BLUEGREEN ALLIANCE

# Domestic Content Bonus for Clean Energy Tax Credits

## A User Guide for Project Developers

The Inflation Reduction Act of 2022 offers a historic investment in the clean energy economy, U.S. manufacturing, and family sustaining jobs. Core to the law is a set of tax credits to spur deployment of clean energy projects. The law also establishes several bonus credits that can be layered on top of these base credits for projects that meet certain requirements. This guide is focused on one particular bonus credit: the 10% domestic content bonus credit. The U.S. Treasury Department **released interim guidance** on this bonus credit in May 2023. To access this domestic content bonus credit, developers can rely on U.S.-made iron and steel and an array of solar, wind, and battery components that are already domestically produced.[1] Additional domestic capacity, including for segments where U.S. capacity is limited or still in its nascency, is expected to come online swiftly thanks to the Inflation Reduction Act's more than $40 billion in direct investments in domestic clean tech manufacturing.[2]

### The Rationale for the Domestic Content Bonus

Over the last 50 years, the United States has seen widespread outsourcing of manufacturing, largely to countries with weaker labor and environmental standards, under the logic that such outsourcing would be more efficient. Instead, workers lost a primary source of high-paying union jobs, communities lost tax revenue, and our nation lost the industrial base that is the backbone of modern economies. Meanwhile, the loss of good manufacturing jobs disproportionately impacted workers without a college degree and workers of color, contributing to economic and racial inequality. Black manufacturing employment, for example, has fallen by 30% since the 1990s.[3] The outsourcing of U.S. manufacturing also exacerbated global industrial climate pollution, as energy-intensive manufacturing shifted to countries with lower environmental and labor standards and higher emissions.

This legacy of outsourcing has contributed to deep U.S. dependency on highly concentrated overseas supply chains for solar, wind, battery, and other clean technologies. As we build the growing clean energy economy, we face a clear choice. We can continue to hitch our climate goals to vulnerable overseas supply chains that are marred by labor abuses, higher levels of pollution, and shipping bottlenecks. Or we can build our clean energy future on a foundation of good jobs, clean manufacturing, a reliable industrial base, and greater equity.[4]

The Inflation Reduction Act makes a historic investment in clean energy deployment and reducing our climate pollution, while coupling both labor and domestic content standards with clean energy tax credits. For the first time ever, an additional 'bonus' tax credit is available for taxpayers utilizing domestically-sourced components and materials.

This domestic content bonus, combined with the Inflation Reduction Act's historic supply-side investments in clean technology manufacturing, offers an opportunity to build a stronger U.S. clean energy industrial base. Doing so would help to advance several goals:

- Linking climate action with the creation of high-paying manufacturing jobs;
- Helping to reverse the economic and racial inequality fed by manufacturing job losses;
- Countering forced labor and other human rights violations that plague several overseas clean energy supply chains;
- Supporting clean manufacturing of the aluminum, steel, and cement that go into solar, wind, and other clean technologies rather than relying on emissions-intensive production overseas;
- Building reliable supply chains for clean energy rather than exposing our climate goals to shipping bottlenecks and geopolitical conflict; and
- Fostering global competition in clean tech manufacturing to keep driving down costs, rather than pinning our climate goals on trust that the world's monopoly producers will maintain low prices.

The domestic content bonus builds on already enacted policies that seek to support U.S. manufacturing, create good jobs, and stimulate demand for cleaner manufacturing. Buy America policies—including those in the Build America Buy America Act (BABA), which was included in the 2021 Bipartisan Infrastructure Law—require that when federal dollars are used to fund public infrastructure projects, U.S.-made products and materials must be prioritized. Buy America laws ensure that taxpayer dollars support domestic manufacturing jobs and responsible manufacturing practices, not corporations that outsource production to countries with lower labor and environmental standards. Similarly, Buy Clean policies direct taxpayer dollars to be spent on materials that are manufactured in a cleaner, more efficient, environmentally-friendly manner. Building on Buy America and Buy Clean, the domestic content bonus provides an incentive for developers to use domestically-produced materials, further supporting efforts to build a reliable, equitable, and clean domestic manufacturing base.

## The Business Case for Using the Domestic Content Bonus

The business case for clean energy developers to use the domestic content bonus is clear. In addition to supporting climate, jobs, and equity goals, domestic sourcing is also affordable, particularly after enactment of the Inflation Reduction Act. Even before the law's historic investments to slash the costs of U.S. clean energy manufacturing, the costs of domestic sourcing were negligible. For example, a Princeton study released before the Inflation Reduction Act found that even if a solar developer were to source 100% of its components and materials from domestic producers (which far exceeds the requirements of the domestic content bonus), it would spell a just 7% increase in costs—less than the value of the 10% bonus credit.[5] That is, taking the domestic content bonus would be the profitable move even if we ignore the Inflation Reduction Act investments to cut domestic manufacturing costs.

But those investments are hard to ignore, given their sheer scale. The Inflation Reduction Act invests nearly $40 billion in clean technology manufacturing, primarily through the Advanced Manufacturing Production Credit (45X) and the Advanced Energy Project Investment Credit (48C). Credit Suisse estimates that, since 45X is an uncapped credit, federal investments in clean technology manufacturing could actually reach $260 billion and stimulate $265 billion of private spending over the next decade.[6] In addition, the expansion of the 48C tax credit provides $10 billion for investments in clean technology manufacturing. Companies are not able to stack 45X and 48C, but the criteria for 48C is wider and includes investments in other clean technologies such as geothermal and hydropower. In addition, 48C also funds investments to reduce emissions and boost competitiveness in domestic manufacturing of aluminum, steel, and other materials that go into solar panels, wind turbines, and other clean technologies.

