flows
- Feedwater and condensate pumps to provide increased flow
- Main transformers to be compatible with the increased electrical output
- Circulating water system to reject additional energy due to power uprate (e.g., upgrades to natural draft cooling towers or the addition of supplemental mechanical draft cooling towers).

Table 3. Typical components impacted by power uprate.

System	Component	Power Uprate Impact
Condensate and Feedwater	Main Condenser	The thermal performance of the condenser may be challenged by the increased steam flow. The larger load on the condenser will also increase condenser backpressure and reduce margin to various setpoints (e.g., low pressure [LP] vacuum). Increases in steam flow velocity could cause flow-induced vibrations or increased erosion on the shell, tubes, or supports.

System	Component	Power Uprate Impact
	Feedwater Heaters (FWHs) and Vents/Drains	Implementation of power uprate may require larger FWHs with nozzles, drain coolers, and other equipment sized to accommodate the higher feedwater flow rates, extraction steam flow rates, and drain flow rates.
	Condensate Filter Demineralizers	The condensate filter demineralizers will be required to handle increased flow rates and temperatures as a result of power uprate. These conditions could challenge the effectiveness of the filtration media. Power uprate conditions could increase the required frequency of backwash or resin regeneration activities. It is common for utilities to add new demineralizer vessels or supplement existing systems with new, skid-based systems.
	Pumps and Prime Movers	Pumps in multiple systems will need to be evaluated to ensure capacity is adequate for the increased flow rates (e.g., sufficient net positive suction head). Required upgrades could include impeller upgrades, motor upgrades, or full replacements. Common pumps that are upgraded as part of power uprate include: • Condensate pumps and condensate booster pumps • Feedwater pumps • Auxiliary feedwater pumps • Heater drain pumps.
Nuclear Steam Supply Systems	Steam Dryer/Separators (BWR)	Steam dryers have been significantly impacted at several BWRs following EPU implementation due to flow and acoustically-induced vibration. These impacts result from increased main steam flow at EPU conditions and the potential increase in high cycle fatigue due to adverse flow effects. Material failure can result in loose parts that could damage safety-related equipment downstream of the steam dryers. The Nuclear Regulatory Commission has required licensees to demonstrate a 100% margin on the maximum alternating stress in the steam dryer components for projected EPU conditions. As a result, steam dryer replacement has become common for EPUs.
	Steam Generator (PWR)	Steam generators are a common pinch point for PWR power uprates and require evaluation for several critical parameters, including heat transfer capacity, moisture carryover, flow-induced vibrations at the increased flow rate, and water level stability. In the past, PWR stations typically elected to limit their percentage uprate to avoid the expense and risk of performing steam generator replacements.
Main Steam and Turbine Cycle	Moisture Separator/ Moisture Separator Reheater	Power uprates result in increased steam flow and drain flow in the MSRs, which may necessitate upgrades or replacements. As the HP turbine steam flow is increased with EPU, industry experience has shown that the cross-around relief valves and actuators often require modifications or replacement to increase relieving capacity.

System	Component	Power Uprate Impact
	Piping and Supports	The main steam piping and its supports require evaluation for vibration and erosion issues due to the increased steam flow rate.
	Main Turbine	The main turbine requires evaluation to ensure adequate flow passing capability for increased steam flow. Almost universally, a complete retrofit of the HP turbine flow path is required for an EPU. While less common, LP turbines, or selected components within the LP turbine, may also require modification. Associated piping expansion joints (or bellows) may also require replacement to accommodate higher design temperatures and pressures (e.g., extraction steam, crossover/crossunder piping).
Electrical Generation and Distribution	Main Generator and Auxiliaries	The main generator requires evaluation to confirm that its megavolt-amperes (MVA) rating is sufficient for EPU conditions. In many cases, the main generator will require a stator and rotor rewind or full replacement for EPU. Other common modifications for power uprate include exciter replacements, hydrogen cooler replacements, current transformer replacements, and main generator protective relay replacements.
	Isophase Bus Duct	The power uprate will result in more current traveling through the isophase bus, which could challenge the ampacity rating of the conductors. The increased current will also generate more heat, which could necessitate upgrades to the isophase bus duct cooling equipment.
	Large Transformers	Stations may be required to increase the capacity of the main transformers to accommodate the higher main generator MVA output. Industry evidence suggests that full replacement of the main power transformers is the most common approach.
	AC Distribution Systems and Grid Stability	Power uprate will increase the power flow from the station to the grid. Issues associated with the grid interface include local grid voltage regulation, avoidance of transmission system overloads, oscillatory behavior, and protection from fault currents. Modifications to breakers, disconnects, or sections of transmission line are common with extended power uprates. Utilities may also be required to install new inductors or capacitor banks for reactive power requirements.
Reactor Fuel and Monitoring	Fuel	Fuel performance characteristics are assessed as part of the fuel reload analysis. The core power distribution is often modified to allow for an increase in the overall core power while limiting the absolute power in any individual fuel bundle. Utilities may elect to use new fuel designs, enrichments, or higher batch fractions to provide additional operating flexibility and maintain cycle length.

System	Component	Power Uprate Impact
	Spent Fuel Pool/Spent Fuel Storage	The spent fuel pool cooling system requires an evaluation to determine its capability to remove the decay heat from the spent fuel post power uprate implementation. If a new fuel design is implemented, utilities may also be required to modify the spent fuel pool storage racks or spent fuel handling procedures. Depending on the results of the spent fuel criticality analyses, utilities may be required to install additional neutron absorbing inserts in the storage racks or implement new administrative controls to limit the placement of fuel to approved storage configurations.
	Nuclear Instrumentation	Nuclear instrumentation will need to be recalibrated to read 100% at the new licensed power level. The instrument ranges may also need to be adjusted such that the overlap between source, intermediate, and power range remains adequate. The increase in power level will increase flux at various neutron detectors (especially in-core detectors). These detectors will require replacement more frequently.
Cooling / Heating, Ventilation, and Air Conditioning (HVAC)	Cooling Water Systems (e.g., Circulating, Service Water)	An evaluation of the ultimate heat sink is required to confirm adequate heat removal capability for the uprate conditions during all seasons and for all design basis events. Utilities may be required to perform upgrades to cooling towers or request revision of the water permit to increase discharge flow and/or temperature.
	HVAC Systems	Power uprate will result in increased heat loads in spaces throughout the plant, particularly in rooms and air spaces where main steam lines traverse as well as in rooms with large motors. HVAC systems will need to be evaluated for potential changes to the post-accident heat load due to power uprate.

Power uprates also require comprehensive evaluation of margins in plant safety and emergency response systems and processes, e.g., containment internal pressure during a hypothetical accident, capacity if the emergency core cooling systems, control room habitability given larger potential accident radiation doses, etc. However, this report is focused on the major components that are expected to be replaced as a result of power uprates. Therefore, like the approach taken by the IRS in Notice 2024-41, it does not include a comprehensive list of all the systems, components, and processes that may be affected by power uprates. Instead, this report creates the exclusive and exhaustive list of MPCs for inclusion in a power uprate project.

3.4 Future Power Uprate Component Procurement Projections

3.4.1 Utility Survey Approach

A utility survey was performed to gauge which components may need to be procured to facilitate future nuclear power uprates throughout the domestic fleet, providing a benchmark against historic component modifications. The survey requested input on the components that may be procured for each thermal power uprate type being pursued by the utility's fleet (i.e., MUR, SPU, and EPU), the quantity of components expected to be procured for each utility's fleet, and potential suppliers for those components. The survey template and instructions sheet are included in Appendix A.

The survey was sent out to 17 domestic nuclear utilities. 76% of the utilities responded with their power uprate intentions (i.e., if they are pursuing power uprate and if so, what type of uprate and what component procurements are anticipated if known).

3.4.2 Utility Survey Results

The results of the utility survey are summarized by power uprate type in the subsections below. The survey results generally align with the historical components impacted by power uprate discussed in Section 3.3.

Ultimately, the quantities of components expected to be procured for future power uprates will increase as utilities make final decisions on pursuing power uprate and as more comprehensive component evaluations are completed for planned uprates. However, the components listed herein are considered adequate for the purposes of understanding current domestic manufacturing capability and developing a proposed domestic content safe harbor model for power uprates.

3.4.2.1 Measurement Uncertainty Recapture

The survey results confirmed that plants pursuing MURs are generally not expecting significant component upgrades other than the installation of new feedwater flow measurement devices. Participating utilities noted that future MURs may require modifications to select other components based on available plant specific margin. Potential components that may be impacted includes:

- Feedwater pumps
- Condensate pumps
- Heater drain pumps
- Main generator auxiliaries
- High pressure turbine diaphragms
- MSRs
- Relief valves

In general, the impact of MUR on plant components is expected to be minor compared to SPUs and EPUs.

