


U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Advanced Manufacturing Office

Multi-Year Program Plan Framework Overview - Draft

June 14, 2016

Advanced Manufacturing Office

www.manufacturing.energy.gov

Purpose of Multi-Year Program Plan (MYPP)

Transparent AMO 5- to 10-year plan that is available to internal and external stakeholders

- ✓ Clearly communicates AMO plans and priorities
- ✓ Serves as an operational guide for AMO to manage activities toward programmatic and agency goals
- ✓ Provides resource for EERE management on program priorities, activities, progress toward goals, and potential risks and barriers
- ✓ Informs Funding Opportunity Announcements (FOAs), Annual Operating Plans (AOPs), and budget formulation

AMO MYPP Key Target Audiences

- EERE and DOE Management
- Manufacturers and their Supply Chain
- Research Community: Universities, National Labs, Entrepreneurs/Makers
- Manufacturing Trade Associations and other NGOs
- Venture Capitalists and Finance Community
- State and Local Governments, Municipalities
- Other Government, including other DOE Offices, other Federal Agencies, Congress, and White House
- General Public
- International Organizations

AMO MYPP Strategic Inputs

- President's Climate Action Plan (CAP)
- 2014–2018 DOE Strategic Plan
- Advanced Manufacturing Partnership (AMP2.0)
- Quadrennial Energy Review (QER)
- Quadrennial Technology Review (QTR)
- EERE Strategic Plan
- Legislative Authority
  - P.L. 95-91, "U.S. Department of Energy Organization Act" (1977)
  - P.L. 102-486, "Energy Policy Act of 1992"
  - P.L. 109-58, "Energy Policy Act of 2005"
  - P.L. 110-140, "Energy Independence and Security Act of 2007"

MYPP Schedule

Milestone	Planned Date
AMO MYPP Off-site	Apr 14-15
AMO Peer Review MYPP Framework Presented for Feedback	Jun 14-15
Draft 1 MYPP	Jul 31
AMO/EERE Management Team MYPP Review	Aug 31
Draft 2 MYPP	Sep 30
Stakeholder MYPP Input	Nov 15
Final MYPP	Dec 31

Requests to Reviewers

The full set of targets & milestones will be emailed 6/16/16.

By 7/8/16 provide feedback on :

1. Draft AMO Vision, Mission, Strategic Goals, and Success Indicators (All of AMO activities included?)
2. Technology and Deployment areas being addressed (Critical gaps? Key advanced manufacturing challenges addressed?)
3. Draft targets and milestones (Are the targets/milestones SMART, i.e. specific, measureable, achievable, realistic, timely? Appropriate emphasis across areas?)

