Pacific Northwest
NATIONAL LABORATORY

PI Introduction to PNNL Technology Tracking

Technology Tracking Team

Pacific Northwest National Laboratory

PNNL-SA-223417

U.S. DEPARTMENT OF ENERGY BATTELLE

PNNL is operated by Battelle for the U.S. Department of Energy



What is Technology Tracking?

Procedures and processes used in gathering information on research and development (R&D) projects funded by DOE including:

- Technology development
- Commercialization
- Energy, environmental, and economic benefits
- Technical and manufacturing readiness levels

Technology tracking data uses:

- Program performance and results (GPRA[1])
- Support DOE Office program missions and goals
- Return on DOE R&D Investments
- Budget defense
- Institutional memory
- Strategic planning & management of R&D programs

PNNL Tracking History

- *PNNL Tracking since 1980*
- *Tracking over 3,000 projects*
- *Industry/Manufacturing (AMO, AMMTO, IEDO)*
- *Bioenergy (BETO) Buildings (BTO) Geothermal (GTO) Hydrogen & Fuel Cells (HFTO), Vehicles (VTO) Wind (WETO)*
- *Integrated Strategies Office (ISO) - DOE wide impact evaluations using PNNL's prior work[2].*

Public access to this data has been in the form of DOE factsheets and annual reports

1. *The Government Performance and Results Modernization Act of 2010 detailed over 150 changes to the 1993 Government Performance and Results Act.*
2. *PNNL Technology Tracking portfolio to include SBIR/STTR and DOE funded projects.*

PNNL Technology Tracking – Golden Rules

- PNNL **will not** request:
  - Business confidential information
  - Business sensitive information

- PNNL **is not** involved with
  - Project Go-No-Go Decisions
  - DOE Funding Decisions

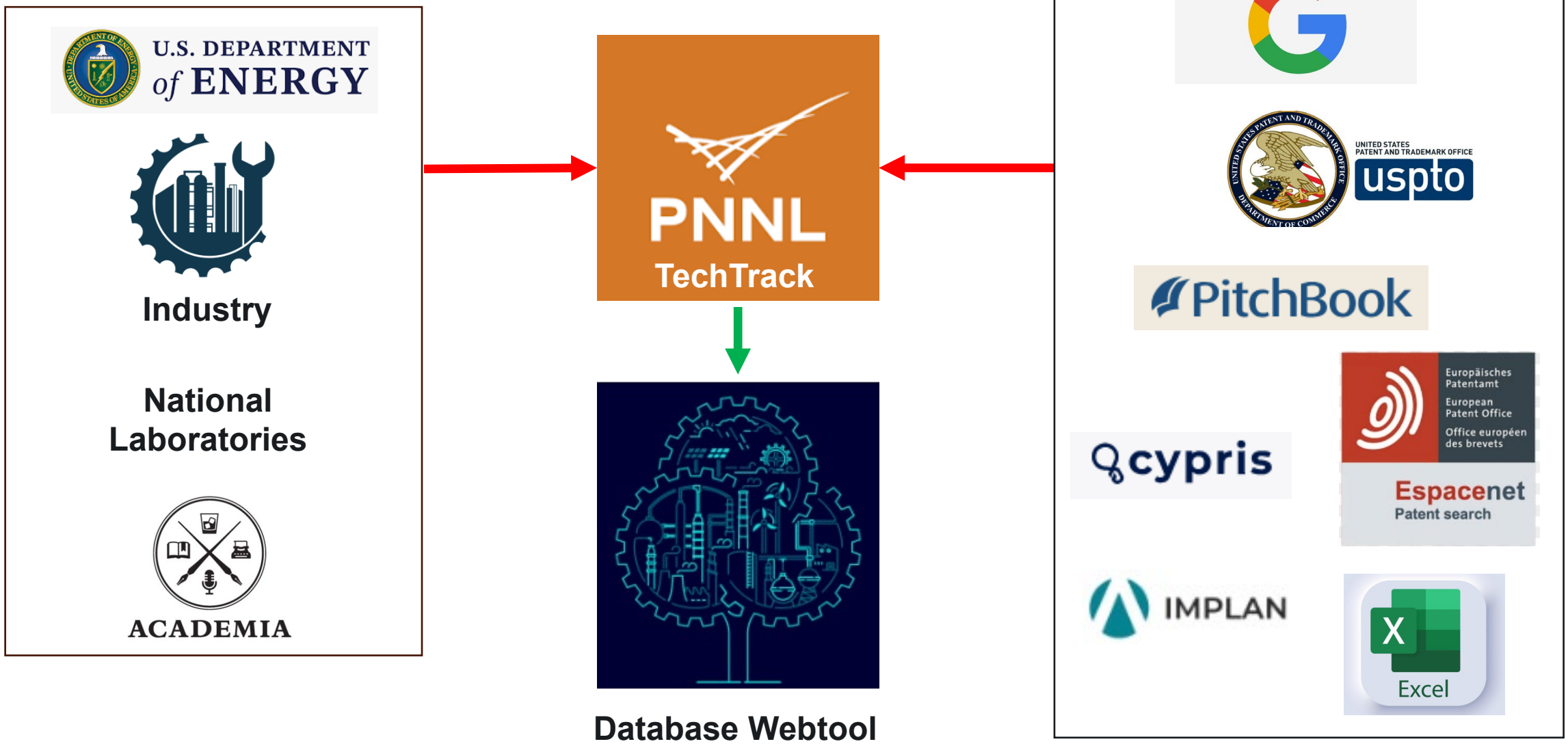
Technology Tracking
DATA GATHERING PROCESS