3.4.2.2 Stretch Power Uprate

The survey results indicate that many plants expect that future SPUs may require significant plant changes such as to the following components:

- Condensate filter demineralizers
- MSRs
- Isophase bus ducts
- Condensate pumps
- Heater drain pumps
- FWHs
- HP turbines
- Main generator and auxiliary systems
- Large transformers and current transformers.

As shown in Figure 2, SPUs were commonly the first uprate type performed on many units. These historical SPUs may not have involved as many significant component replacements since they were performed earlier in plant life and may have had additional margin compared to uprates performed later in plant life. As a result, future SPUs may require more significant component replacements than historical SPUs.

3.4.2.3 Extended Power Uprate

The survey results confirmed the OE described in Table 3 for components expected to be procured for upcoming EPUs. There were common themes in the components expected to be procured for EPU. Specifically, a large majority of utilities (75% or greater) planning for an EPU responded that the following components would need to be upgraded or replaced:

- HP turbines
- Isophase bus ducts
- Condensate and feedwater system pumps
- Generator auxiliaries
- FWHs
- MSRs
- Condensate filter demineralizers.

These results align with OE for commonly impacted components for EPU as described in Sections 3.1.3 and 3.3.

It is important to note that plants who responded to the survey are largely not expecting to procure new steam generators or main condensers while margins could, and likely will, be impacted for these components. Upgrades or replacements to steam generators, main condensers, or wholesale replacements of main generators (including frame) would require significant capital investment and thus pose large "pinch-points" to further uprate the plant and may ultimately serve as upper-bound limits for the uprate. In addition, replacement of these large components is seen as a high-risk project that could result in significant schedule and cost overruns for project execution; thus, utilities may be reluctant to commit to larger-size uprates that require these replacements.

3.4.2.4 Component Quantities for All Uprate Types

As a part of the utility survey, nuclear utilities also reported the quantity of each component that they expect will require replacement or modification to support power uprate. The total component quantities across surveyed utilities and all power uprate types are reported in Figure 3. These are components for the uprates that have already been planned; the number of components will increase when utilities decide to uprate additional plants. Note that only the top component quantities are shown in Figure 3 for brevity, providing a snapshot of relative demand across various component types. It is evident that the power uprate demand for pumps, FWHs, MSRs, and valves/actuators will be relatively high in coming years. Plants will need to replace multiples of each component to support a single power uprate, which contributes to the greater quantity shown (e.g., a single unit may need to replace four FWHs compared to a single main generator to support an EPU). Utilities also provided insight into potential suppliers of components, as discussed further in Section 5.

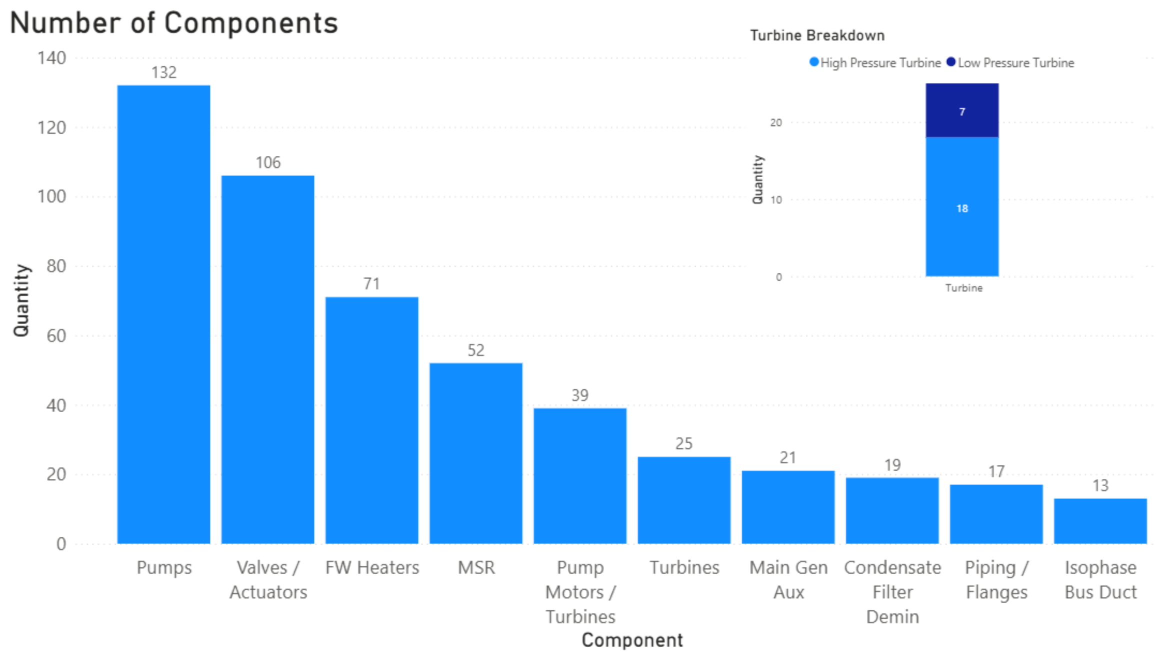

Figure 3. Reported component quantities for all uprate types.

4. PROPOSED NUCLEAR PLANT POWER UPRATE DOMESTIC CONTENT SAFE HARBOR MODEL

With the components expected to be procured for future power uprates well understood, a safe harbor model for meeting the domestic content rule is proposed in the subsequent subsections.

4.1 Safe Harbor Overview

Application of the Adjusted Percentage Rule (as described in Section 2.2) may present a challenge to taxpayers. Specifically, the Adjusted Percentage Rule requires taxpayers to obtain the direct material and labor costs from domestic and international suppliers for all MPCs, which may be difficult. Therefore, in lieu of calculating the contribution of each component to the overall cost of the project, the IRS has created an Elective Safe Harbor for solar, wind, and battery storage projects as described in Notice 2023-38 [3], Notice 2024-41 [4], and Notice 2025-08 [17]. The safe harbor is a simplified approach to demonstrating compliance with domestic content requirements as it does not require a discrete MPC cost breakdown.

An example safe harbor for a land-based wind project is provided in Table 4. The safe harbor:

- Identifies representative APCs for a given energy project or qualified facility,
- Determines if the representative APCs are categorized as steel and iron components or Manufactured Products (see Section 2.2.2), which are broken into MPCs as appropriate, and
- Assigns an Associated Cost Percentage to all MPCs, which add up to 100%.

Table 4. Example safe harbor for land-based wind, recreated from Reference [4].

APC	MPC	Value
Wind Turbine	Blades	31.2
	Rotor Hub	9.9
	Nacelle	47.5
	Power Converter	8.9
	Production	0.9
Wind Tower Flanges	Material	0.8
	Production	0.8
Tower	—	Steel/Iron Product
Steel or iron rebar in foundation	—	Steel/Iron Product
Total	—	100

The taxpayer using the safe harbor determines if each MPC is manufactured domestically or internationally. If each MPC in a particular Manufactured Product is manufactured domestically, the taxpayer may also count the "Production" line item in the APC. If the sum of the Associated Cost Percentage ("Value" Column in Table 4) for all U.S. MPCs is greater than the required adjusted percentage (see Section 2.2.3), then the domestic content requirements are met. Note that all steel and iron components subject to the Steel or Iron Rule still must be domestically manufactured when using the safe harbor.

4.2 Proposed Nuclear Plant Power Uprate Safe Harbor

Each nuclear plant power uprate will be plant-specific with regards to the necessary component procurements. That is, each plant will likely require a unique combination of components to be procured due to historical plant modifications previously performed and level of uprate pursued. Further, the list of components that could be procured for a nuclear plant power uprate is more exhaustive than those for other generation technologies. Thus, the proposed safe harbor model for nuclear plant power uprates was developed to reflect historical precedents for other technologies as much as reasonably possible noting that no precedents for nuclear power or additions of capacity currently exist. Specifically, the proposed model develops a component-specific "Weighting Factor" concept that could be used by each taxpayer to create a plant-specific safe harbor table based on the type and quantity of components being procured. This model is presented in detail in Section 4.2.1.

4.2.1 Proposed Nuclear Plant Power Uprate Safe Harbor Model

The proposed nuclear plant power uprate safe harbor model is:

1. Identify the type and quantity of each MPC procured for the power uprate based on plant-specific power uprate evaluations
2. For each MPC, multiply the total quantity by an associated Weighting Factor (based on each component's relative cost) to obtain an "MPC Score"
3. Sum all MPC Scores to get a "Total Score"
4. Divide each MPC Score by the Total Score to obtain a normalized "MPC Value" for each MPC
5. Assess strategies for meeting the required adjusted percentage based on the resultant MPC Values.