With those new investments, the business case for the domestic content bonus becomes airtight. A new analysis from Princeton and Dartmouth researchers finds that the 45X tax credit created by the Inflation Reduction Act will, for the first time, make U.S.-produced wind and solar components cheaper than imports for every single segment of the wind and solar supply chains.[7] Assessing the same scenario from the pre-Inflation Reduction Act study, the authors find that if a solar developer were to source 100% of a solar module's components from domestic producers, the cost would now be 30% cheaper than imported solar modules, thanks to 45X.[8] That is, buying domestically produced components will make good business sense even before accounting for the value of the 10% domestic content bonus. That additional value is essentially free revenue for developers that have made the prudent decision to source domestically. Even if domestic sourcing temporarily spells marginal costs as domestic manufacturing comes online, the 10% credit will more than offset those dwindling costs, making it the economical choice.

Additional studies agree that the Inflation Reduction Act will have a game-changing impact in making U.S.-made clean energy components cheaper than imports. Credit Suisse finds that 45X will make solar and wind components manufactured in the U.S. the cheapest in the world from 2025-2030. Based on current projections, solar modules could be up to 60% cheaper and wind turbines 50% cheaper before the credit expires in 2032, compared to the cost of production without the 45X tax credit applied.[9] Domestically produced batteries and other energy storage components are also eligible for a credit of up to $45 per kilowatt, which is projected to decrease current costs by nearly 25%.[10]

Beyond costs, another commonly-cited barrier to domestic sourcing in clean energy projects is the limited availability of U.S.-made components. While the U.S. currently has low domestic manufacturing capacity for certain segments of the wind, solar, energy storage, and other clean technology supply chains (as outlined below), new manufacturing facilities funded by Inflation Reduction Act investments, are expected to fill those gaps soon. In fact, the White House recently announced that, since passage of the Inflation Reduction Act less than a year ago, companies have already announced more than $200 billion in private investments to manufacture solar, wind, energy storage, and electric vehicle components.[11] Similarly, American Clean Power has tracked company announcements of 46 new clean technology manufacturing facilities since the law went into effect, including solar, offshore and onshore wind, and battery facilities.[12] The Solar Energy Industries Association now anticipates their goal of 50 GW of domestic solar manufacturing capacity will be met by 2030, expedited by Inflation Reduction Act investments, including for the production of polysilicon, ingots, wafers, cells, modules, racking and trackers, and inverters.[13] After the Inflation Reduction Act, developers can start to plan for more comprehensive domestic clean energy supply chains, making it easier to use the domestic content bonus.

## Qualifying for the Credit

In order to receive the domestic content bonus credit, a certain share of the steel, iron, and "manufactured products" used in the construction of a qualifying facility must be produced in the United States. The tax credit is structured as an "adder." Project owners have a choice of an investment tax credit (ITC) on the project cost or production tax credits (PTCs) on the first 10 years of electricity output. For projects that meet the domestic content standard established in the Inflation Reduction Act and on which ITCs are claimed, the adder is 10% of the project cost. If a project qualifies for the base ITC of 30% and the domestic content adder of 10%, then the total ITC is 40%. For projects on which PTCs are claimed, the base PTC amount is multiplied by 1.1. Thus, if a project qualifies for base PTCs of $27.50 per megawatt hour, the PTCs with the domestic content adder are $30.25.

To qualify for the bonus tax credit, an energy facility must ensure:

- 100% of iron and steel products are produced in the United States. This requirement applies to items directly incorporated into the project that are "made primarily of steel or iron and are structural in function." The following are examples of items requiring 100% domestically made iron and steel:
  - Solar:
    - Steel photovoltaic module racking
    - Pile or ground screws
    - Foundation rebar
  - Onshore wind:
    - Towers
    - Foundation rebar
  - Offshore wind:
    - Towers
    - Jacket foundations
  - Battery storage:
    - Foundation rebar
- 40% initially—increasing to 55% over time—of the total cost of all "manufactured products" are produced in the United States (the percentage starts at 20% for offshore wind projects). This requirement applies to all manufactured items directly incorporated into the project, excluding those that fall under the iron and steel requirement. As described below, the calculation of the domestic percentage takes into account a manufactured product's components but not its subcomponents. The following are manufactured products to which this requirement applies, with examples of components that factor into the calculation:
  - Solar:
    - Photovoltaic trackers
    - Inverters
    - Photovoltaic modules, including components (e.g., photovoltaic cells, mounting frames, and glass), <u>but not subcomponents</u> (e.g., photovoltaic wafers, polysilicon)
  - Onshore wind:
    - Tower flanges
    - Turbines, including components (e.g., nacelles, blades, and rotor hubs), <u>but not subcomponents</u> (e.g., gearboxes, generators)
  - Offshore wind:
    - Tower flanges
    - Transition pieces
    - Monopiles
    - Inter-array cables
    - Offshore substations
    - Export cables
    - Turbines, including components (e.g., nacelles, blades, and rotor hubs), <u>but not subcomponents</u> (e.g., gearboxes, generators)
  - Battery storage:
    - Battery containers/housing
    - Inverters
    - Battery packs, including components (e.g., cells, packaging, thermal management system), <u>but not subcomponents</u> (e.g., anodes, cathodes)

The manufactured products percentage is calculated using the manufacturing facility's costs and not what the developer pays the manufacturer for such items. Moreover, it focuses on only three "direct" costs of the manufacturer and not all of its costs. For each manufactured product, the developer must ask the manufacturer for the: (1) wages, (2) payroll taxes, and (3) amounts it paid suppliers for the components and raw materials it used to make the manufactured product.

Here are the steps developers need to take to calculate the manufactured products percentage:

- **Denominator:** Add together the three amounts named above for all directly incorporated manufactured products, regardless of their origin. (The list above includes all "manufactured products" named in the guidance). The total sum is the denominator.

- **Numerator:** Add together certain qualifying costs for all directly incorporated manufactured products. The costs that get added together in the numerator vary by manufactured product
  - If the product is manufactured in a foreign facility, nothing goes in the numerator.
  - If the product is manufactured in a U.S. facility that sourced all of the components in the United States, then the same three costs that go in the denominator also go in the numerator for that product (see the guidance for the full list of qualifying components). A component made in a U.S. manufacturing facility is treated as U.S.-made even if its subcomponents were made outside of the United States (e.g., if a photovoltaic cell, a component, is made in the United States, it qualifies as U.S.-made even if the wafers, a subcomponent, were imported).
  - If the product is manufactured in a U.S. facility that used one or more imported components, then the costs that go into the numerator are just the amounts the manufacturer paid to suppliers for the U.S.-made components.