Data gathered from public domain, and POCs/PIs as needed

- Technology Title/Summary
- Original Technology Developer and Partners
- Current Technology Owner/Developer/Distributer
- Applications
- Technical Description
- Graphics/Photographs
- Capabilities
- Benefits (Qualitative & Quantitative)
- Year Developed
- Year Commercialized
- Year 1st Funded
- Installations/Units Sold
- Energy Savings
- Technology History
- Marketing Information
- Patents, Trade Pubs & Journals

Note: Addition information could be gathered as requested or needed

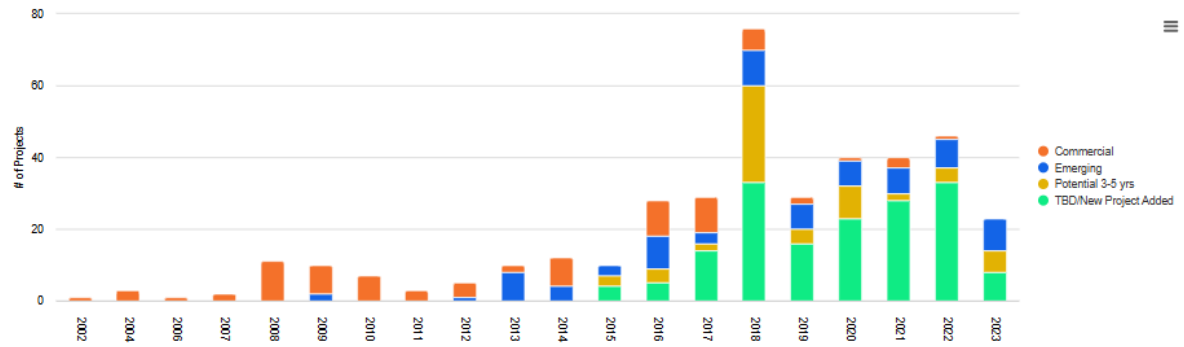
Technology Tracking Data Flow



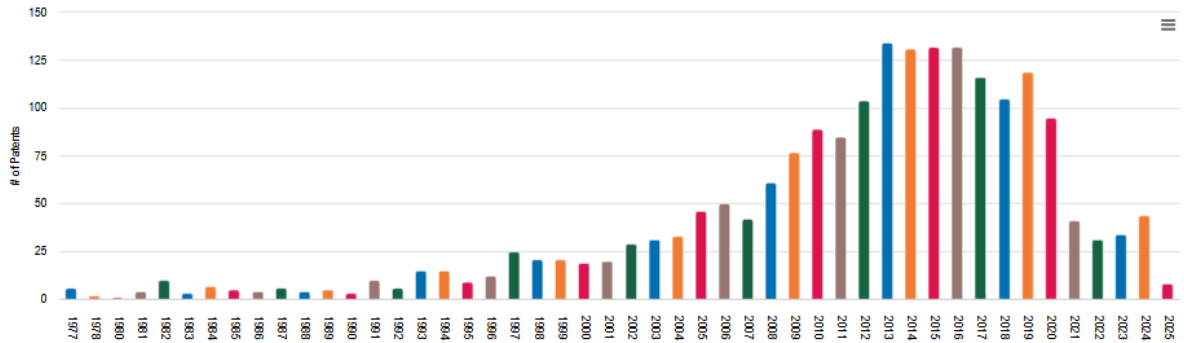
Technology Tracking Database Webtool

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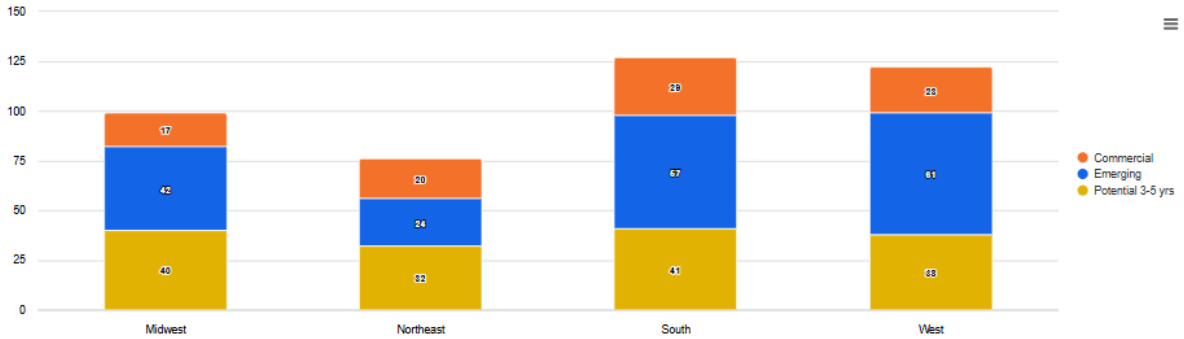
Tracked Projects by Award Date and Status



Patents Awarded by Year



Tracked Projects by Status and Census Region



About the Technology Tracking Database



Research and development (R&D) investments by the U.S. Department of Energy (DOE) spur technology innovation and assist industry in overcoming some of the greatest technical challenges in energy technology development. DOE funds R&D with competitively selected industry partners to address the research and technical challenges industry could not or would not achieve on their own, or in the same timeframe. In addition, DOE provides R&D funding to competitively selected universities and to DOE national laboratories to tackle high-risk R&D challenges.