If the sum of MPC Values for a subset of U.S. Manufactured Products is greater than the required adjusted percentage (i.e., 40%–55% depending on start of construction), then the utility can demonstrate that they meet domestic content requirements, increasing the value of the tax credit selected. Thus, the resultant "plant-specific" safe harbor uprate table produces the same result as the safe harbor tables developed for non-nuclear technologies (i.e., list of MPCs and corresponding "Value" as shown in Table 4). The safe harbor table provides a simplified approach to satisfying the Adjusted Percentage Rule as the utility only needs to evaluate the manufacturing country of origin for the components used to meet the required adjusted percentage.

4.2.2 Safe Harbor Development

Based on the results of the documentation review and industry surveys, the typical nuclear power plant systems and components that may be procured for a power uprate are well-known. Each of the identified systems is listed as an APC in Table 6 below. Each APC is broken into several potential MPCs, or components that could be procured for power uprate. The list of MPCs in Table 6 should be considered the exclusive and exhaustive set of MPCs, similar to safe harbors issued for other technologies.

The key aspect of the proposed safe harbor concept is the Weighting Factor assigned to each MPC. The Weighting Factor must be based on relative cost of each MPC. It is recognized that the direct material and labor costs for each MPC will vary depending on the supplier and specific agreements between the supplier and the utility. In addition, costs are expected to be affected by market conditions, such as domestic and global demand for a given component, cost of raw materials, cost of energy, labor costs, and inflation rate among other factors. As a result, rough order of magnitude cost estimates would be reasonable for the purpose of the safe harbor. That is, the Weighting Factors should allow taxpayers to plan for reasonable methods (or combinations of MPCs) to achieve the required adjusted percentage based on projected cost ranges, while also encouraging procurement of U.S. based manufacturing products.

A public literature search was conducted to determine if prior research could provide cost inputs needed for the proposed safe harbor concept. Several references were found that document efforts to categorize costs of nuclear power plants; however, cost data in these references was found to be insufficient for the purpose of this effort. Specifically, prior industry efforts:

- Primarily provide cost information at the system, or APC level,
- Typically, only cover full replacements of components whereas several MPCs for power uprates could have partial replacements,
- Utilize outdated data (e.g., over 30 years old), and/or
- Do not include a breakdown of the direct manufacturing costs.

Thus, this report identifies an industry gap for current publicly available cost ranges for nuclear plant component replacement projects. It is recommended a subsequent effort be initiated to fill this gap. This subsequent research would not only be helpful for this effort but would also assist utilities in reasonably estimating component replacement projects as part of power uprates or life-cycle management projects. This could help support strategic capital planning and prevent unexpected cost-overruns that have been seen in the industry.

In the absence of current, referenceable component cost data, this report assigns a Weighting Factor to each identified MPC using hypothetical cost estimates. While the cost estimates used to assign the Weighting Factors are informed by engineering judgement and informed by industry input (e.g., supplier and utility feedback), they should not be considered definitive. That is, the goal of this report is to deliver a proposed safe harbor concept for demonstration of eligibility for meeting domestic content requirements, not provide accurate cost estimates.

With this in mind, the safe harbor concept proposed herein assigns each MPC one of six Weighting Factors ranging from 1 to 75 as shown in Table 5. The specific weighting factors are based on cost ranges as shown in Table 5 below.

Table 5. Hypothetical component weighting factors.

Category	Cost Range ($M)	Weighting Factor
I	0-2	1
II	2-6	4
III	6-10	8
IV	10-30	20
V	30-50	40
VI	50+	75

The validity of the proposed safe harbor concept was evaluated as follows:

- Generate example uprates (Section 4.4) with specific MPCs selected using information collected via utility surveys.
- Evaluate if the proposed safe harbor concept produces reasonable results (i.e., combinations of MPCs) and meets the intent of the domestic content requirement (i.e., encourage procurement of U.S. based manufacturing products). This was done through:
  - An analysis of the example uprates and
  - An evaluation of the dependency of the Weighting Factors on hypothetical MPC cost (see Appendix B).

These exercises conclude that the proposed concept produces reasonable combinations of MPCs needed to meet the domestic content requirements and would encourage procurement of US based manufacturing products. Additional takeaways are as follows:

- The large range of potential costs across MPCs highlights the importance of procuring higher cost components domestically.
- The approach results in number of unique combinations of MPCs for the example uprates which will encourage taxpayers to investigate different avenues for procuring "lower-cost" MPCs domestically. That is, if one "lower-cost" MPC cannot be manufactured domestically, there are various alternates that could be used to help reach the required threshold; thus, encouraging the taxpayer to procure components domestically rather than abandon trying to meet the domestic content threshold.
- It is important to include "lower cost" MPCs in the proposed safe harbor concept. Eliminating the lowest cost MPCs places heavier emphasis on higher-category MPCs and significantly reduces the number of potential combinations of MPCs to achieve the required adjusted percentage.
- Using the median value of a potential cost range for the Weighting Factor is a reasonable approach.
- Additional research is recommended for current publicly available cost information to help inform the hypothetical cost ranges and MPC cost assignments.

Note that, consistent with the safe harbors developed for other non-nuclear technologies, all steel and iron components that are structural in function must be manufactured in the U.S.

Table 6. Hypothetical weighting factors for nuclear power plant applicable project components.

APC	MPC	Cost Category	Weighting Factor
Nuclear Steam Supply	Steam Dryer	VI	75
	Steam Generator	VI	75
Reactor Fuel[3] and Monitoring	Spent Fuel Pool Upgrades (i.e., rack addition or cooling modification)	IV	20
	Nuclear Instrumentation	II	4
Emergency Core Cooling	Residual Heat Removal Heat Exchanger	II	4
	Emergency Service Water Heat Exchanger	II	4
Condensate and Feedwater	Main Condenser	VI	75
	Main Condenser Tube Bundle	III	8
	Condensate Filter Demineralizer or Polisher	II	4
	Feedwater Heater[2]	II	4
	Feedwater Pump	II	4
	Reactor Feed Pump	II	4
	Feedwater Pump Turbine	II	4
	Reactor Feed Pump Turbine	II	4
	Condensate Pump	I	1
	Condensate Booster Pump	I	1
	Auxiliary Feedwater Pump	I	1
	Heater Drain Pump	I	1
	Feedwater Heater Tube Bundle[2]	I	1
	Feedwater Heater Drains and Dump Valve	I	1
Main Steam	Moisture Separator Reheater	IV	20
	Moisture Separator Reheater Tube Bundle	III	8
	Main Steam Isolation Valve	II	4
	Main Steam Stop Valve	II	4
	LEFM Instrumentation	I	1
Turbine Cycle	LP Turbine	VI	75
	HP Turbine	V	40
	LP Turbine Bladed Rotor	IV	20
	HP Turbine Bladed Rotor	IV	20
	LP Turbine Stationary Blade Row Upgrade	II	4
	HP Turbine Stationary Blade Row Upgrade	II	4

APC	MPC	Cost Category	Weighting Factor
Electrical Generation and Distribution	Main Generator Replacement	VI	75
	Main Generator Stator Rewind	V	40
	Isophase Bus Duct	IV	20
	Main Transformer	IV	20
	Main Generator Rotor Rewind	III	8
	Isophase Bus Duct Cooling Upgrade	III	8
	Main Generator Circuit Breaker	II	4
	Auxiliary Transformer	II	4
	Generator Auxiliary System (hydrogen coolers, stator coolers, exciter, protective relays, automated voltage regulator)[1]	I	1
	Current Transformer	I	1
Cooling and HVAC	Circulating Water Pump	III	8
	Service Water Heat Exchanger	II	4
	Cooling Cell Addition to a Modular Mechanical Draft Cooling Tower	II	4
	Fan and Motor Upgrades for Mechanical Draft Cooling Tower	I	1
	Fill Media Replacement for Mechanical or Natural Draft Cooling Tower	I	1
	HVAC Replacement or Addition (i.e., chiller, area/equipment cooler, fan)	I	1
Other	Piping Segments and Piping Supports	See Note 4	
	Valves and Valve Actuators		
	Cabling		
	Expansion Joints and Bellows		
	Small Pump Motors and Turbines		
	Small Heat Exchangers		
	Distribution System Components		
Structural Steel or Iron[5]	—	—	Steel/Iron Product

Notes:

1. Count each auxiliary system as a separate MPC.
2. The feedwater heater MPC refers to a single heater unit, not the entire heater stage. Count each heater within the stage as a separate component quantity.
3. Reactor fuel is not included as an MPC in this initial iteration of the safe harbor approach. The industry has ongoing efforts to determine if reactor fuel should be counted as either an incremental cost or fixed cost when determining tax credits for nuclear power uprates. Reactor fuel may be added to the safe harbor approach in the future.
4. Components outlined in the "Other" category are smaller items, or items that could vary widely in costs depending on scope (e.g., piping costs are dependent on length). The report proposes to bundle these items to get credit for domestic procurement with a conversion factor of $1M = 1 point. The taxpayer must have direct cost justification information for utilizing this "Other" MPC. As an example, if a taxpayer purchased several dozen valves for an upgrade of the moisture

APC	MPC	Cost Category	Weighting Factor

separator reheater drain system with a total cost of $2M, they may take credit for a Quantity of one “Other” MPC line item with a value of 2. Alternatively, a taxpayer may elect to include smaller components as an individual line item, e.g., reheater drain valve with a quantity of components with individual cost of each valve multiplied by a number of valves (this approach is seen as more complicated).