- **Manufactured products percentage**: Divide the numerator by the denominator to arrive at the final manufactured products percentage. The calculation is an aggregate calculation for all of the manufactured products. Each product individually does not have to reach the domestic content threshold. Instead, both the numerator and denominator should include the relevant domestic costs for all of the manufactured products, as outlined above.

It appears in some cases that the Treasury Department intends for the construction contractor—rather than the manufacturing facility—to be treated as the manufacturer. This is true of wind turbines (defined as the nacelle, blades, rotor hub, and power converter) and solar trackers. In these cases, the wages, payroll taxes, and direct materials costs of the construction contractor would be the relevant costs for these items.

The manufactured products percentage that must be met to qualify for the bonus will increase over the next 4-5 years to correspond with an expected increase in U.S. manufacturing capacity. The percentage is fixed in the year construction of the project starts for tax purposes. For offshore wind manufactured products, a developer must meet the following percentage schedule to utilize the bonus credit:

- 20% in 2024
- 27.5% in 2025
- 35% in 2026
- 45% in 2027
- 55% in 2028

For all other manufactured products, a developer must meet the following percentage schedule to utilize the bonus credit:

- 40% in 2024
- 45% in 2025
- 50% in 2026
- 55% in 2027

## State of Domestic Supply Chains

The expansive clean tech manufacturing investments spurred by the Inflation Reduction Act will substantially bolster domestic supply chains for clean energy deployment. As of March 2023, more than 45 new utility-scaled clean energy manufacturing facilities (or facility expansions) have been announced since the law was passed in August 2022.[14] But developers don't have to wait for this new capacity to come online in order to take advantage of the domestic content bonus credit. There are already well over 575 established clean power-related manufacturing facilities in the United States.[15] These facilities are producing many of the key components of solar, wind, and energy storage supply chains today. In the Appendix, we highlight some of the materials and components for whichdomestic production is most active, based on BGA's review of these supply chains.

Developers can begin sourcing these components domestically to reap the rewards of the credit.

Additional information about the domestic manufacturing capacity for the major components for these supply chains can be found in BGA's clean energy supply chain assessment and accompanying map of clean energy manufacturing facilities.[16] The supply chain assessment assigns each component to one of four levels of current domestic manufacturing capacity, based on the domestic supply rate for the component, or if data are not available, the number of active facilities producing the component.[17] The components highlighted in the Appendix are those that meet the threshold for moderate or significant domestic manufacturing according to these definitions.

Within these sectors, developers should give additional preference to domestic suppliers that give workers a free and fair choice to join a union. Suppliers with union partnerships are more likely to have robust workforce development programs to ensure a well-trained and stable workforce, reducing supply chain risks. In addition, a preference for unionized suppliers will help ensure that the build-out of our clean energy supply chains creates high-quality jobs and helps build a fairer economy.

### Solar Supply Chain

While the United States has lost significant global market share in component manufacturing for the photovoltaic (PV) supply chain in recent decades, U.S. manufacturing capacity does exist for certain components.[18] Today, there are over 100 facilities manufacturing various components for solar energy on U.S. soil.[19] This provides U.S. developers with opportunities to include domestic content in solar installations. Some of the components and materials with the most active domestic production include metallurgical-gradesilicon (MGS), solar-grade polysilicon, polymeric film lamination, backsheets, modules, racking (mounting structures), and combiner boxes. There are several areas in the solar PV supply chain where domestic manufacturing capacity is currently limited or nonexistent. For example, there is no active production of crystalline silicon ingot, PV wafers, or PV cells; and limited production of flat glass. However, thanks to the clean manufacturing investments in the Inflation Reduction Act, production of these components will scale up soon. A number of new domestic plants to produce these components have already been announced since the law's passage.

### Onshore Wind Supply Chain

The onshore wind industry has a relatively strong domestic manufacturing base, especially for the larger components of wind installations. In fact, the United States is one of only five countries with capacity to produce all major components for onshore wind turbines—with the exception of large castings used in hubs and nacelles.[20] Larger and heavier components, like nacelle assemblies and towers, as well as generators and bearings, have the highest levels of domestic production. Smaller turbine components, such as electronic components, face higher competition from imports.

### Offshore Wind Supply Chain

The domestic supply chain for the offshore wind industry is much less developed than onshore wind. The current domestic capacity for this industry is limited to two cable facilities and one offshore substation facility. That being said, significant investments are already helping to ramp up the supply chain. To date, about 15 manufacturing facilities for major offshore wind components have been announced, a handful of which are already under construction.[21] Additional supply chain investments are expected in the coming year.

Because of the nacency of this supply chain, the domestic content requirements for the bonus credit start at a lower level for offshore wind projects than for other industries—a 20% minimum in 2024 compared to a 40% minimum for all other industries. The requirements also ratchet up more slowly, culminating in a 55% minimum domestic content threshold by 2028, where other industries must meet this level by 2027.

### Energy Storage Supply Chain

U.S. demand for grid energy storage is projected to substantially increase within the next few decades. Currently, the majority of grid storage is provided by pumped storage hydropower for long-duration energy storage and by lithium-ion batteries for short-term energy storage. In the first half of 2020, lithium-ion batteries were used for 98% of commissioned utility-scale stationary storage projects.[22] Over the next decade, lithium-ion batteries are expected to represent over 95% of added capacity for short-term energy storage.[23] For this reason, this section is largely focused on lithium-ion batteries.

The domestic supply chain for lithium-ion batteries, which serves the stationary grid storage sector as well as the electrified transportation sector, is well established and growing.[24] The increasing demand for electric vehicles has been a strong driver for the battery market, leading many domestic battery manufacturers to expand operations, often with assistance from the U.S. Department of Energy (DOE) and the U.S. Advanced Battery Consortium.[25] The supply chain segments with the strongest domestic production include certain electrolyte materials, anode materials, cells, modules, packs, and battery control systems. The domestic supply is more limited for the key metals at the base of the battery supply chain, including lithium, cobalt, nickel, and manganese.