This web portal contains data on the Advanced Materials and Manufacturing Technologies office's (AMMTO) R&D funded projects and resulting technology developments, including near-market and commercial technologies, over the period 1976—2024. A commercial technology is defined as an invention or intellectual property that is developed into a technology (hardware, software, methods, or processes) and enters the market as "first sale," "in-use in a production application," or "sale of a commercial license." Near-market technologies are defined as technologies that are projected to be commercialized in less than 5 years. (e.g. Technical Readiness Levels (TRLs) and Manufacturing Readiness Levels (MRLs) 1-8).

The information in this database is current as of Fiscal Year 2025, and includes technologies that are tracked for AMMTO using a methodology that links technologies to specific AMMTO-funded projects, and verified with the technology developers annually for up to 10 years. Pacific Northwest National Laboratory (PNNL) maintains this data for this database.

This database is not comprehensive, however, PNNL has endeavored to capture whenever possible, technologies resulting from DOE national laboratory R&D, where the R&D funding source DOE or non-DOE may be unclear. Also included, where AMMTO program funding and collaboration has been identified, are technologies resulting from Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) programs.

Users of this web portal can select any combination of search filters:

- AMMTO Pillar, Focus Area and Subprogram
- Project Title
- Project lead and partner organizations
- Keyword search

From your selection, you will be provided with a listing of identified technologies and have the options to:

- Select any individual technology to view and download pertinent information e.g. factsheets or final reports.
- Download the search results in a formatted spreadsheet.