5. As discussed in Section 2.2.2, all structural steel/iron components must be procured domestically. Structural steel and iron component costs are not included in the manufactured product safe harbor calculation. An example of a steel/iron component that could be impacted by power uprate is a cooling tower structural modification.

4.3 Nuclear Safe Harbor Applicability

Nuclear utilities pursuing a power uprate may choose to use either the nuclear power uprate safe harbor model or the Adjusted Percentage Rule (as described in Section 2.2.3). The purpose of the power uprate safe harbor is to provide a simplified, graded model to demonstrate domestic content requirement compliance. The developed safe harbor model is intended to be used for any nuclear power uprate type (i.e., EPU, MUR, SPU, or efficiency uprate) and plant type (i.e., PWR or BWR). The safe harbor is particularly useful when higher cost category components are procured domestically. Since these higher cost components will make up a larger percentage of the overall direct component costs, the utility will need to identify fewer individual component costs (i.e., the safe harbor reduces the burden for the taxpayer as intended).

For many proposed uprates, the Adjusted Percentage Rule is expected to require a significant effort and reliance on vendor support to provide full cost breakdowns of each component. Nevertheless, the Adjusted Percentage Rule may be preferred in certain cases in lieu of using the typical safe harbor model. Examples of this may include but are not limited to:

- When a utility is close to achieving the required adjusted percentage (i.e., 40%–55%) for a given project using the safe harbor model and would benefit from a more detailed breakdown of component costs
- Where a utility is procuring unique plant-specific components that are not included on the typical nuclear power uprate safe harbor table
- Smaller power uprates that do not require significant component procurement

In any of these scenarios, the taxpayer may elect to first use the proposed typical safe harbor model as an initial screening tool.

4.4 Nuclear Power Uprate Safe Harbor Examples

The following sections provide example applications of the proposed nuclear plant power uprate safe harbor model for various reactor types and uprate types. For all examples below, it is assumed that construction of the power uprate project begins after 2026. Therefore, the required domestic content Adjusted Percentage for Manufactured Products is 55% as discussed in Section 2.2.3. It is also assumed that all steel and iron components subject to the Steel or Iron Rule are manufactured in the U.S., such that the utility is eligible for the domestic content bonus if they meet the required Adjusted Percentage (i.e., 55%) for Manufactured Products.

4.4.1 Example 1 Pressurized-Water Reactor Extended Power Uprate

A hypothetical utility is performing an EPU for a single PWR unit. The utility has performed a power uprate feasibility assessment and determined the type and quantity of components that will be impacted by the EPU. The impacted components are listed in Table 7, along with the associated Weighting Factor, MPC Score, and normalized MPC Value. Unless otherwise noted in the MPC column, the scope includes full component replacement.

Table 7. PWR EPU example safe harbor model.

APC	MPC	Quantity	Weighting Factor	MPC Score	MPC Value
Condensate and Feedwater	Feedwater Heater	4	4	16	9.64%
	Feedwater Heater Tube Bundle	6	1	6	3.61%
	3 Condensate Pumps 3 Condensate Booster Pumps 2 Heater Drain Pumps	8	1	8	4.82%
	3 Feedwater Pumps	3	4	12	7.23%
	Condensate Filter Demineralizer and Polisher	2	4	8	4.82%
Turbine Cycle	High Pressure Turbine	1	40	40	24.10%
Electrical Generation and Distribution	Isophase Bus Duct	1	20	20	12.05%
	Generator Auxiliaries	4	1	4	2.41%
	Current Transformer	1	1	1	0.60%
	Main Generator Stator Rewind	1	40	40	24.10%
Cooling and HVAC	Cooling Cell Addition to Mechanical Cooling Tower	1	4	4	2.41%
	HVAC Units	6	1	6	3.61%
Other	Other - 15 Misc. Valves and Actuators	1	1	1	0.60%
Total				166	100.00%

For this example, the HP Turbine Replacement and Main Generator Stator Rewind combine to have a total Component Value of over 48%. Thus, at least one of these components must be procured domestically to comply with the domestic content requirements (i.e., 55% threshold). This puts emphasis on procuring these components domestically.

There are various procurement paths that this example utility may take to comply with the domestic content requirements. Figure 4 shows three example options of domestically procured MPCs for the hypothetical PWR EPU (not inclusive of all potential options). The values in Figure 4 are rounded to the nearest percentage point for brevity. Options 1 and 2 show that the MPC Value of domestically procured MPCs is greater than 55% and therefore meet domestic content requirements. Option 3 shows that the MPC Value of domestically procured MPCs falls below 55% and therefore does not meet domestic content requirements.

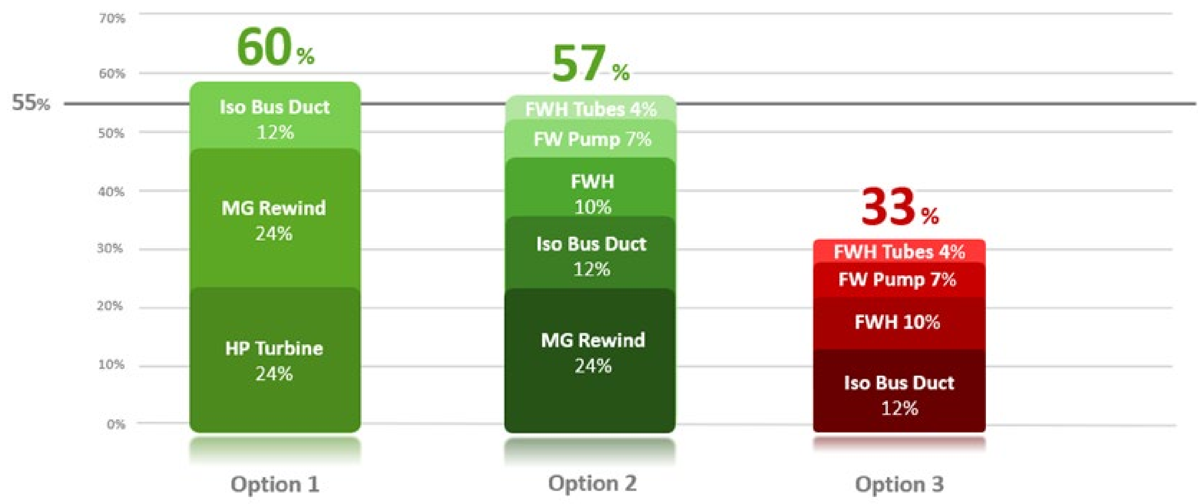

Figure 4. PWR EPU example domestic procurement options.

4.4.2 Example 2 Boiling-Water Reactor Extended Power Uprate

A hypothetical utility is performing an EPU for a single BWR unit. The utility has performed a power uprate feasibility assessment and determined the type and quantity of components that will be impacted by EPU. These impacted components are listed in Table 8, along with the associated Weighting Factor, MPC Score, and normalized MPC Value. Unless otherwise noted in the MPC column, the scope includes full component replacement.

Table 8. BWR EPU example safe harbor model.

APC	MPC	Quantity	Weighting Factor	MPC Score	MPC Value
Nuclear Steam Supply	Steam Dryer	1	75	75	29.07%
Fuel and Monitoring	Nuclear Instrumentation	1	4	4	1.55%
Condensate and Feedwater	3 Condensate Pumps 3 Condensate Booster	6	1	6	2.33%
	2 Reactor Feed Pumps	2	4	8	3.10%
	Condensate Filter Demineralizers	2	4	8	3.10%
	Feedwater Heater Drains and Dump Valve	10	1	10	3.88%
Main Steam	Moisture Separate Reheater Tube Bundle	1	8	8	3.10%
Turbine Cycle	LP Turbine Stationary Blade Row	3	4	12	4.65%
	High Pressure Turbine	1	40	40	15.50%
Electrical Generation and Distribution	Main Generator	1	75	75	29.07%
	Generator Auxiliaries	3	1	3	1.16%
	Isophase Bus Duct Cooling Upgrade	1	8	8	3.10%
Other	Other – 15 Misc. Valves and Actuators	1	1	1	0.39%
Total				258	100.00%

Procurement options for demonstrating compliance with the domestic content requirements are more limited for Example 2 than Example 1. This is due to the main generator being replaced instead of rewound, so it is assigned a more significant Weighting Factor. This puts higher emphasis on procuring this MPC domestically.