There are several technologies in various stages of commercial viability that are projected to compete with lithium-ion batteries in the coming years.[26] Multiple battery chemistry options are currently being researched and developed, including sodium-ion, iron-air, and rechargeable magnesium. Additionally, hydrogen and compressed air energy storage are attracting interest as long-duration energy storage possibilities. Each of these domestic supply chains are still in their infancy, but it will be important to monitor their development moving forward.

### Key Materials

To qualify for the domestic content bonus credit, developers of clean energy projects should prioritize domestically sourced iron and steel for all structural components, and domestically manufactured aluminum products. The growth of wind and solar deployment and manufacturing, fueled by Inflation Reduction Act investments, is expected to cause U.S. clean energy-related demand for steel and aluminum to grow several fold by 2035.[27] At the same time, the Inflation Reduction Act also offers investments that could support an increased supply of U.S.-made steel and aluminum, including manufacturing tax credits and a new DOE program to help make these energy-intensive industries cleaner and more competitive.[28]

#### Iron and Steel

Iron and steel are integral for clean energy supply chains. In wind energy, for example, these materials are used in the fabrication of the towers, rotors, nacelles, and foundations, among other components. In fact, between 66% and 79% of a turbine's total mass comes from its steel components, while an additional 5% to 17% come from the iron and cast iron components.[29] Common turbine models require between 107 to 132 metric tons (mt) of steel and 18 to 20.8 mt of cast iron per MW of installed capacity.[30] Solar PV systems also require hefty inputs of steel, at around 67.9 mt of steel per MW of installed capacity, largely for the frames, mounting structures, and tracking systems.[31]

Domestic production of iron and steel is significant. Based on 2022 volumes, the U.S. was the world's fourth-largest steel producing country (for raw steel), and the eighth-largest producer of pig iron.[32] There are currently three companies that produce pig iron and raw steel across 11 integrated steel mills, and another 50 companies that produce raw steel at about 100 domestic mini mills.[33] These facilities have a collective production capacity of 106 million mt per year.[34] In 2022, they supplied about 86% of the domestic consumption of steel mill products.[35]

Currently, demand for steel from clean energy represents a small portion of the domestic production capacity.[36] In 2022, domestic solar and wind energy projects consumed about 1.7 million tonnes of steel. That's about 2% of the 82 mt of raw steel produced in the U.S. that year.[37]

**Aluminum**

While the domestic content bonus does not specifically require a certain percentage of aluminum to be domestically made, aluminum is a primary material for several clean energy components that count toward the bonus. Solar PV systems use around 19 tonnes of aluminum per MW of installed capacity, largely within the frames, mounting structures, and tracking systems.[38] Meanwhile, common wind turbine models require up to 1.6 tonnes of aluminum, for cable mounting systems and rotor components, per MW of installed capacity.[39] Aluminum is also key for grid energy storage, as it is an ingredient for several common cathode chemistries for lithium-ion batteries.

While domestic production of primary aluminum has declined precipitously in recent decades, the United States is a major producer of secondary (recycled) aluminum. Recycled aluminum is aluminum that is recovered from scrap metal and re-melted into ingot, billet and bar forms for further processing by downstream manufacturers. In 2022, domestic secondary smelters provided over 65% of the 5.1 million metric tons of aluminum consumed within the United States.[40] There are over 50 firms engaged in secondary smelting, a segment that continues to represent a growing share of total U.S. aluminum output. Over the last decade alone, the aluminum industry has committed or invested over $6.5 billion for new domestic facilities or expansions, with the vast majority aimed at secondary smelting and downstream production.[41]

In 2022, domestic wind and solar projects used about 200,000 mt of aluminum—less than 5% of the total domestic supply of aluminum (primary and secondary combined) that year.[42,43]

## Conclusion

Using domestically manufactured materials and products in clean energy projects is the sound business choice for clean energy developers. Even for sectors where domestic content can be slightly more expensive than imports in the near term, the 10% bonus tax credit more than offsets these marginal costs and leads to greater cost savings. These savings will only increase over time as the costs of U.S.-made wind and solar components fall below the costs of imports—a result of the manufacturing tax credits in the Inflation Reduction Act. Apart from this strong business case, domestic sourcing also supports a clean energy future that's built on a foundation of good jobs, clean manufacturing, a reliable industrial base, and greater equity. Sourcing from domestic suppliers is a good choice for supporting both clean energy developers' bottom line and broadly-shared climate, jobs, and justice objectives.

# Appendix: Components With Significant U.S. Production

## Solar Components with Significant U.S. Production

**Metallurgical-grade silicon:** Metallurgical-grade silicon metal (MGS) is a purified form of silicon produced from quartzite (silica). It is used to make polysilicon for solar wafers and semiconductors. The U.S. is one of about 15 countries with MGS production capacity. It is currently produced at six U.S. plants, all east of the Mississippi River.[44] In 2022, these plants supplied more than 50% of the total domestic MGS consumption.[45]

**Solar-grade polysilicon:** Polycrystalline silicon (polysilicon), obtained by refining MGS, is used to produce crystalline silicon (c-Si) cells, the technology used for the vast majority of global PV modules. Outside of China, the United States and Germany have the largest polysilicon manufacturing capacity.[46] There are currently four polysilicon facilities in the United States, with a fifth idled plant expecting to reopen this year. As of 2020, just three of these plants (in Michigan, Washington, and Tennessee) had capacity to sufficiently supply the entire U.S. solar industry at 2020 levels.[47] While U.S. plants have been operating under capacity since Chinese duties were placed on U.S. polysilicon in 2014, interest in domestic production is growing.[48] For example, a leading U.S. manufacturer of polysilicon is expanding and modernizing a next generation facility in Michigan; and an idled facility that is reopening in Washington, mentioned earlier, is slated to supply polysilicon for a newly announced $2.5 billion solar manufacturing project in Georgia.[49]

**Encapsulant film:** Encapsulant film is a polymeric material that is used to form a protective barrier for the PV cells. The films are made by extruding a resin form of ethylene vinyl acetate (EVA) or polyolefin elastomers (POE). While the domestic encapsulant film production is highly concentrated, with a single manufacturer, the material is currently produced across five U.S. facilities.