Phased Rollout Plan
DOE -> PIs-> Public Access

Technology Tracking Database - Input

1. PNNL Technology/Project Due Diligence
2. **PNNL-PI Meetings***
3. PNNL drafts article
4. PI/Organization Review & Approve
5. PNNL input to database

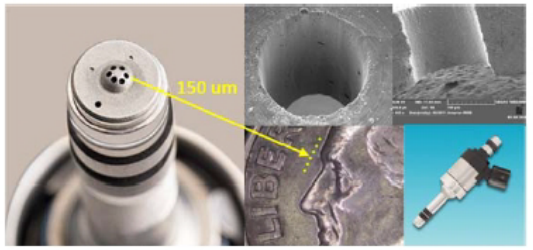
High Metal Removal Rate for Machining Difficult Materials

Laser Machining Platform for Producing High-Precision Components

Machining is the broad term used to describe the removal of material from a part by one or several operations involving cutting, grinding, or other non-traditional methods, such as chemical, electrical, or fluid jet cutting. Demand for machined components that meet higher and more stringent standards of performance and precision have resulted in multiple machining advancements in tooling, computer control (CNC), 2-D and 3-D CAD software, and interface platforms. Unfortunately, there are limits to machining small parts with complex shapes and micron-sized features with high accuracy. When machining smaller features, the material properties, the heat generated, and the material removal method can greatly affect the quality and precision of the produced part.

Delphi Automotive Systems, LLC, with assistance from AMO, has developed an automated, ultrafast laser machining device to produce gasoline direct injection (GDi) fuel injector seats. Recent interest in GDi injector development has been driven by future legislations for CO_2/fuel consumption and emission reductions. These performance requirements have led to the need for precise fuel delivery and complex injector head design, including hole shape and pattern. Delphi uses their developed laser manufacturing process to add precisely patterned and shaped holes to the injector seat. The use of ultrafast (femtosecond) lasers overcomes the limitations of machining advanced materials into high-precision components. Short laser pulses can use thermal ablation to produce a part without requiring post-processing, eliminating machining defects. This machining platform removes material with micron precision, without modification or damage to the remaining material, in a single-step manufacturing process. The laser system and process reduces cost and allows flexibility in hole placement, resulting in highly precise production parts. The system accommodates CAD input which allows rapid prototyping of new developing specifications for GDi components.

Delphi has deployed laser machining into their GDi fuel injector seat production; initial results have demonstrated 67% energy savings compared to electrical discharge machining (EDM). Delphi's collaborators are further developing the technology for electronic and biomedical manufacturing processes.



Delphi's Laser Machined Multec® GDi Multi-Hole Fuel Injector

Overview

- Developed by Delphi Automotive Systems, LLC, in collaboration with Microlution, Inc. and Raydiance, Inc.
- Commercialized in 2014.

Applications

Can be used for the production of highly complex, small (micron-scale) parts that by design require high precision and accuracy.

Capabilities

- Achieves femtosecond (10–15 sec) pulse times to eliminate thermal effects.
- Achieves <3 sec cycle time, including part load and unload.
- Achieves small scale machining of the order of 10's–100's microns (1 x 10^{-6} m).
- Provides automated, synchronized, multi-axis positioning during laser machining operation.
- Provides high part production throughput while holding stringent dimension precision and accuracy tolerance.

Benefits

Environment
Process enables manufacturing of components to meet fuel economy/CO_2 standards that will reduce oil consumption and emissions.

Flexibility
Ultrafast laser machining can be used in other applications and materials, such as ceramics (electronics) and precious metals (biomedical).

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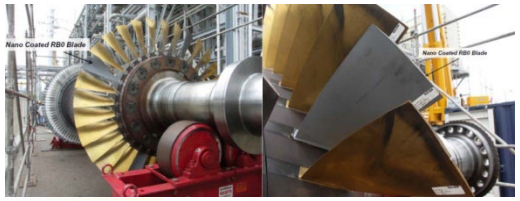
Technologies – Thank you!

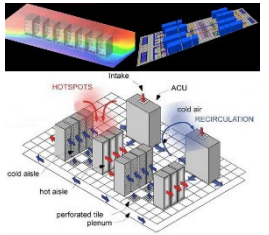
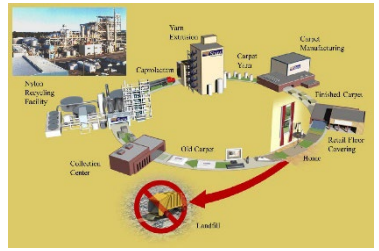
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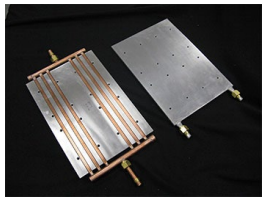
Questions?

