

Summary of Supply Chain Opportunities

Recent findings from the MESC's Supply Chain Readiness Level analysis and resulting discussion of findings have identified several areas that represent **opportunities for further investment to strengthen critical clean energy supply chains.**

This section summarizes these findings for technologies included in the initial scope of the Supply Chain Readiness Level tool.



Solar PV

- Crystalline Silicon PV
- Cadmium Telluride PV



Grid

- Large Power Transformers
- Distribution Transformers



Batteries

- NMC-Graphite Batteries
- LFP-Graphite Batteries



Wind

- Offshore Wind



Hydrogen

- Alkaline Electrolyzer
- PEM Electrolyzer

Supply Chain Investment Opportunities:

Solar – Crystalline Silicon PV

Immediate Opportunities

- Expansion of upstream processing and refining of raw materials and precursors for polysilicon production (e.g., quartz, metallurgical grade silicon, trichlorosilane, tetrachloride, silane, etc.)
- Additional production capacity for polysilicon refining focusing on facilities that prioritize carbon free electricity for feedstock
- Increase capacity for ingot/wafers and fabrication of specialized capital equipment (e.g., ingot pullers, diamond saws), and , and consumables (e.g., graphite, crucibles, diamond wire) needed for production
- Investment in alternative methods of production of ingot / wafers (e.g., kerfless wafers, direct wafering) and associated production of precursors materials
- Advance capacity in cell and module manufacturing and specialized capital equipment for projects with strong upstream domestic suppliers and portfolio of offtake
- Manufacturing capacity for balance-of-module components including rolled glass, backsheets, module frames, and encapsulant film extrusion, among others that is cost competitive and meets domestic specifications
- Additional production capacity for balance-of-system components including inverters, power electronics, motors, among other areas
- On-shoring production of capital equipment for current generation and leading-edge technologies needed for facilities
- Stand-up recycling and closed-loop production capacity for solar modules in critical areas (e.g., glass, aluminum frames, argon, copper, silver, other critical metals)

Long-term Opportunities

- Investments in at-scale production facilities for advanced solar cell technologies and modules (e.g., c-Si and tandems)
- Recycling capacity for ingot / wafer

Additional Considerations

- Workforce and skill development programs

Supply Chain Investment Opportunities:

Solar – Cadmium Telluride Solar PV

Immediate Opportunities

- Invest in access, refining, and processing capacity for copper and zinc to expand availability of tellurium and cadmium—a byproduct of smelting primary metals; establish new, more efficient tellurium extraction processes at scale
- Advance capacity in cell and module manufacturing for projects with strong upstream domestic suppliers and portfolio of offtake
- Manufacturing capacity for balance-of-module components including float glass, aluminum, galvanized steel, among others
- Production capacity for balance-of-system components including inverters, power electronics, motors, among other areas
- Stand-up recycling and closed-loop production capacity for solar modules in critical areas (e.g., glass, aluminum frames, copper, cadmium, tellurium, selenium, molybdenum, other metals)
- On-shoring production of capital equipment for current generation and leading-edge technologies needed for facilities

Long-term Opportunities

- Secure access to critical minerals: fluorine, tellurium, selenium, cadmium, aluminum, tin
- Investments in at-scale production facilities for thin-film tandem solar cell and module technologies (e.g., copper indium gallium diselenide, c-Si, and perovskite tandems with CdTe top or bottom cells)

Additional Considerations

- Recycling programs with state and local governments to ensure modules have responsible end-of-life management

Supply Chain Investment Opportunities: Grid Components – Large Power Transformers

Immediate Opportunities

- Increase access to reserves, refining, and recycling capacity of copper for processing into copper windings and continuously transposed conductor
- Expansion of production capacity and quality of grain oriented electrical steel (GOES) to meet production specs of domestic laminations and cores for LPT OEMs
- Add domestic production capacity for stack / wound cores, laminations, and modular design-builds for LPTs to accelerate economy-wide electrification
- Invest in production facilities focused on manufacturing LPTs critical in moving electricity from power generation and transmission lines (e.g., step-up, step-down transformers) to the distribution network
- Prioritize facility expansions that include test beds and production lines within the same manufacturing campus
- Advanced manufacturing capacity for critical LPT components including bushings, insulating materials, tap changers, conservator systems, among other areas
- Expand recycling capacity for metals and alloys in transformers and associated electrical components supply chain

Long-term Opportunities

- Domestic production of key components for higher-rating LPTs (500 MVA+) that are currently sourced solely outside the US

Additional Considerations

- Expand opportunities for end-of-life recycling for critical materials
- Support for investments in casting and forging machines to accommodate larger widths of metals

Supply Chain Investment Opportunities: Grid Components - Distribution Transformers