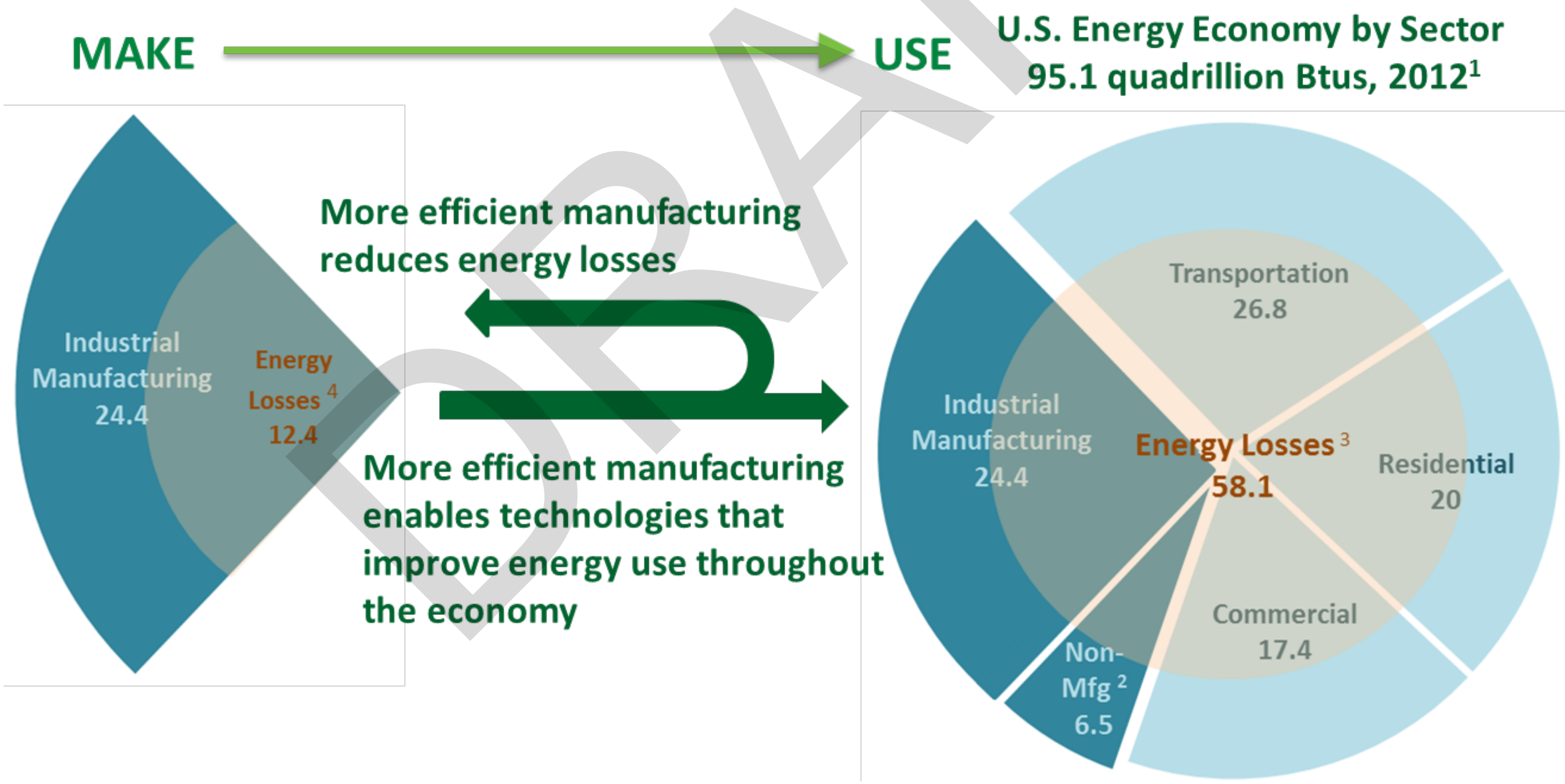
AMO Draft Vision and Mission

Draft Vision
U.S. global leadership in manufacturing for a sustainable clean energy economy.

Draft Mission
Catalyze research, development and adoption of advanced manufacturing technologies and practices to drive U.S. economic competitiveness through energy productivity.

AMO Draft Strategic Goals

- Improve the productivity and energy efficiency of U.S. manufacturing
- Reduce life cycle energy and resource impacts of manufactured goods
- Transition DOE supported innovative technologies and practices into U.S. manufacturing capabilities
- Strengthen and advance the U.S. manufacturing workforce