**Polymeric backsheet (laminators):** Backsheets, which insulate and protect inner components of solar modules, are typically made of three films laminated together. Materials used vary significantly, but the core layer is typically polyester (PET), while the outer layer is often polyvinylidene fluoride (PVF) or polyvinylidene difluoride (PVDF). Independent laminators purchase these films and laminate desired stacks together into backsheets. There are at least three backsheet laminators that currently operate eight facilities in the United States.[50]

**Modules:** Modules are made up of many electrically connected photovoltaic cells that are mounted and laminated onto an assembly. U.S. module assembly (with imported cells) grew significantly in 2018 and 2019, largely as a result of U.S.-placed tariffs on imported modules.[51] Accordingly, the International Energy Agency (IEA) considers the United States to have high module assembly capacity, providing 4% of the global production in 2021.[52] As of 2020, the United States had enough solar module manufacturing capacity to fill one third of its current deployment needs (about 7 GW of solar panels per year).[53] Today, there are at least 24 domestic facilities that produce PV modules.[54] This includes over 20 c-Si module facilities with around 6.3 GW annual capacity and 3 thin film (cadmium telluride, or CdTe) PV module facilities with over 3 GW annual module capacity.[55]

**Inverters:** Inverters convert direct current (DC) electricity from the PV modules into alternating current (AC) for connection to the grid. U.S. inverter manufacturing grew strongly until 2016 when many U.S. manufacturers began to close U.S. facilities to streamline production in China or Europe.[56] While this has meant that the share of domestically produced PV inverters has declined in recent years, there are over two dozen domestic facilities producing inverters.[57] At least one additional manufacturer of U.S. facilities specialize in specific inverter types, such as residential, solar inverters has announced plans to expand production to the United States in 2023 to meet rising demand.[58] Some of these U.S. facilities specialize in specific inverter types, such as residential, utility, hybrid, or micro inverters, but at least eight produce multiple types of inverters. There are also at least three domestic facilities that produce optimizers, a component that helps maximize the energy output of a PV system.

**Trackers:** PV trackers are used to orient modules more directly toward the sunlight to increase energy production per module. There are about 15 manufacturers that produce trackers across over 25 U.S. facilities. Nine of these facilities are operated by one company, GameChange Solar, which as of 2020, was the third largest supplier of U.S. trackers. The second largest supplier of U.S. trackers, Array Technologies, is also based in the United States, with a facility in New Mexico.[59]

**Racking systems:** Racking systems (also known as mounting systems) provide mechanical support for modules and connect them to the solar trackers. They are largely made of galvanized or stainless steel and aluminum. Domestic production is generally more competitive since international shipping represents a significant portion of the item's cost. There are more than 20 companies that produce racking systems domestically. These companies operate more than 30 domestic facilities. In some cases, they may manufacture the products in-house, but they often outsource to third party suppliers. Such suppliers include steel and aluminum producers for raw materials, and mills and other manufacturing companies that make the products with desired specs.[60] There are also over a dozen other U.S. facilities that produce various steel tubing for the solar industry, which are used for structural support or tracking systems; and dozens more that produce other physical balance of system components.

**Combiner box and charge controllers:** Combiner boxes consolidate multiple DC inputs into one main feed that distributes to a solar inverter. At least four companies operate six domestic plants that manufacture combiner boxes for the solar industry. There are also at least three facilities that produce charge controllers, which regulate the flow of electricity from the PV modules to the load.

## Onshore Wind Components with Significant U.S. Production

**Nacelles:** Nacelles are the housing that contain all of the generating components of wind turbines, including the gearbox, generator, and shafts. They are the single-largest cost associated with wind turbine installations.[61] Nacelle assembly involves combining the many components of a turbine nacelle to produce a complete turbine nacelle unit. Domestic nacelle production accounts for 75-85% of U.S. consumption—whereby domestic and imported components are assembled into complete nacelles in the United States.[62] This is the highest domestic content level of all wind components. As of 2021, domestic nacelle assembly capability was 12.3 GW per year.[63] There are currently at least five manufacturers that fabricate and/or assemble nacelles across five U.S. facilities.

**Blades:** Blades enable turbines to generate electricity by converting wind energy to low-speed rotational energy.  Domestic blade manufacturing capacity has declined in the last five years due to strong import competition. As of 2021, only about 15% to 25% of blades used in U.S. wind projects were sourced from domestic suppliers.[64] While there are fewer domestic producers than facilities are still currently producing blades domestically. This includes one facility that reopened in Iowa earlier this year after temporarily idling in 2021.[65] A sixth facility is expected to reopen in Iowa in 2024.[66]

**Towers:** Towers are the tubular or lattice structure that supports a turbine's nacelle and rotor. They are generally made from several steel sections that are assembled on-site. In 2021, domestic content of towers ranged from 55% to 75%.[67] As of 2021, the United States had capacity to produce towers sufficient for 9.2 GW of wind capacity per year.[68] Towers are currently produced in the United States by at least nine companies across eleven domestic facilities.

**Generators:** Generators convert mechanical energy from the rotors into electrical energy. Some are driven by gearboxes while others are direct-drive systems attached directly to rotors. About 36% of generators in the U.S. wind market are domestically produced.[69] These are produced by at least nine facilities run by six manufacturers, many of which also produce other related electrical equipment.

**Bearings:** A range of precision bearings are used across wind turbines to assist rotation throughout the turbines. About 75% of bearings used in onshore wind, by value, are produced domestically. There are more than

## Energy Storage Components with Significant U.S. Production

**Liquid electrolytes and additives:** Electrolytes, which can be in liquid or solid form, enable ions to move between the positive and negative electrodes of a battery cell. The United States held about 7% of the global capacity for electrolyte production for lithium ion batteries as of 2021 (existing and under development).[71] There are currently about six domestic facilities that produce liquid electrolytes, with several additional facilities planned. There are also about six domestic facilities that produce electrolyte additives for battery applications.