Immediate Opportunities

- Expansion of production volume and quality of GOES to meet production specs of domestic laminations and cores for distribution transformers (DTs)
- Scale-up production capacity of Hi-B GOES and amorphous steel to meet high efficiency production specs of DT OEMs and utility customers
- Vertically integrated facilities producing laminations, cores, windings, and final assembly to take advantage of economies of scale
- Invest in facilities with committed offtake focused on producing standardized and/or modular design of specifications
- Promote investments in projects focused on refurbishment of DTs to meet modern specifications
- Increase manufacturing of major components including mineral oil, carbon steel, cellulose and alternative insulation materials, porcelain, tap changers, and conservator bladder

Long-term Opportunities

- At-scale production of flexible, hybrid, or solid-state transformers—across a range of distribution scale functions

Additional Considerations

- Expand opportunities for end-of-life recycling for critical materials
- Support for investments in casting and forging machines to accommodate larger widths of metals

Supply Chain Opportunities: Batteries (NMC & LFP)

Immediate Opportunities

- Securing supply of IRA-compliant upstream feedstock for critical minerals (e.g., lithium, natural graphite, nickel, cobalt).
- Delivering FOAK projects on 'unconventional' lithium resources (e.g., DLE on brines, clays).
- Increase midstream processing capacity for critical minerals (e.g., to carbonate / hydroxide, sulfates, anode-grade natural and synthetic graphite materials).
- Building out production capacity for other key intermediaries, precursors, and electroactive materials (e.g., pCAM/CAM).
- Battery reuse and recycling facilities that include recovery of metals such as lithium, nickel, cobalt, and graphite.
- Expanding available supply of critical precursor chemicals for separators and electrolyte salts (e.g., DMC, EC).
- Invest in capital equipment, tooling, and castings and forgings to improve domestic sourcing.
- Supporting technologies (e.g., dry calendaring, pre-lithiation) to improve battery performance and production throughput.

Long-term Opportunities

- Supporting the advancement of technologies that can circumvent current chemistry bottlenecks.

Additional Considerations

- Invest in projects in proximity to offtakers and end markets to gain economies of scale advantages from industrial clustering.
- Cultivating a skilled workforce necessary for a resilient supply chain.

Supply Chain Opportunities: Offshore Wind

Immediate Opportunities

- Manufacturing capacity in proximity to OSW deployment areas for blades, nacelles, towers, and monopiles as well as supporting components such as subsea cables and substation equipment.
- Shipbuilding of installation vessels and manufacturing of critical equipment / components needed for final assembly and operations.
- Expanding domestic production capacity for specialized materials (e.g., carbon fiber) and large castings and forging (e.g., flanges, bearings, etc.) to accommodate offshore wind components.
- Processing, refining, and recycling capacity for metals, alloys (e.g., manganese, chromium, niobium, and vanadium), and permanent magnets (e.g., neodymium, dysprosium).
- Production capacity for monopile-grade steel and floating platforms plates.
- Specialized equipment to increase line yield rates (e.g., mold sets, resin injection systems) and improve site installation.

Long-term Opportunities

- Availability of long-life lubricants to maintain turbines.

Additional Considerations

- Development of quayside infrastructure and wind port manufacturing facility projects.
- Production of low-carbon concrete for platform installation.

Supply Chain Investment Opportunities: Clean Hydrogen – Alkaline Electrolyzers

Immediate Opportunities

- Capacity to manufacture engineered material including anode, cathode, bi-polar plates, gas diffusion layers, stainless steel, gaskets and membrane.
- Processing and refining for raw materials including nickel (key focus), chromium, potash, and zirconium.
- Increased availability of balance of plant equipment, such as transformers and other electrical equipment.
- Investment in manufacturing and final assembly to create demand pull and accelerate progression along learning and scale curves given relatively limited production capacity today.

Long-term Opportunities

- N/A

Additional Considerations

- Copper mining and processing capacity for supporting electrical components.
- Material and manufacturing capacity of stainless steels to support hydrogen transportation and storage.

Supply Chain Investment Opportunities: Clean Hydrogen – PEM Electrolyzers

Immediate Opportunities

- Capacity to manufacture engineered material including anode, cathode, bi-polar plates, gas diffusion layers, porous transport layer, stainless steel, gaskets and membrane.
- Processing and refining for several materials including iridium (key focus), fluorspar, titanium, platinum, and carbon.
- Increased availability of balance of plant equipment, such as transformers and other electrical equipment
- Investment in manufacturing and final assembly to create demand pull and accelerate progression along learning and scale curves given relatively limited production capacity today.

Long-term Opportunities

- Exploration of alternative processes to produce membranes (vs. Nafion™ perfluorosulfonic acid) due to low capacity, high cost, and environmental risks.

Additional Considerations

- Copper mining and processing capacity for supporting electrical components.
- Material and manufacturing capacity of stainless steels to support hydrogen transportation and storage.