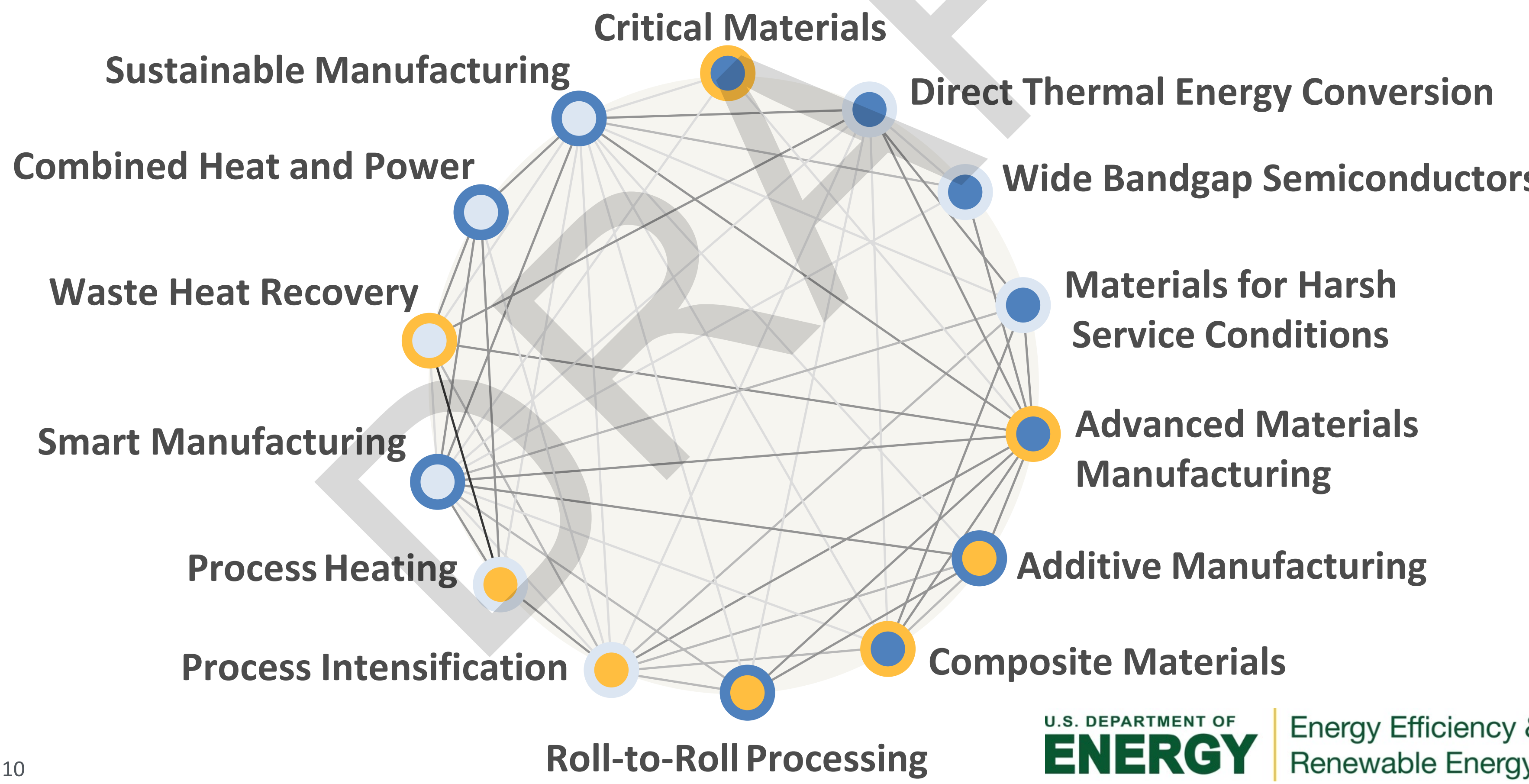


AMO Draft Success Indicators

- Demonstrate selected advanced manufacturing technologies and deploy practices that double the rate of energy intensity (energy consumed per unit of physical output) improvement compared to current typical technology
- AMO supported advanced materials, manufacturing technologies and targeted end use products have the potential to reduce lifecycle energy impact by 50% by 2025 compared to current state-of-the-art.
- 25% of U.S. manufacturing facilities implement AMO energy management products, practices and measures by 2025.
- Double AMO supported technical education and training in advanced manufacturing made available for Engineering Universities, Community Colleges, and Technical High Schools by 2025.

Technology Areas based on QTR

Manufacturing Systems – Unit Operations	Production / Facility Systems – Energy and Resource Utilization	Beyond the Plant Boundaries – Supply Chain and Life Cycle



Technology + Deployment Areas

A. Manufacturing Systems/Unit Ops *Equipment used for manufacturing process and non-process unit operations*	1. Additive Manufacturing 2. Process Heating 3. Process Intensification 4. Roll-to-Roll Processing
B. Production/Facility Systems *Equipment, process flow, and energy strategies that comprise a goods-producing facility*	1. Combined Heat and Power Systems 2. Waste Heat Recovery Systems 3. Smart Manufacturing 4. Sustainable Manufacturing
C. Supply Chain Systems *Network of facilities and operations involved in moving materials through industry, from extraction of raw materials to the production of finished goods*	1. Advanced Materials Manufacturing 2. Composite Materials 3. Critical Materials 4. Direct Thermal Energy Conversion 5. Materials for Harsh Service 6. Wide Bandgap Semiconductors
D. Practices *Technology assistance and workforce development*	1. Industrial End User Technical Assistance 2. Workforce Development

Additive Manufacturing

Objective: Develop additive manufacturing (AM) technologies that (1) increase the reliability at which parts can be produced at specifications required by industry, (2) increase the range of high-performing materials, and (3) advance the characterization of AM—in order to reduce life cycle energy use and enable more innovative products compared to conventional manufacturing methods.

#	TARGET	FISCAL YEAR
A1.1	Demonstrate AM components whose physical properties and cost/value outperform conventionally produced parts by 20% in specific applications.	2021
	➢ A1.1.1 Develop polymer materials designed for composite tooling and autoclave survivability.	2017
	➢ A1.1.2 Develop a nickel superalloy suitable for gas turbine applications with high temperature stability and good performance.	2018
	➢ A1.1.3 Develop AM, bio-derived reinforced polymers with specific strengths equal to or higher than 6000 series aluminum alloys.	2019
	➢ A1.1.4 Develop a suite of computational tools, new high temperature alloys, and optimized designs based on microstructure control.	2020
	➢ A1.1.5 Develop new aluminum alloys designed for additive manufacturing with mechanical properties appropriate for automotive and aircraft applications.	2020

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Additive Manufacturing, continued

#	TARGET	FISCAL YEAR
A1.2	Develop rapid methodologies (e.g. incorporating in-situ measurement, data frameworks, analysis, and visualization tools) to qualify and certify AM components as they are built, at 50% of the current typical cost of certification.	2021
	➢ A1.2.1 Demonstrate rapid qualification methodologies for electron beam powder melt processing of Ti alloys with automatic defect detection and process evaluation from in-situ process metrology.	2017
	➢ A1.2.2 Extend qualification tools to incorporate the characterization data emerging from coordinate measurement, nondestructive tomography, and optical and electron microscopy characterization.	2018
	➢ A1.2.3 Extend tools to incorporate machine learning and the spatial- temporal measurement of thermal measurements, and ex-situ characterization of residual stress and distortion.	2019
	➢ A1.2.4 Extend qualification tools to import results from computational modeling for a complex geometry.	2020
	➢ A1.2.5 Deploy rapid qualification tools to the collaborating organizations for the powder-bed metal AM process and explore the generality of the same.	2021

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Additive Manufacturing, continued