Additives are components (such as Vinylene Carbonate) that are incorporated into electrolytes to improve the battery performance.

**Anode materials – graphite:** Most lithium-ion batteries have a graphite anode, which can either be produced from natural or synthetic graphite.[72] There are currently about five domestic facilities that produce natural battery grade graphite and about five that produce synthetic battery grade graphite. A handful of facilities for both natural and synthetic graphite are currently planned or in development.

**Battery cells:** Battery cells are the basic unit of lithium ion batteries that convert chemical energy into electric energy. They are composed of a cathode, anode, separator, and electrolyte within a case. The United States maintains about 13% of the global manufacturing capacity for lithium-ion battery cells.[73] There are at least seven facilities that currently produce lithium ion cells for electric vehicle (EV) batteries or energy storage in the United States.[74] According to the DOE, as of 2022, most of the cell production is for batteries that use nickel cobalt aluminum oxide (NCA) chemistry.[75] At least 10 additional cell production facilities have been announced or are currently under construction.[76]

**Battery management systems (BMS) and Thermal management systems:** BMS monitor and protect the battery pack and optimize performance, while thermal management systems control the temperature of the cells according to their specifications. There are more than ten domestic facilities that produce battery management systems, and more than 20 facilities that produce thermal systems for lithium ion batteries.[77]

**Battery modules**: A battery module is a collection of cells in a protective frame. The United States has substantial module manufacturing capabilities, with at least eight facilities that assemble modules for energy storage or transportation applications.[78]

**Battery packs:** Battery packs are the final form of a battery system that is installed into a energy storage system, vehicle, or other application.[79] They are composed of a series of modules, the control and protection systems, and other components.

# Endnotes


1 This guide is broadly applicable for all users of the domestic content bonus, including private clean energy developers, public entities, and non-profit organizations. Throughout the document, we refer to "developers" as shorthand for all entities seeking to take advantage of the domestic content bonus.

2 American Clean Power (ACP), *Clean Energy Investing in America*, December 2022. Available online: https://cleanpower.org/wp-content/uploads/2022/12/ACP_Clean_Energy_Investing_In_America_Report_Q422.pdf

3 Economic Policy Institute (EPI), *Botched policy responses to globalization have decimated manufacturing employment with often overlooked costs for Black, Brown, and other workers of color*, 2022. Available online: https://www.epi.org/publication/botched-policy-responses-to-globalization/

4 BlueGreen Alliance, Why Do We Need to Onshore Manufacturing of Clean Energy Goods? June 2022. Available online: https://www.bluegreenalliance.org/wp-content/uploads/2022/06/MFG-Clean-Energy-Goods-Fact-Sheet-2022_FINAL_61522_.pdf

5 Princeton University, *Influence of high road labor policies and practices on renewable energy costs, decarbonization pathways and labor outcomes*, 2021. Available online: https://www.dropbox.com/sh/ad9pzifo9w1a49u/AAC2milGD44MlwXo1Sk7EAgsa?dl=0

6 Credit Suisse, *US Inflation Reduction Act: A Catalyst for Climate Action*, November 30, 2022. Available online: https://www.credit-suisse.com/about-us-news/en/articles/news-and-expertise/us-inflation-reduction-act-a-catalyst-for-climate-action-202211.html

7 Dartmouth College Sustainable Transitions Lab and Princeton University ZERO Lab, *Effects of Renewable Energy Provisions of the Inflation Reduction Act on Technology Costs, Materials Demand, and Labor*, June 2023. Available online: https://doi.org/10.5281/zenodo.8027939

8 ibid.

9 Credit Suisse, *US Inflation Reduction Act: A Catalyst for Climate Action*, November 30, 2022. Available online: https://www.credit-suisse.com/about-us-news/en/articles/news-and-expertise/us-inflation-reduction-act-a-catalyst-for-climate-action-202211.html

10 Congressional Research Service, *Tax Provisions in the Inflation Reduction Act of 2022*, August 10, 2022. Available online: https://crsreports.congress.gov/product/pdf/R/R47202

11 White House, Investing in America, Updated May 2023. Available online: https://www.whitehouse.gov/invest/

12 ACP, *Clean Energy Investing in America*, April 2023. Available online: https://cleanpower.org/investing-in-america/

13 Solar Energy Industry Association, "U.S. Solar Manufacturing Poised for Boom if Energy Tax Incentives Move Ahead," March 30, 2022. Available online: https://www.seia.org/blog/us-solar-manufacturing-poised-boom-if-energy-tax-incentives-move-ahead

14 ACP, *Clean Energy Investing in America*, 2023. Available online: https://cleanpower.org/wp-content/uploads/2023/04/ACP_Clean-Energy-Investi\ng-in-America_April-2023.pdf

15 ibid.

16 BlueGreen Alliance, "Map and Analysis: Building a Strong Manufacturing Base for Clean Energy in the US." Available online: https://www.bluegreenalliance.org/resources/clean-energy-supply-chain-analysis/

17 U.S. Department of Energy (DOE). *Electric Grid Supply Chain Review: Large Power Transformers and High Voltage Direct Current Systems*, 2022 Available online: https://www.energy.gov/sites/default/files/2022-02/Electric%20Grid%20Supply%20Chain%20Report%20-%20Final.pdf

18 National Renewable Energy Laboratory (NREL), *Expanding the Photovoltaic Supply Chain in the United States: Opportunities and Challenges*, 2019. Available online: https://www.nrel.gov/docs/fy19osti/73363.pdf

19 U.S. DOE, Solar Manufacturing Map. Available online: https://www.energy.gov/eere/solar/solar-manufacturing-map; Solar Energy Industries Association (SEIA), SEIA Solar and Storage Supply Chain Dashboard, 2023. Available online: https://fortress.maptive.com/ver4/SEIA_scm