As in Example 1, there are several ways that the utility in Example 2 may demonstrate compliance with the domestic content requirements using the safe harbor model. These options rely on ensuring either the steam dryer or main generator is manufactured domestically.

4.4.3 Example 3 Measurement Uncertainty Recapture

A hypothetical utility is performing a MUR for a single unit. The utility has determined that it has sufficient system margin to handle a 1.5% increase in power without any plant modifications. The utility is planning to install two feedwater flow measurement devices (LEFMs) on each of the unit's three feedwater lines. These components are listed in Table 9, along with the associated Weighting Factor, MPC Score, and normalized MPC Value.

Since the only MPCs being procured for this power uprate are the LEFMs, these devices must be procured domestically for the MUR to qualify for the domestic content tax credit bonus.

Table 9. MUR example safe harbor model.

APC	MPC	Quantity	Weighting Factor	MPC Score	MPC Value
Main Steam	LEFMs	6	1	6	100.00%
Total				6	100.00%

4.4.4 Example 4 Measurement Uncertainty Recapture with Limited Margin

A hypothetical utility is performing a MUR for a single unit. The utility has determined that, in addition to installing two feedwater flow measurement devices on each feedwater line, the site will need to replace two HP turbine blade rows based on limited plant margin. The impacted MPCs are listed in Table 10 below, along with the associated Weighting Factor, MPC Score, and normalized MPC Value.

As shown in Table 10, since the HP Turbine Blade Row Replacement MPC Value is twice that of the LEFMs, the turbine blade rows must be procured domestically for the MUR to qualify for the domestic content tax credit bonus.

Table 10. MUR with limited margin example safe harbor model.

APC	MPC	Quantity	Weighting Factor	MPC Score	MPC Value
Main Steam	LEFMs	4	1	4	33.33%
Turbine Cycle	HP Turbine Blade Row	2	4	8	66.67%
Total				12	100.00%

5. DOMESTIC MANUFACTURING CAPABILITIES

5.1 Supplier Outreach Approach

Utilizing the results of the utility survey, a list of suppliers expected to provide components for power uprates was generated (see Section 3.4.2). These suppliers were interviewed to understand domestic manufacturing capabilities for components expected to be procured for future power uprates. In total, 14 interviews were conducted, covering discussions on:

- Steam Generator
- Steam Separator & Dryer
- Pumps
- Valves and actuators
- Isophase bus ducts
- Switchgear
- Condensate filter demineralizers
- FWHs
- HP and LP turbines
- Main generator and generator auxiliaries
- Instrumentation

- MSRs

The following key topics were covered during supplier interviews and are summarized in subsequent sections:

- Feasibility of manufacturing components domestically, including:
    - General location (i.e., domestic vs international) for manufacturing elements (material procurement, processing, assembly, and testing)
    - Current and planned capacity to manufacture components domestically
    - Perceived ability to move manufacturing activities to the U.S. if needed
- Potential challenges related to suppliers' capability to fulfill increased demand as a result of nuclear plant power uprate projects, life-cycle management projects, and future deployment of new nuclear reactors.

5.2 Domestic Manufacturing Feasibility

5.2.1 Current Domestic Capabilities and Gaps

Based on supplier discussions, it is apparent that significant portions of the manufacturing process for many components take place domestically. Specifically, the following key positive takeaways regarding current domestic manufacturing capabilities were observed:

- Many component suppliers had positive responses regarding "fully" manufacturing components domestically with regards to the four manufacturing elements discussed in Section 2.2.
    - This primarily included "lower-cost" components, such as condensate filter demineralizers, certain pump types, generic valves and actuators, and select electrical components including switchgear
    - In addition, there are also some "higher cost" components, such as isophase bus duct systems, that seem to be able to be fully manufactured domestically
- Other suppliers noted that the processing, assembling, and testing of components can be performed domestically, but there can be uncertainty regarding raw material origins.
- Suppliers noted that primary system (i.e., nuclear steam supply system) and safety-related components may be more easily domestically manufactured due to export controls concerns.

Conversely, suppliers also noted a number of potential gaps that would impact the ability to domestically manufacture certain components expected to be procured for power uprate. Key observations regarding potential domestic manufacturing gaps are:

- Domestic manufacturing of forged components, such as steam generators, turbine rotors, large pumps, and rotors for main generators, is limited since most nuclear suppliers have moved large-scale foundries overseas over the last several decades. Many large-scale foundries for non-nuclear manufacturing (e.g., for shipbuilding) have also been moved internationally and compete with some of the supply chains for similar materials and forgings.
- Some components, such as LP turbines, can be considered more specialized products that may be sourced internationally. While these components may not be required for thermal power uprates, they may be procured for thermal efficiency upgrade projects.
- There is also a bottleneck on larger and more costly components that take significant time and effort to design and manufacture (particularly main generators, turbines, FWHs, MSRs, and large pumps). Suppliers of these components are already near maximum capacity and have a backlog of requests for a variety of reasons, including power uprates, supply for new and existing natural gas plants, new nuclear plants, and demands from other industries. For example, one supplier indicated there is up to

a 5-year lead time on turbines due to a significant demand. Increased demand due to additional power uprate requests could further extend this lead time.

- Suppliers of lower-cost, high-quantity components may have multiple manufacturing locations both domestically and internationally. Since component manufacturing in the U.S. is often less cost effective, suppliers will default to the less expensive international option. Utilities should specify that they need U.S.-based manufactured equipment in the associated procurement specification. Suppliers indicated that a domestic manufacturing request may require additional costs and a longer lead time due to more limited fulfillment options in the U.S. It is expected this would be addressed on a case-by-case basis considering customer requirements and supplier sourcing strategy.
- While many suppliers indicated testing of manufactured products occurs primarily domestically, one supplier mentioned an exception for select equipment, including very large pumps. That is, there are some cases in which specialty testing capabilities does not exist in the U.S. Utilities will need to confirm the location of all manufacturing activities for each component procured, even when multiple items are procured from the same supplier.

5.2.2 Ability to Increase Domestic Manufacturing Capabilities

Suppliers were supportive of nuclear plant power uprates and expressed their desire to increase their component supply to the nuclear industry. Several suppliers of domestically manufactured components have already started to prepare for increased demand due to power uprates. These suppliers indicated that they have been monitoring nuclear utility initiatives over the last several years to ensure that their organization is appropriately sized to support nuclear needs. For example, one supplier has already taken an advanced action to develop a team dedicated to supporting power uprate manufacturing needs.

Multiple domestic suppliers, particularly with lower-cost components, noted that they could ramp up their supply quickly since they have the equipment necessary but would need to add additional personnel shifts in addition to capital investment to increase output.

Nevertheless, it will be more challenging for suppliers to increase domestic capacity for select components that are currently primarily manufactured overseas. Suppliers indicated it is unlikely that large-scale foundries that have been relocated overseas will be moved back to the U.S. since these foundries were moved for economic reasons, and it would take significant long-term financial incentive to re-establish qualified domestic sub-supplier capability. Note nuclear suppliers considered returning large forgeries to the U.S. during the first nuclear renaissance in the early 2000s, but ultimately, that shift did not occur. Past sunk cost investments during this timeframe may further impact forge masters considering increasing capacities in the near-term.