#	TARGET	FISCAL YEAR
A1.3	Develop AM systems that deliver consistently reliable parts with predictable properties and defect detection to six standard deviations (“six-sigma”) for specific applications.	2021
	➢ A1.3.1 Demonstrate full closed loop control with error detection, QA/QC on CI-BAAM.	2017
	➢ A1.3.2 Demonstrate manufacturing of both multi-material and metal CI-BAAM (Cincinnati Incorporated Big Area Additive Manufacturing) on parts that exceed 1000 lb.	2018
	➢ A1.3.3 Achieve six sigma process reliability on AM systems.	2019
	➢ A1.3.4 Develop the tool path generation software and kinematic system capable of 5-axis AM without the need for support structures and with variable nozzle size for surface finish.	2020
	➢ A1.3.5 Develop and demonstrate a large scale hybrid AM system capable of 5 axis manufacturing of multiple materials (polymer, carbon fiber and metal).	2021

Process Heating

Objective: Develop alternative low thermal budget technologies that reduce the energy requirements of materials processing and improve processes and products.

#	TARGET	FY
A2.1	Develop low thermal budget (LTB) unit operation/manufacturing technologies that reduce energy intensity (energy consumed per unit of physical output) by at least 50% compared to current typical technology.	2025
	➢ A2.1.1 Evaluate the current breakdown - by application and equipment - of the 7 Quads of U.S. energy use in process heating, to estimate the energy savings potential and identify technologies with the potential to provide a >50% energy intensity improvement.	2018
	➢ A2.1.2 Develop LTB electromagnetic (EM) energy sources to improve upon and/or replace current thermal-based heating/drying/curing processes.	2025
	➢ A2.1.3 Develop advanced materials characterization techniques and multi-physics modeling related to advanced process heating methods and associated manufacturing platforms (sensors/models/controls) to enable robust operation and automatic process control.	2025
A2.2	Develop advanced process heating unit operations that provide improved properties, quality, and/or product value at cost parity to conventional techniques.	2025
A2.3	Drive greater uptake of state-of-the-art process heating technologies and improvements via socialization of the Process Heating Sourcebook, the Process Heating Assessment and Survey Tool (PHAST) and trainings, and greater focus on process heating at the IACs.	2025

Process Intensification

Objective: Research and develop technologies that significantly improve industrial process productivity and energy efficiency through optimized molecular level kinetics, thermodynamics, and heat and mass transfer.

#	TARGET	FY
A3.1	Develop process intensification technology with an order of magnitude energy intensity (kJ/kg) improvement relative to 2016 current typical technology.	2030
	➢ A3.1.1 Demonstrate process intensification technology at pilot-scale with >20% energy intensity (kJ/kg) improvement relative to 2016 current typical technology.	2025
A3.2	Develop modular process intensification technology that doubles energy productivity (economic output per unit energy input).	2030
	➢ A3.2.1 Demonstrate at pilot scale at least one modular chemical process that has a 10x reduced capacity cost ($/(kg per day)) with improved energy intensity (kJ/kg) and 20% lower emissions and/or 20% lower environmental waste (kg waste/kg product) relative to commercial state-of-the-art technology.	2025
A3.3	Develop tools and technologies to deploy modular chemical process intensification in selected existing processes at cost parity.	2030
	➢ A3.3.1 Develop tools and technologies to reduce the cost to deploy modular chemical process intensification in selected existing processes by 50%.	2025

Process Intensification, continued

#	TARGET	FY
A3.4	Develop technologies that optimize catalyst selectivity, activity and stability and enable at least 20% improvements in energy intensity compared to 2016 state-of-the-art technology.	2030
	➢ A3.4.1 Develop selective active site catalysts to handle diverse feedstock streams to produce only the class of products desired at conversion rates >40%.	2030
	➢ A3.4.2 Develop methane direct activation catalysts that will convert natural gas from remote and stranded sources to liquid fuels or chemicals at conversion rates > 40%.	2030
	➢ A3.4.3 Develop oxygen-air separation catalysts that will produce a 99% pure oxygen stream at a 50% reduction in capital costs compared to 2016 2016 state-of-the-art technologies.	2030
	➢ A3.4.4 Develop water splitting catalysts that will produce hydrogen at a 50% reduction in capital costs compared to 2016 2016 state-of-the-art technologies.	2030

Roll-to-Roll Processing

Objective: Develop technologies to reduce cost, increase precision, and enable in-line quality control and defect detection, resulting in expanded use of roll-to-roll processing to produce clean energy technologies.