20 U.S. DOE, Wind Energy Supply Chain Deep Dive Assessment, 2022. Available online: https://www.energy.gov/sites/default/files/2022-02/Wind%20Supply%20Chain%20Report%20-%20Final%202.25.22.pdf

21 ACP, *Offshore Wind Market Report*, 2023. Available online: https://cleanpower.org/wp-content/uploads/2023/05/ACP_Offshore_Wind_Market_Report_2023_PUBLIC.pdf

22 Federal Consortium of Advanced Batteries, *National Blueprint for Lithium Batteries*, 2021. Available online: https://www.energy.gov/sites/default/files/2021-06/FCAB%20National%20Blueprint%20Lithium%20Batteries%200621_0.pdf

23 U.S. DOE, *Grid Energy Storage Supply Chain Deep Dive Assessment*, 2022. Available online: https://www.energy.gov/sites/default/files/2022-02/Energy%20Storage%20Supply%20Chain%20Report%20-%20final.pdf

24 IBISWorld, *Battery Manufacturing in the US*, 2022. Available online: https://my.ibisworld.com/download/us/en/industry/801/1/0/pdf

25 ibid.

26 U.S. DOE, *Grid Energy Storage Supply Chain Deep Dive Assessment*, 2022. Available online: https://www.energy.gov/sites/default/files/2022-02/Energy%20Storage%20Supply%20Chain%20Report%20-%20final.pdf

27 Dartmouth College Sustainable Transitions Lab and Princeton University ZERO Lab, *Effects of Renewable Energy Provisions of the Inflation Reduction Act on Technology Costs, Materials Demand, and Labor*. Available online: https://doi.org/10.5281/zenodo.8027939

28 Inflation Reduction Act investments that could support aluminum and/or steel manufacturing include the 45X and 48C manufacturing tax credits and the Department of Energy's Advanced Industrial Facilities Deployment Program.

29 National Renewable Energy Laboratory, 2015 Cost of Wind Energy Review, 2017. Available online: https://www.nrel.gov/docs/fy17osti/66861.pdf

30 European Commission, Joint Research Centre, Raw materials demand for wind and solar PV technologies in the transition towards a
decarbonised energy system, 2020. Available online: https://op.europa.eu/en/publication-detail/-/publication/19aae047-7f88-11ea-aea8-01aa75ed71a1

31 ibid.

32 U.S. Geological Survey (USGS), Iron and Steel, Mineral Commodity Summary, 2023. Available online: https://pubs.usgs.gov/periodicals/mcs2023/mcs2023-iron-steel.pdf

33 ibid.

34 ibid.

35 ibid.

36 Dartmouth College Sustainable Transitions Lab and Princeton University ZERO Lab, *Effects of Renewable Energy Provisions of the Inflation Reduction Act on Technology Costs, Materials Demand, and Labor*. Available online: https://doi.org/10.5281/zenodo.8027939

37 USGS, *Iron and Steel, Mineral Commodity Summary*, 2023. Available online: https://pubs.usgs.gov/periodicals/mcs2023/mcs2023-iron-steel.pdf

38 International Renewable Energy Agency (IRENA), *Renewable energy benefits: Leveraging local capacity for solar PV*, 2017. Available online: https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2017/Jun/IRENA_Leveraging_for_Solar_PV_2017.pdf

39 European Commission, Joint Research Centre, *Raw materials demand for wind and solar PV technologies in the transition towards a decarbonised energy system*, 2020. Available online: https://op.europa.eu/en/publication-detail/-/publication/19aae047-7f88-11ea-aea8-01aa75ed71a1

40 USGS, *Mineral Commodities Summary*, 2023. Available online: https://pubs.usgs.gov/periodicals/mcs2023/mcs2023.pdf

41 Aluminum Association, "$2.5 Billion Low Carbon Recycling & Rolling Plant Investment Meets Growing U.S. Aluminum Demand," May 11, 2022. Available online: https://www.aluminum.org/25-billion-low-carbon-recycling-rolling-plant-investment-meets-growing-us-aluminum-demand

42 Dartmouth College Sustainable Transitions Lab and Princeton University ZERO Lab, *Effects of Renewable Energy Provisions of the Inflation Reduction Act on Technology Costs, Materials Demand, and Labor*, 2023. Available online: https://doi.org/10.5281/zenodo.8027939

43 USGS, *Aluminum, Mineral Commodities Summary*, 2023. Available online: https://pubs.usgs.gov/periodicals/mcs2023/mcs2023-aluminum.pdf

44 SEIA, SEIA Solar and Storage Supply Chain Dashboard, 2023. Available online: https://fortress.maptive.com/ver4/SEIA_scm

45 USGS), *Silicon Mineral Commodity Summaries*, 2023. Available online: https://pubs.usgs.gov/periodicals/mcs2023/mcs2023-silicon.pdf

46 DOE, *Solar Photovoltaics Supply Chain Deep Dive Assessment*, 2022. Available online: https://www.energy.gov/sites/default/files/2022-02/Solar%20Energy%20Supply%20Chain%20Report%20-%20Final.pdf

47 SEIA, *The Solar+ Decade & American Renewable Energy Manufacturing*, 2020. Available online: https://www.seia.org/sites/default/files/2022-01/SEIA-American-Manufacturing-Vision-2020_FINAL_0.pdf

48 U.S. DOE, *Solar Photovoltaics Supply Chain Deep Dive Assessment*, 2022. Available online: https://www.energy.gov/sites/default/files/2022-02/Solar%20Energy%20Supply%20Chain%20Report%20-%20Final.pdf

49 Chemical and Engineering News, "Hanwha will buy polysilicon from REC Silicon," February 10, 2023. Available online: https://cen.acs.org/energy/renewables/Hanwha-buy-polysilicon-REC-Silicon/101/i6

50 U.S. DOE, Solar Photovoltaics Supply Chain Deep Dive Assessment, 2022. Available online: https://www.energy.gov/sites/default/files/2022-02/Solar%20Energy%20Supply%20Chain%20Report%20-%20Final.pdf