5.3 Additional Supplier Insights

During the interviews, suppliers also identified challenges related to fulfilling the increased demand for domestically-produced components for nuclear power uprates. These challenges are listed below for considering the feasibility of meeting the domestic content requirement:

- **Nuclear Power Uprate Forecast:** Suppliers reported that it has been challenging to obtain a realistic and comprehensive forecast from utilities regarding if or when they will need major components for various initiatives, including power uprate, life extension, and planned component replacements. Given the lack of advanced notice, component requests often result in urgent and emergent work for suppliers, which may contribute to higher costs and supply chain bottlenecks. Several suppliers indicated that it would be helpful for utilities to share upcoming initiative schedules with nuclear vendors as soon as feasible so that suppliers can integrate demand across the industry and strategically plan for upcoming demand changes. This advanced notice is particularly important for components that have a long lead time. Conversely, it is helpful for suppliers to advise utilities of market trends and demand signals for their project uprate timelines. Several suppliers described their current strategies for obtaining realistic demand forecasts:

- A supplier has successfully created a demand forecast through their regional utility partner network, participation in industry groups (e.g., Nuclear Energy Institute task force), and industry events (e.g. conferences for key components). As a part of this strategy, supplier representatives frequently meet with utility partners and are embedded in operational planning. This approach has been effective for planning but may be challenging for smaller or specialty suppliers.
- Another supplier noted that they have visibility for upcoming power uprates since they have been included as a part of the utility's uprate design phase. This has given the supplier a 4–5 year notice ahead of when the physical equipment will actually be needed. This has been an effective approach in certain scenarios, but most suppliers are not involved in the design phase of power uprate planning.
- Suppliers noted that engineering studies conducted early in the power uprate process typically provide some advanced notice to suppliers of potential demand. It is critical that utilities and suppliers understand lead time for completing these studies, sourcing the equipment, and understanding downstream interdependencies to reduce overall implementation timeline.

- **Demand Beyond Power Uprates:** Suppliers are concerned that the peak in domestic manufacturing demand to support power uprates may only last for a relatively short period of time (i.e., "bubble", rather than long-term pipeline). Ramping up manufacturing capacity involves significant capital and operational investments, such as procurement of new equipment, facility expansion, and hiring new workers. It is a challenging financial decision to invest significant resources without reasonable assurance that increased capacity will be needed in the longer term (i.e., to support future reactor builds).
    - Suppliers indicated that the decision to ramp up capacity domestically could be facilitated by certain guaranties from the industry and/or the U.S. government. For example, guaranteed component orders for a long term (e.g., over a decade) would provide certainty and facilitate capacity expansion.
- **Financial Resources:** As described above, increasing domestic manufacturing capacity involves supplier investment. Suppliers indicated that moving manufacturing capabilities back to the U.S. after it has recently been outsourced (as discussed in Section 5.2.2) would be extremely challenging and would likely require significant financial incentives. Suppliers highlighted strategies to optimize the tax credit benefit to utilities:
    - Expand the time horizon of the PTC and ITC eligibility to encourage utilities to perform power uprates in the medium to long term. This would help to mitigate the component bottleneck risk since the timeframe for performing power uprate with tax credits is extended.
- **Labor Resources:** Suppliers expressed concern about domestic labor shortages for both skilled craft (e.g., machinists and welders) and specialty technical positions (e.g., design engineers). This is a longer-term challenge that impacts the domestic nuclear industry more broadly since it takes significant time to train personnel and even longer to build an educational pipeline to address future staffing shortages. Suppliers described several strategies to bolster the nuclear workforce:
    - Increased U.S. government support for nuclear manufacturing apprenticeships to improve training feasibility, such as government-supported wage subsidies or training cost reimbursement for apprentice employers.
    - Increased labor wages for trade work to incentivize growth in the nuclear manufacturing field.

5.4 Domestic Content Tax Credit Feasibility Summary

The major gaps in domestic manufacturing for future power uprates are primarily associated with raw material procurement and forgings for higher cost components (e.g., forgings for turbines, generators, large pumps). As described in Section 2.2, procurement of raw materials and manufacturing of subcomponents may not be considered in qualifying a product or component in the context of the Adjusted Percentage Rule. Nevertheless, it is noted as a gap in the domestic manufacturing process for general awareness.

Modification or replacement of higher cost components are inherently weighted more heavily when trying to meet the domestic content requirement. Therefore, if these higher cost components are needed as a part of an uprate, utilities will have limited ability to demonstrate compliance with domestic content requirements. As shown in Example 2 in Section 4.4.2, if the main generator is not able to be procured domestically, nearly all remaining components must be procured in the U.S. This provides little flexibility for utilities and will make it very challenging to meet domestic content requirements.

Further, portions of the manufacturing process for certain components are also currently only available internationally. Domestic content bonus tax credit feasibility could be improved if utilities were able to claim exemptions for components that are not currently produced in the U.S. from the nuclear power uprate safe harbor methodology (similar to the exemptions provided for those utilizing the direct, or elective, pay option discussed in Section 2.2.5). This would prevent such taxpayers from being penalized for not being able to procure select components domestically. If and when qualified domestic manufacturing capabilities for subject components becomes available, these components could be added back to the nuclear power uprate safe harbor table. Ultimately, increasing domestic content tax credit feasibility would encourage utilities to buy more U.S. manufactured equipment.

Domestic content tax credit feasibility is also challenged by supply chain capabilities (i.e., components that currently can be manufactured in the U.S. but are expected to have a high demand in coming years, thus requiring more international content in order to meet the demand). This is expected to include components such as turbines, main generators, large pumps, FWHs, and MSRs. However, not all of the highest cost pinch point components will require replacement or modification for the first set of power uprates. For example, as discussed in Section 3.4, none of the utilities who responded to the survey are currently planning to replace their steam generators. However, it is anticipated that many plants have the potential of larger power uprates if steam generators are replaced. Thus, the U.S. supply chain capabilities could be improved with strategic ramp up of manufacturing capacity for components that are expected to be in high demand as listed above.

These conclusions primarily apply to EPUs and SPUs since they both are expected to require similar levels of component procurement (see Section 3.4.2.2). MURs typically will only require new flow measurement instrumentation and a limited number of component replacements. If an MUR only requires an installation of new flow measurement instrumentation, it will be relatively easy to demonstrate domestic content compliance. If other component procurements are necessary, these will likely need to be U.S. sourced in order to meet domestic content requirements (as shown in Example 4 in Section 4.4.4).

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Appendix A
Utility Survey Template

Appendix A Utility Survey Template

Nuclear Plant Power Uprate Domestic Content Survey

Nuclear Plant(s) (Optional):	[TBD]

Instructions:
For each row, identify if the plant/fleet is expected to replace or modify the SSC by each uprate type (i.e., MUR, SPU, or EPU). See example row below and attached instructions for additional details about the survey's purpose, background and instructions.

No.	SSC Impacted by Uprate	Impacted by MUR?	Impacted by SPU?	Impacted by EPU?	Quantity of SSC Impacted	Potential SSC Suppliers	Notes
Example	Condensate Filter Demineralizers	N	Y	Y	4	List potential demin vendor(s) for the fleet	Two units will need to replace two CFDs. One unit will replace for SPU while the other unit will replace for EPU.
1	Condensate Filter Demineralizers						
2	Cooling Water Systems (circulating, service water)						
3	Cooling Towers						
4	Condensate Pumps						
5	Feedwater Pumps						
6	Auxiliary Feedwater Pumps						
7	Heater Drain Pumps						
8	Feedwater Heaters						

9	Main Condenser						
10	Main Steam System						
11	Main Steam Isolation Valves						
12	High- Pressure Turbine						
13	Low-Pressure Turbine						
14	Turbine Valve						
15	Moisture Separator Reheater						
16	Fuel						
17	Nuclear Instrumentation						
18	Heating Ventilation and Air Conditioning (HVAC) Systems (Please List in Notes Specific Components)						
19	Steam Dryer and Separators (for BWRs)						
20	Steam Generator (for PWRs)						
21	Spent Fuel Pool						
22	Main Generator						

23	Main Generator Auxiliaries (Please List in Notes Specific Components)						
24	Isophase Bus Duct						
25	Large Transformers						
26	AC Distribution System Equipment						
27	Others (SSCs that were not listed above)						

Nuclear Plant Power Uprate – Domestic Content Utility Survey

1. Purpose of the Survey

The purpose of this survey is to garner insights into which Structures, Systems, and Components (SSCs) at nuclear power plants (NPPs) are expected to be impacted by power uprates and the potential suppliers for those SSCs.

Data collected through this survey will inform the development of generic guidance for meeting the requirements of the Inflation Reduction Act (IRA) domestic content adder for nuclear plant power uprates. This guidance is ultimately intended to make it easier for nuclear utilities to meet and demonstrate the eligibility for this requirement.

2. Domestic Content Adder Background

The IRA provides two credits that nuclear power plants may leverage for a power uprate of existing nuclear facilities: Section 48E, which details a Clean Electricity Investment Tax Credit (ITC), and Section 45Y, which details a Clean Electricity Production Tax Credit (PTC). Utilities must select one of these credits for their power uprate. Both credits include a potential 10% adder to the value of the credit if "Domestic Content" requirements are met.