#	TARGET	FY
A4.1	Develop technologies to reduce the cost of continuous R2R manufacturing processes for selected products (e.g., water, fuel cells, and other electronic membranes) by 50% compared to current typical technology.	2025
	➢ A4.1.1 Increase the throughput of R2R processes by 5 times for batteries/capacitors and 10 times for printed electronics	2020
	➢ A4.1.2 Develop resolution capability to detect, align and co-deposit multiple layers of coatings, and print <1 µm features using continuous processes at full commercial size-scale.	2025
	➢ A4.1.3 Develop scalable and reliable R2R processes for solution deposition of ultra-thin (<10 nm) films for active and passive materials.	2025
A4.2	Develop in-line instrumentation tools that will evaluate the quality of materials in-process with respect to final product performance against specifications.	2025
	➢ A4.2.1 Develop in-line quality control technologies to identify defects during continuous processing at size-scales of <1 µm at 300 ft/min for R2R processing in air, and <10 nm at 20 ft/min for vacuum processing.	2025

Combined Heat and Power Systems

Objective: Develop CHP technologies that reduce on-site engineering, increase fuel flexibility, enable grid integration, and fit the needs of a larger variety of users, in order to accelerate deployment and reduce fuel use and greenhouse gas emissions through improved efficiency over traditional separate electric power and thermal energy systems.

#	TARGET	FY
B1.1	Support 20% reduction in installed cost of commercially available, packaged (<10 MW) CHP systems (while maintaining >75% system efficiency at higher heating value (HHV)).	2025
	➢ B1.1.1 Partner with at least 25 vendor allies to create a robust eCatalog of at least 100 preapproved and warranted packaged CHP systems with service agreements to be used in multiple markets.	2025
	➢ B1.1.2 Establish fifteen utility / state market mover partners.	2025
B1.2	Advance the development of CHP systems that are responsive to grid requirements.	2030
	➢ B1.2.1 Develop cost-effective 1-20 MW CHP systems capable of automatically providing capacity response and other ancillary market support to the electrical grid (with >75% efficiency at HHV).	2024
	➢ B1.2.2 Develop cost effective high power to heat (P/H) ratio CHP systems with >65% electric generation efficiency, >75% system efficiency (HHV), and P/H >= 1.5.	2026

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Combined Heat and Power Systems, cont'd

#	TARGET	FY
B1.3	Provide resources that lead to 20GW of installed capacity of CHP nationwide.	2030
	➢ B1.3.1 Increase by 50% deployment of cost effective CHP systems that are fueled with renewable and opportunity fuels (with >75% efficiency at HHV).	2030
	➢ B1.3.2 Support the doubling of utilities that own/incent CHP as part of their business model.	2030
	➢ B1.3.3 Introduce over 75% of high technical potential commercial/industrial markets to CHP and waste heat to power opportunities.	2030
	➢ B1.3.4 Conduct CHP assessments for at least 50% of target markets with most significant CHP technical potential.	2025
	➢ B1.3.5 Establish 100 Partnerships with cities, states and utilities to encourage the usage of CHP.	2025
	➢ B1.3.6 Develop resources used by at least 5 utilities/planners that increase the synergy between CHP and microgrids and renewables including smart control systems.	2025

Waste Heat Recovery Systems

Objective: Develop waste heat recovery systems and associated technologies that enable the cost-effective capture and use of energy from waste heat in order to reduce overall energy demands of manufacturing facilities.

#	TARGET	FISCAL YEAR
B2.1	Develop reliable systems that enable waste heat recovery from high-temperature (>650°C), low-temperature (<230°C), and heavily contaminated industrial waste heat streams, demonstrating cost effectiveness via a calculated payback period of less than 2 years.	2030
	➢ B2.1.1 Develop lower cost, reliable pre-treatment technologies for waste heat recovery systems to remove contaminants from hot input streams (e.g. flue gas).	2020
	➢ B2.1.2 Develop reliable advanced waste heat recovery system that uses low temperature (<230°C) waste heat with a calculated payback period of less than two years.	2025
	➢ B2.1.3 Develop reliable advanced waste heat recovery system for high temperature range (>650°C) suitable for harsh service conditions at a projected installed cost of $1000/kW.	2025

Sustainable Manufacturing

Objective: Develop technologies and tools to improve resource efficiency to lower the life cycle impacts of manufactured products.

#	TARGET	FY
B3.1	Develop material reuse, recycling, remanufacturing and/or reprocessing technologies that enable an absolute increase in recycling rate* by 30% of select energy-intensive materials.	2025
B3.2	Develop tools and technologies to reduce the cost of using recycled feedstocks in existing processes to cost parity (including energy) with primary feedstocks.	2025
B3.3	Develop technologies and targeted end use products that have the potential to improve material efficiency compared to current state-of-the-art.	2025
B3.4	Develop technologies and targeted end use products that have the potential to reduce water intensity compared to current state-of-the-art.	2025

*Absolute recycling rate relates to within the manufacturing system

"Smart Manufacturing": Advanced Sensors, Controls, Platforms, & Modeling

Objective: Develop advanced sensors, controls, platforms and modeling technologies that are interoperable, secure, and able to function under the harsh conditions specific to certain manufacturing facilities, while also making these systems less expensive to deploy than current technology, in order to aggressively reduce the energy intensity of complex processes through data collection and optimization.