51 U.S. DOE, *Achieving American Leadership in the Solar Photovoltaics Supply Chain*, 2022. Available online: https://www.energy.gov/sites/default/files/2022-02/Solar%20Energy%20Supply%20Chain%20Fact%20Sheet.pdf

52 International Energy Agency (IEA), *Special Report on Solar PV Global Supply Chains*, 2022. Available online: https://iea.blob.core.windows.net/assets/d2ee601d-6b1a-4cd2-a0e8-db02dc64332c/SpecialReportonSolarPVGlobalSupplyChains.pdf

53 SEIA, *The Solar+ Decade & American Renewable Energy Manufacturing*, 2020. Available online: https://www.seia.org/sites/default/files/2022-01/SEIA-American-Manufacturing-Vision-2020_FINAL_0.pdf

54 U.S. DOE, Solar Manufacturing Map. Available online: https://www.energy.gov/eere/solar/solar-manufacturing-map; SEIA, SEIA Solar and Storage Supply Chain Dashboard, 2023. Available online: https://fortress.maptive.com/ver4/SEIA_scm; Solar Power World, U.S. Solar Panel Manufacturers, 2023. Available online: https://www.solarpowerworldonline.com/u-s-solar-panel-manufacturers/

55 ibid.; First Solar, "First Solar to Invest up to $1.2 Billion in Scaling Production of American-Made Responsible Solar by 4.4 GW," August 30, 2022. Available online: https://investor.firstsolar.com/news/press-release-details/2022/First-Solar-to-Invest-up-to-1.2-Billion-in-Scaling-Production-of-American-Made-Responsible-Solar-by-4.4-GW/default.aspx

56 NREL, *Spring 2022 Solar Industry Update*, 2022. Available online: https://www.nrel.gov/docs/fy22osti/82854.pdf

57 NREL, *Expanding the Photovoltaic Supply Chain in the United States: Opportunities and Challenges*, 2019. Available online: https://www.nrel.gov/docs/fy19osti/73363.pdf

58 PV Magazine, "Enphase to open new US manufacturing lines," October 28, 2022. Available online: https://www.pv-magazine.com/2022/10/28/enphase-to-open-new-us-manufacturing-lines/

59 U.S. DOE, *Solar Photovoltaics Supply Chain Deep Dive Assessment*, 2022. Available online: https://www.energy.gov/sites/default/files/2022-02/Solar%20Energy%20Supply%20Chain%20Report%20-%20Final.pdf

60 ibid.

61 IBISWorld, *Wind Turbine Manufacturing in the US*, 2022. Available online: https://my.ibisworld.com/download/us/en/industry/715/1/0/pdf

62 U.S. DOE, *Land Based Wind Market Report*, 2022. Available online: https://www.energy.gov/sites/default/files/2022-08/land_based_wind_market_report_2202.pdf

63 ibid.

64 ibid.

65 Iowa Starting Line, "Another Wind Blade Company Returns To Iowa Because Of Federal Funding," December 22, 2022. Available online: https://iowastartingline.com/2022/12/22/another-wind-blade-company-returns-to-iowa-because-of-federal-funding/

66 Des Moines Register, "Wind blade manufacturer TPI plans to reopen Newton plant. But new jobs might be months away," November 4, 2022. Available online: https://www.desmoinesregister.com/story/money/business/2022/11/04/tpi-composites-newton-iowa-10-year-lease-reopen-plant/69619151007

67 U.S. DOE, *Land Based Wind Market Report*, 2022. Available online: https://www.energy.gov/sites/default/files/2022-08/land_based_wind_market_report_2202.pdf

68 ibid.

69 ibid.

70 U.S. DOE, *Wind Energy Supply Chain Deep Dive Assessment*, 2022. Available online: https://www.energy.gov/sites/default/files/2022-02/Wind%20Supply%20Chain%20Report%20-%20Final%202.25.22.pdf

71 U.S. DOE, *Grid Energy Storage Supply Chain Deep Dive Assessment*, 2022. Available online: https://www.energy.gov/sites/default/files/2022-02/Energy%20Storage%20Supply%20Chain%20Report%20-%20final.pdf

72 NREL, NAATBatt Lithium-Ion Battery Supply Chain Database, 2022. Available online: https://www.nrel.gov/transportation/li-ion-battery-supply-chain-database.html

73 ibid.
74 ibid.
75 ibid.
76 SEIA, Solar and Energy Storage Supply Chain Database, 2023. Available online: https://fortress.maptive.com/ver4/SEIA_scm; U.S. DOE, *Grid Energy Storage Supply Chain Deep Dive Assessment*, 2022. Available online: https://www.energy.gov/sites/default/files/2022-02/Energy%20Storage%20Supply%20Chain%20Report%20-%20final.pdf
77 NREL, NAATBatt Lithium-Ion Battery Supply Chain Database, 2022. Available online: https://www.nrel.gov/transportation/li-ion-battery-supply-chain-database.html
78 ibid.; SEIA, Solar and Energy Storage Supply Chain Database, 2023. Available online: https://fortress.maptive.com/ver4/SEIA_scm
79 U.S. DOE, Grid Energy Storage Supply Chain Deep Dive Assessment, 2022. Available online: https://www.energy.gov/sites/default/files/2022-02/Energy%20Storage%20Supply%20Chain%20Report%20-%20final.pdf; NREL, NAATBatt Lithium-Ion Battery Supply Chain Database, 2022. Available online: https://www.nrel.gov/transportation/li-ion-battery-supply-chain-database.html; SEIA, Solar and Energy Storage Supply Chain Database, 2023. Available online: https://fortress.maptive.com/ver4/SEIA_scm
80 NREL, NAATBatt Lithium-Ion Battery Supply Chain Database, 2022. Available online: https://www.nrel.gov/transportation/li-ion-battery-supply-chain-database.html; SEIA, Solar and Energy Storage Supply Chain Database, 2023. Available online: https://fortress.maptive.com/ver4/SEIA_scm

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