Per the IRA, the domestic content requirement is satisfied if it can be shown "…that any steel, iron, or manufactured product which is a component of such facility… was produced in the United States…". For cases involving additional capacity to existing facilities (i.e., power uprates), this is expected to apply to the "new" materials required for the additional capacity only (i.e., not the existing plant materials). Manufactured products that are components of a qualified facility upon completion of construction are deemed to have been produced in the U.S. if not less than the adjusted percentage of the total costs of all such manufactured products of such facility are attributable to manufactured products (including components) that are mined, produced, or manufactured in the U.S. The adjusted percentage is 40% if construction begins before 2025, 45% if construction begins in 2025, 50% if construction begins in 2026, and 55% if construction begins after 2026.

Current guidance for meeting the requirements of the domestic content adder is tailored towards non-nuclear technologies (e.g., solar and wind). DOE's Light Water Reactor Sustainability (LWRS) Program is currently performing research to (1) assess the feasibility for nuclear plant power uprates to meet this requirement and (2) develop a "safe harbor", i.e., a simplified approach in lieu of adjusted percentage rule, for nuclear power plants to meet the domestic content requirement.

3. Survey Instructions

The survey template lists nuclear plant SSCs that may be impacted by a power uprate based on industry OE. “Impacted” refers to an SSC that requires modification or replacement to allow the plant to operate at a higher power level. This survey considers the three power uprate types: Measurement Uncertainty Recapture (MUR), Stretch Power Uprate (SPU), and Extended Power Uprate (EPU).

NPP Survey Template Completion Instructions:

Answer “Y” or “N” for the three columns asking if a specific SSC will be impacted by each power uprate type. Your answers may be informed by which SSCs were impacted during prior fleet uprates and/or what SSCs are expected to be impacted in future power uprates based on preliminary site studies.

Identify the total required number of SSCs to support future power uprates for your fleet. For example, if you know that each of your two PWRs will need 4 Heat Exchanger replacements for an upcoming EPU, enter “8” into the “Quantity” column.

List any SSCs that are missing from the template using the line item “Others”.

Enter a list of suppliers that will potentially provide these SSCs. If you have not identified potential suppliers yet, enter “N/A” for “Potential Suppliers”.

If you have any comments for your survey responses, add them to the optional “Notes” field.

Points of contact for any questions:

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Appendix B
Evaluation of Proposed Safe Harbor Concept Using Example Uprates

Purpose

This appendix documents an evaluation to determine if the proposed safe harbor approach concept produces reasonable results (i.e., combinations of MPCs) and meets the intent of the domestic content requirement (i.e., encourage procurement of U.S. based manufacturing products).

It is noted that in developing the safe harbor concept, hypothetical MPC costs were used. There are no recent reports with cost ranges available for the identified MPCs. As a result, this appendix assesses the concept of the safe harbor approach and does not attempt to validate the proposed cost assignments and range of weighting factors used.

Approach

In the absence of current, referenceable component cost data, this report assigns a Weighting Factor to each identified MPC using hypothetical cost estimates. While the cost estimates used to assign the Weighting Factors are informed by engineering judgement and to some extent informed by industry input (e.g., supplier and utility feedback), they should not be considered definitive. That is, the goal of this report is to deliver a proposed safe harbor concept for demonstration of eligibility for meeting domestic content requirements, not providing accurate cost estimates.

The safe harbor concept proposed herein assigns each MPC one of six Weighting Factors ranging from 1 to 75 as shown in Table B-1 below. Each cost category is assigned a typical range with the weighting factor being the median value of that range.

Table B-1. Cost range of hypothetical cost categories.

Category	Cost Range ($M)	Weighting Factor
I	0-2	1
II	2-6	4
III	6-10	8
IV	10-30	20
V	30-50	40
VI	50+	75

This appendix documents evaluations to assess the proposed safe harbor concept with the goal of answering the following questions:

- Does the proposed concept create reasonable methods (or combinations of MPCs) that satisfy the safe harbor while encouraging procurement of U.S. based manufacturing products?
- Is using the median value within a proposed cost range as the weighting factor reasonable?
- What would be the impact of adjusting cost categories for certain components?

Key Takeaways

Example Uprates Analysis

Example uprates 1 and 2 in Section 4.4 document hypothetical PWR and BWR EPUs, respectively, that were informed by industry surveys. The number of combinations of MPCs that could get the utility to 55% domestic procurement and the distribution of costs across MPCs was investigated. The Example 1 and 2 results are summarized in the tables below, re-sorted from greatest to lowest MPC value. The distribution across Weighting Factors is shown in Figure B-1.

Table B-2. Example 1 results sorted by MPC value.

MPC	Quantity	Category	Weight	Total	MPC Value
High-Pressure Turbine	1	V	40	40	24.1%
Main Generator Stator Rewind	1	V	40	40	24.1%
Isophase Bus Duct	1	IV	20	20	12.0%
Feedwater Heater	4	II	4	16	9.6%
Feedwater Pumps	3	II	4	12	7.2%
Condensate, Condensate Booster, and Heater Drain Pumps	8	I	1	8	4.8%
Condensate Filter Demineralizer	2	II	4	8	4.8%
Feedwater Heater Tube Bundle	6	I	1	6	3.6%
HVAC Units	6	I	1	6	3.6%
Main Generator Auxiliaries	4	I	1	4	2.4%
Cooling Cell Addition to Mechanical Cooling Tower	1	II	4	4	2.4%
Current Transformer	1	I	1	1	0.6%
Other - Valves and Actuators	1	I	1	1	0.6%

Table B-3. Example 2 results sorted by MPC value.

MPC	Quantity	Category	Weight	Total	MPC Value
Steam Dryer	1	VI	75	75	29.07%
Main Generator	1	VI	75	75	29.07%
High-Pressure Turbine	1	V	40	40	15.50%
Low-Pressure Turbine Blade Row	3	II	4	12	4.65%
Feedwater Heater Resize Drains and Dump Valves	10	I	1	10	3.88%
Reactor Feed Pump	2	II	4	8	3.10%
Condensate Filter Demineralizer	2	II	4	8	3.10%
Isophase Bus Duct Cooling Upgrade	1	III	8	8	3.10%
Moisture Separator Reheater Tube Bundle	1	III	8	8	3.10%
Condensate Pumps and Condensate Booster Pumps	6	I	1	6	2.33%
Nuclear Instrumentation	1	II	4	4	1.55%
Main Generator Auxiliaries	3	I	1	3	1.16%
Other - Valves and Actuators	1	I	1	1	0.39%

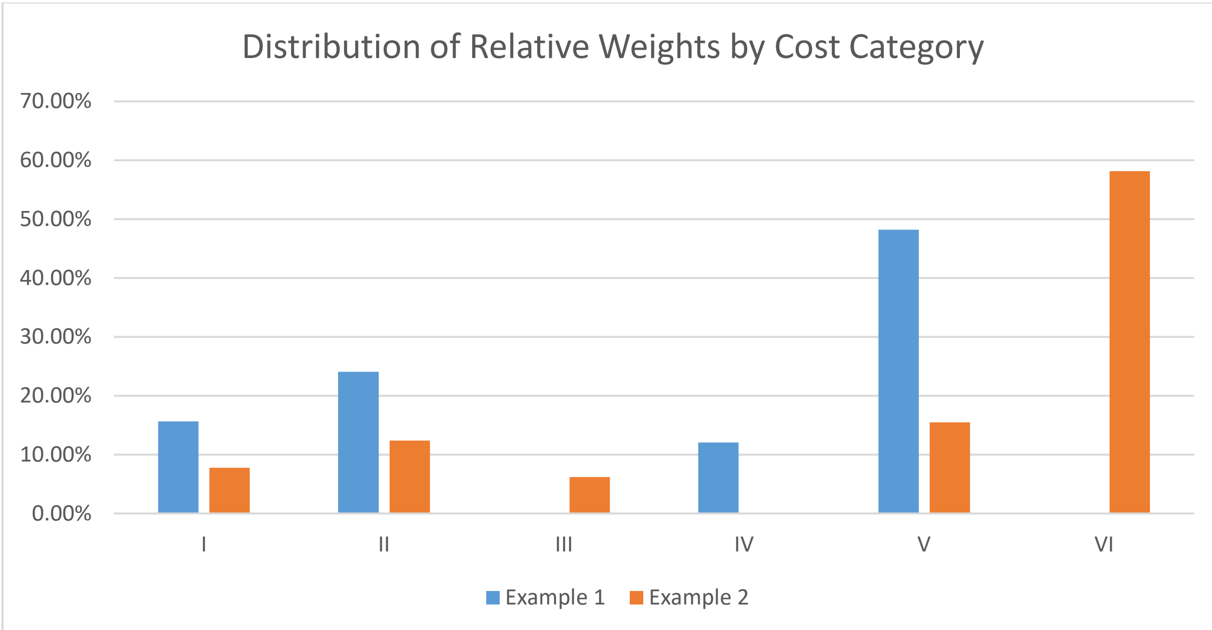

Figure B-1. Distribution of relative weights for Examples 1 and 2

A Microsoft Excel macro was then developed to automatically calculate all unique combinations of MPCs in which the MPC Values add up to at least 55%. The macro calculates the minimum number of combinations such that no additional MPCs are added once a combination reaches 55%. The macro indicates there are 153 unique combinations for satisfying the requirement for Example 1 and 183 unique combinations for satisfying the requirement for Example 2.