#	TARGET	FISCAL YEAR
B4.1	Develop advanced sensors, controls, platforms, and models for Smart Manufacturing that reduce energy intensity (energy consumed per unit of physical output) by 15% compared to current typical technology.	2025
B4.2	Reduce the cost of advanced sensors, controls, platforms, and models for Smart Manufacturing in existing processes by 50% compared to current typical technology.	2025

Advanced Materials Manufacturing

Objective: Accelerate the research, development, and deployment of new materials, in order to integrate these materials into advanced clean energy technologies.

#	TARGET	FY
C1.1	Develop structural materials with increased strength to weight ratio by 20% that are cost-competitive with existing commercial products.	2025
	➢ C1.1.1 Produce a coil of advanced high strength steel with a minimum tensile strength of 1200 MPa and minimum elongation of 15%.	2017
	➢ C1.1.2 Produce a coil of advanced high strength steel with a minimum tensile strength of 1500 MPa, achieving a continuous processing rate of 8 feet per minute.	2019
	➢ C1.1.3 Develop cold formable advanced high strength steel with a minimum tensile strength of 1800 MPa and a >30% cost and weight reduction over conventionally produced steels.	2021
	➢ C1.1.4 Prototype an automotive part using 1500 Flash Bainite	2018

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Advanced Materials Manufacturing, continued

#	TARGET	FY
C1.2	Develop materials with 50% improved thermal or electrical conductivity.	2025
C1.3	Develop a range of new process technologies that can produce kilogram-scale atomically precise products for order-of-magnitude performance improvements and Quad-scale impact on national energy consumption.	2030
	➢ C1.3.1 Develop a new class of separation membrane materials (which achieve thicknesses below 10 nm, incorporate molecular pores for 100% selectivity, are atomically flat, and are strongly cross-linked) to increase permeance by 10X over state-of-the-art polymer membranes.	2020
	➢ C1.3.2 Develop a new class of atomically precise catalysts for 10,000x improvements in catalytic activity compared to state-of-the-art catalysts, with energy consumption less than 25% over the theoretical limits.	2025
	➢ C1.3.3 Develop a sustained program to design and construct nanosystems for automated, programmable, atomically precise manufacturing using positional assembly (“molecular additive manufacturing”).	2030
	➢ C1.3.4 Develop molecular additive manufacturing technologies able to produce materials near their theoretical strength (10X above state-of-the-art) for transportation applications.	2030

Composite Materials

Objective: Develop and demonstrate technologies that (1) reduce embodied energy and GHG emissions and (2) reduce cost to be competitive with current materials and manufacturing methods, to enable the widespread use of composite materials in clean energy applications such as vehicles, wind turbines, and compressed gas storage.

#	TARGET	FY
C2.1	Reduce production cost of finished carbon fiber composite components for targeted clean energy applications by 50% compared to 2015 state-of-the-art technology.	2025
	➢ C2.1.1 Develop an automotive-grade carbon fiber (minimum 25 MSI stiffness and 250 ksi tensile strength) at pilot scale with >10% full scale modeled cost reduction.	2018
	➢ C2.1.2 Fabricate 40L compressed gas carbon fiber storage tanks in less than 30 minutes.	2018
	➢ C2.1.3 Produce 1000 lbs. of lignin-based carbon fiber matte that can be chopped and used as high temperature thermal insulation and can be produced at ≤$5/lb.	2019
	➢ C2.1.4 Develop an automotive-grade carbon fiber (minimum 25 MSI stiffness and 250 ksi tensile strength) at pilot scale with >50% full scale modeled cost reduction.	2020
	➢ C2.1.5 Reduce need for hand lay-up and reduce cycle time on large composite structures by 50% compared to 2016 current typical component technology.	2023

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Composite Materials, continued

#	TARGET	FY
C2.2	Develop composite molding manufacturing process with <90 second part-to-part cycle time for a structural component with surface area >0.5m^2	2020
	➢ C2.2.1 Develop automated molding process for thermoset system with cycle time <90 seconds at laboratory scale.	2018
	➢ C2.2.2 Develop automated molding process for thermoplastic system with cycle time <90 seconds at laboratory scale.	2019
C2.3	Develop technologies that reduce embodied energy and manufacturing GHG emissions of carbon fiber reinforced polymer (CFRP) by 75% compared to 2015 current typical technology.	2025
	➢ C2.3.1 Demonstrate low waste textile preforming process optimizing material use and reducing embodied energy of the component.	2018
	➢ C2.3.2 Develop a low-cost manufacturing process for carbon fibers using Joule heating of PAN/carbon nanotube precursors, and demonstrate potential to reduce energy consumption by 25%.	2019
	➢ C2.3.3 Demonstrate an induction-based CFRP out-of-autoclave forming and curing process for aerospace applications that yields energy savings >25%.	2019
	➢ C2.3.4 Develop process for composite manufacturing using new lower energy carbon fiber resulting in 50% embodied energy reduction.	2020

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Composite Materials, continued