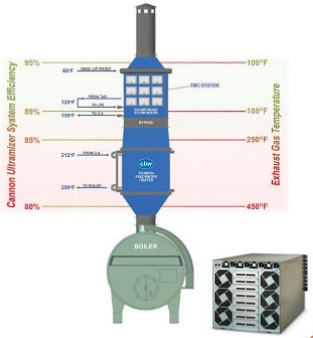
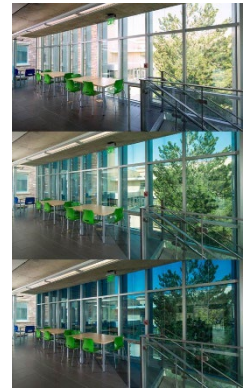


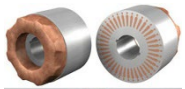


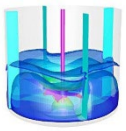




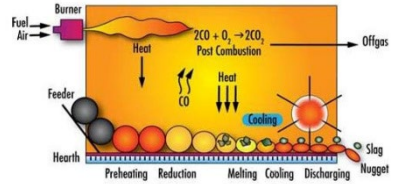




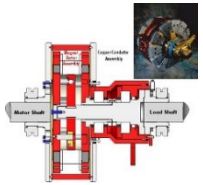
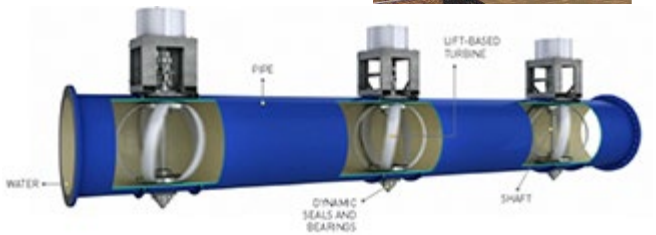












Score: 4.7/10

5W30 Motor Oil
(API Group III - Semi-Synthetic)