Key takeaways are as follows:

- The proposed concept highlights the importance of procuring higher cost components domestically. While there are many unique combinations to reaching the 55% threshold, all combinations for the examples listed require procuring at least one category V or VI component.
- The number of unique combinations will encourage taxpayers to investigate many different avenues of procuring "lower-cost" components domestically. If one component cannot be manufactured domestically, there are various alternates that could be used to help reach the 55% threshold; thus, encouraging the taxpayer to procure components domestically rather than abandon trying to meet the domestic content threshold.

Utilizing the Median Value

To assess the impact of assigning a different weighting value within a proposed cost range, the weight of each category was adjusted to the minimum, median, and maximum value of the cost range, as shown in Table B-4 below.

Table B-4. Safe harbor cost category ranges.

Category	Cost Range ($M)	Minimum Weight	Median Weight	Maximum Weight
I	0-2	0	1	2
II	2-6	2	4	6
III	6-10	6	8	10
IV	10-30	10	20	30
V	30-50	30	40	50
VI	50+	50	75	100

The impact of changing cost category weight on the MPC Value (i.e., the normalized percentage of MPCs) is shown in Figure B-2 below. Example 1 was used, and the components were grouped into their respective categories.

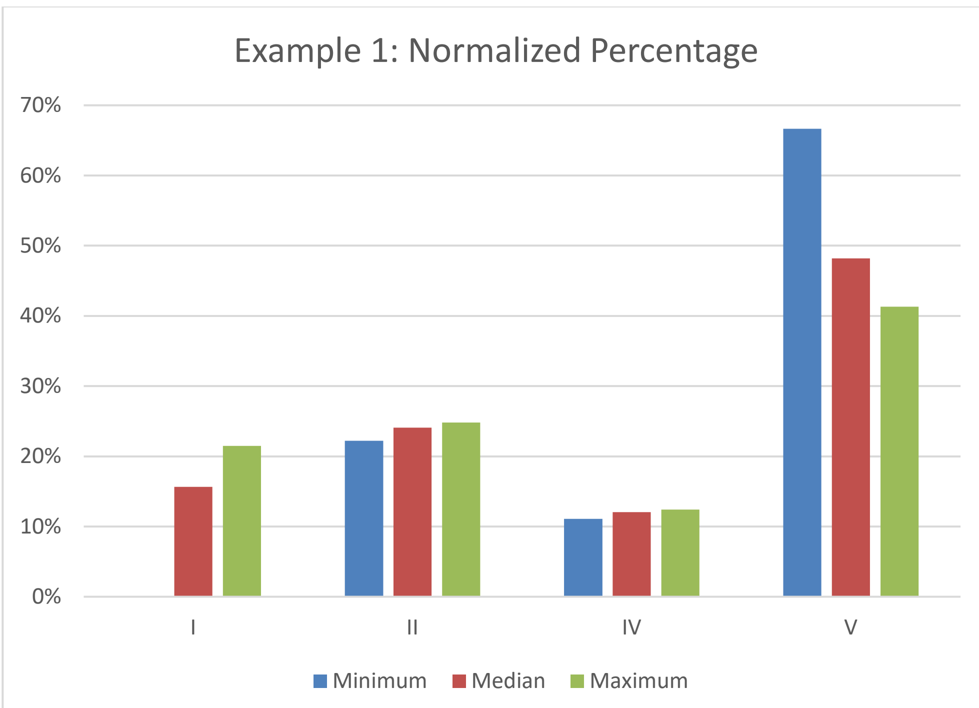

Figure B-2. Impact of cost category weight on normalized percentage, by category.

Additionally, the macro was run for each plant using the minimum, median, and maximum cost category weight, and the number of combinations in each case was recorded. The number of component combinations adding to at least 55% of the overall uprate cost are shown in Table B-5.

Table B-5. Safe harbor combinations.

	Combinations Over 55%		
	Minimum	*Median*	*Maximum*
Example 1	11	153	228
Example 2	27	183	193

Key takeaways from this exercise are as follows:

- It is important to assign a baseline of at least 1 for the lower-cost components. Setting a category to 0 essentially eliminates the lowest cost components, placing heavier emphasis on higher-category components and significantly reducing the number of potential combinations.
- Alternating between the median and maximum cost values for the examples did not significantly impact the distribution of weights between cost categories. It is judged that using the median is a reasonable approach.
- Other example plant test cases were run based on industry surveys. One critical takeaway for taxpayers is that uprates with fewer components are even more dependent on higher-cost components (and in some instances, it is essential to procure the highest-cost components domestically).

Investigating Cost Assignments of Components

To investigate the impact of potentially assigning too low of a Weighting Factor for MPCs, an evaluation was conducted that increases one cost category to its maximum range value (e.g., setting cost category I components to "II" instead of "I") while keeping the rest of the weights the same. This analyzes the impact of potentially underestimating the costs of select components.

The results of this exercise for Example 1 are shown below compared to the Baseline case discussed above.

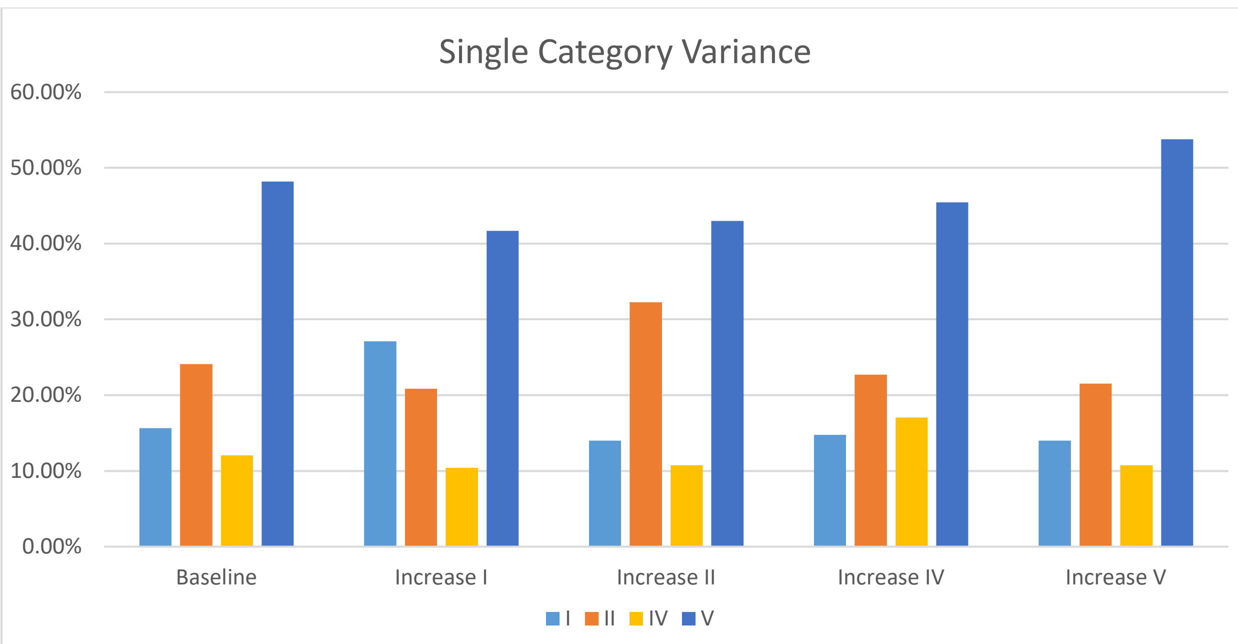

Figure B-3. Cost distribution varying one category at a time.

Cases were also run adjusting specific components up or down a cost category (e.g., setting feedwater tube bundle replacement to II instead of I). The takeaways from this exercise are as follows:

- Adjusting the ranges of the cost categories proposed herein may influence the number of combinations to reach the required adjusted percentage, but the overall distribution of cost percentages across categories results in similar key takeaways as above. That is, it is critical to purchase higher-cost components domestically, if possible, supplemented by lower-cost components as necessary to reach the adjusted threshold.

- “Misassignment” of certain components would influence the overall number of combinations as well, but the key takeaways discussed above would still hold true. To increase confidence in the assigned cost categories, it is recommended additional research be performed to obtain current, reasonable rough order of magnitude cost estimates for the proposed MPCs.