#	TARGET	FY
C2.4	Demonstrate technologies at pilot scale that recycle or reuse >80% of fiber reinforced polymer composites into useful components with projected cost and quality competitive with virgin materials.	2020
	➢ C2.4.1 Determine feasibility of carbon fiber thermoplastic pultruded spar caps for wind blades.	2017
	➢ C2.4.2 Use recovered end of life carbon fibers (>50% of original material) into prototype part and evaluate feasibility and business case for reuse of carbon fibers.	2018
C2.5	Develop fiber reinforced polymer composites with projected cost and embodied energy parity with current typical glass fiber composites and with performance of carbon fiber composites.	2025
	➢ C2.5.1 Establish processing capabilities for biobased or natural fibers with (1) ash content below 500 ppm, (2) room temperature thermal conductivity < 0.35 W/m-K, and (3) flexural strength > 1 Mpa.	2019
	➢ C2.5.2 Complete analysis to identify remaining technical challenges and opportunities in the composites space.	2021

Critical Materials

Objective: Support the increased and consistent availability of materials essential to clean energy applications by diversifying the supply, developing substitutes, and improving reuse and recycling of materials deemed critical.

#	TARGET	FY
C3.1	Develop processing technologies for neodymium and other critical materials needed to meet U.S. clean energy deployment goals.	2025
	➢ C3.1.1 Develop enhanced beneficiation, leaching and extraction of rare earth elements from phosphate processing streams that would be capable of meeting 50% of 2011 U.S. neodymium demand.	2018
	➢ C3.1.2 Develop a new or improved technology for beneficiation of rare earth ores, improving recovery from 60% to 75%.	2018
	➢ C3.1.3 Develop processes or extractants to improve adjacent lanthanide separation factors to enable a 33% reduction in separation, operation and capital costs compared to current typical technology.	2018
	➢ C3.1.4 Demonstrate a new material or process employing cerium with the potential to increase usage of this metal by 20% compared to 2011 demand.	2018
C3.2	Develop a new phosphor that requires 10x less critical rare earth elements from fluorescent lamp phosphors.	2020
	➢ C3.2.1 Perform analysis on potential critical materials in LEDs	2018

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Critical Materials, continued

#	TARGET	FY
C3.3	Develop substitute materials for rare earth permanent magnets that exhibit properties similar to current magnets, but contain 10x less rare earth/critical materials than 2016 state-of-the-art materials.	2025
	➢ C3.3.1 Develop a substitute permanent magnet that exhibits properties similar to current neodymium-iron-boron magnets but containing 50% less critical rare earth content than current typical technology.	2018
	➢ C3.3.2 Fabricate functionally graded magnets with at least comparable energy density relative to current typical technology.	2018
	➢ C3.3.3 Identify a rare-earth poor ferromagnet with a Curie temperature > 400K, a magnetic susceptibility > 1 MA/m, and magneto-crystalline anisotropy > 3 MJ/m^3.	2018
C3.4	Recover and recycle materials from end-of-life (EOL) products and manufacturing waste to increase domestic availability of critical materials for clean energy technologies by 20%.	2025
	➢ C3.4.1 Develop a process to disassemble and recover the rare earth magnet within a hard disk drive, with processing time <1s per hard drive.	2018
	➢ C3.4.2 Develop electro-recycling and pyroprocessing technologies that involve cell design and limited oxidation of scrap materials for recovery of selected critical materials from consumer products with potentially upgraded partially oxidized materials.	2018
	➢ C3.4.3 Demonstrate dispersion-free supported liquid membrane solvent extraction for the separation, concentration, and recovery of critical rare earth elements.	2018

Direct Thermal Energy Conversion Materials, Devices, and Systems

Objective: Develop improved materials, devices, and systems that directly convert energy from one form to another (e.g., waste heat to electricity) without intermediate steps, in order to realize life cycle benefits.

#	TARGET	FISCAL YEAR
C4.1	Develop a thermoelectric generator (TEG) with 30% energy efficiency.	2020
C4.2	Develop a direct thermal energy conversion system with modeled deployment cost of less than $1/watt.	2025

Materials for Harsh Service Conditions

Objective: Increase the durability and reduce the cost of materials and components operating in harsh environments (e.g. high temperature; corrosive) to enable technologies that lower energy use and greenhouse gas emissions.

#	TARGET	FY
C5.1	Develop advanced materials to reduce natural gas leakage from compressor and rotary equipment by 50% as compared to 2016 current typical technology.	2025
	➢ C5.1.1 Complete bench-scale testing of surface modified natural gas rod packing seal materials with ≥25% improvement in wear life compared to conventional fluoropolymer-based (e.g., Teflon™) composite materials.	2016
	➢ C5.1.2 Complete full-scale component level testing of modified natural gas rod packing seals with ≥25% improvement in wear life compared to conventional fluoropolymer-based (e.g., Teflon™) component materials.	2017

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Materials for Harsh Service Conditions, continued

#	TARGET	FY
C5.2	Develop materials for high temperature and pressure steam turbine operation to enable a 100°F increase in service temperature compared to 2016 current typical technology and at cost parity.	2025
	➢ C5.2.1 Develop tailored powders for additive manufacturing to produce materials for high temperature and pressure high value applications such as power generation turbine blades.	2017
C5.3	Develop coatings, surface treatments, and tailored surface layers that provide 50% improvement in wear resistance compared to selected current typical components.	2025
	➢ C5.3.1 Conduct analysis that identifies major opportunities to transfer seal surface treatments to other high value high wear crosscutting applications such as for gears and other rotary equipment and identify pathways to 50% improvement in wear life.	2019

Wide Bandgap Semiconductors for Power Electronics

Objective: Develop wide bandgap (WBG) semiconductor devices, technologies, and applications that result in improvements in energy efficiency and accelerate the adoption of clean energy technologies.

#	TARGET	FY
C6.1	Reduce volume and weight of targeted electrical devices by 50% with respect to their silicon-based equivalent.	2020
C6.2	Increase the efficiency of targeted electrical devices by 3% with respect to their silicon-based equivalent.	2020
C6.3	Demonstrate a 3x improvement in the reliability of targeted electrical devices over their silicon-based equivalent.	2020
C6.4	Develop near-zero energy loss electric machines.	2020
	➢ C6.4.1 Develop a 1MW electric motor, operating at 15,000 rpm, driven by a WBG based, medium voltage, variable speed drive, with a minimum efficiency of 93%.	2020

Industrial End User Technical Assistance

Objective: Provide technical assistance (TA) to large energy users that optimize energy use, reduce emissions, establish energy management systems and increase productivity resulting in a doubling of business as usual (BAU) energy performance.

#	TARGET	FY
D1.1	Expand TA partnership to 25% of large energy user footprint.	2025
	➢ D1.1.1 Expand the Better Plants program to 300 or more partners.	2020
	➢ D1.1.2 Develop and deploy resources to facilitate cyber security vulnerability as part of industrial energy assessments for manufacturers.	2025
	➢ D1.1.3 Educate 50% of Public Utility Commissions across the country on opportunities to design effective energy efficiency programs for the industrial customer including utilizing strategic energy management.	2020
	➢ D1.1.4 30 States implement state and/or ratepayer-funded programs to reduce industrial energy intensity utilizing strategic energy management and other resources.	2025

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Industrial End User Technical Assistance, cont'd

#	TARGET	FY
D1.2	Catalyze a 5x increase in the number of ISO 50001 certified or conformant facilities.	2030
	➢ D1.2.1 25% of Better Plant partner facilities have implemented eGuide related DOE certifications.	2025
	➢ D1.2.2 One thousand (1000) or more U.S. industrial, commercial, institutional and water/wastewater facilities achieve ISO 50001 Conformance or Superior Energy Performance (SEP) certification.	2030
	➢ D1.2.3 eGuide related DOE certifications or SEP certification are accepted as an option for industrial opt-out, self-direct, or to meet regulatory requirements in 15 or more state compliance plans.	2030
	➢ D1.2.4 All IACs have recruited at least 20% of their clients to implement the AMO eGuide related DOE certifications.	2025

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Industrial End User Technical Assistance, cont'd

#	TARGET	FY
D1.3	Support the doubling of energy productivity within our partnerships.	2025
	➢ D1.3.1 Complete the modernization of the AMO energy system software tool suite and associated training resources and make 100% of these resources accessible online and in open source environment.	2020
	➢ D1.3.2 Demonstrate advanced manufacturing technologies in 75 Better Plants facilities.	2022
	➢ D1.3.3 At least 50% of annual IAC clients demonstrate effective use of AMO online resources and outreach materials as measured by IAC client follow up.	2020
	➢ D1.3.4 Launch and publicize a suite of online resources and materials customized for small and medium-sized manufacturers	2019
	➢ D1.3.5 Reduce industrial energy intensity of small and medium-sized manufacturers by 25%	2025

Workforce Development

Objective: Develop skills and increase career pathways (primary, community college, university, on-the-job) to increase number of qualified technical employees in advanced manufacturing.

#	TARGET	FY
D2.1	Train at least 1,000 individuals per year in advanced manufacturing technologies and solutions, including energy management practices.	2025
	➢ D2.1.1 Train at least 50 trainers per year in advanced manufacturing technologies for clean energy, including energy management practices.	2020
	➢ D2.1.2 Train 400 engineering students per year at ABET accredited universities.	2020
	➢ D2.1.3 Train 500 individuals per year in energy system optimization and energy management online and classroom.	2022
	➢ D2.1.4 Train 300 people in-person through In-Plant curriculum.	2022

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Workforce Development, cont'd

#	TARGET	FY
D2.2	Develop or advance 15 workforce curricula focused on manufacturing energy systems and advanced technologies	2030
	➢ D2.2.1 Establish a B.S. in Energy Engineering at 50 schools	2030
	➢ D2.2.2 Implement traineeships and workforce development activities at Virginia Tech focused on WBG semiconductors	2020
	➢ D2.2.3 Implement traineeships and workforce development activities at University of Tennessee focused onWBG semiconductors	2020
	➢ D2.2.4 Develop energy system and CP EnMS curricula	2021

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