Score: 7.6/10

Biosynthetic TECHNOLOGIES



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Back Up Slides

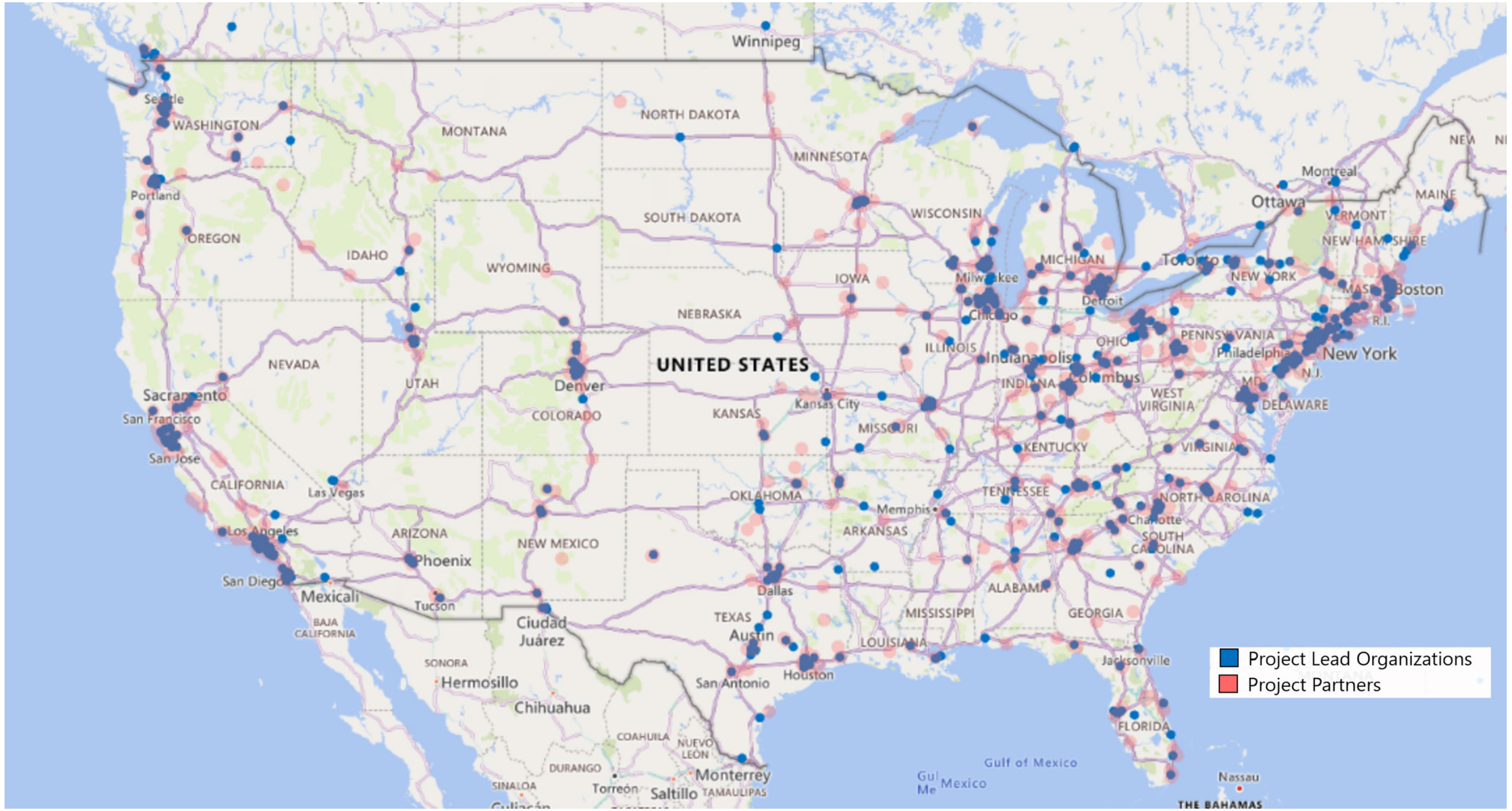
Technology Definitions

Commercial Technology Defined

A commercial technology is defined as an invention or intellectual property that is developed into a technology (hardware, process, technique, design, machine, tool, material or software) and enters the domestic market as "first sale," "in-use in a production application," or "sale of a commercial license."

- Commercial: full-scale unit operational in United States and available for sale
- Emerging: under development; commercialization expected within next 3 years
- Potential: under development but commercialization expected more than 3 years
- Historical/Archived: after 10 years in commercial operation no longer tracked

Technology Tracking Database Webtool



GeoPlot of AMMTO Project Portfolio & Partner Organizations thru' FY2025

Readiness Levels

TRL	TRL Definition	MRL	MRL Definition	Technology Definition
TRL 1:	Basic principles observed and reported	MRL 1:	Manufacturing feasibility assessed	**POTENTIAL** "technology" is in early stages of development and is expected to be more than three years from entering the market
TRL 2:	Technology concept and/or application formulated	MRL 2:	Manufacturing concepts defined	
TRL 3:	Analytical and experimental critical function and/or characteristic proof of concept	MRL 3:	Manufacturing concepts developed	
TRL 4:	Component and/or system validation in laboratory environment	MRL 4:	Capability to produce the technology in a laboratory environment	**EMERGING** "technology" is in mid- to late development and is expected to be three years from entering the market
TRL 5:	Laboratory scale, similar system validation in relevant environment	MRL 5:	Capability to produce prototype components in production relevant environment	
TRL 6:	Engineering/pilot-scale, similar (prototypical) system validation in relevant environment	MRL 6:	Capability to produce prototype system or sub-system in a production relevant environment	
TRL 7:	Full-scale, similar (prototypical) system demonstrated in relevant environment	MRL 7:	Capability to produce prototype systems or sub-systems in a production relevant environment	
TRL 8:	Actual system completed and qualified through test and demonstration.	MRL 8:	Pilot line capability demonstrated; Ready to begin Low Rate Initial Production	
TRL 9:	Actual system operated over the full range of expected conditions.	MRL 9:	Low Rate Production demonstrated; Capability in place to begin Full Rate Production	**COMMERCIAL** "technology" is available for sale or "in-use" (includes software licenses)

TRLs Based on Table 1, DOE G 413.3-4A, Technology Readiness Assessment Guide, (https://www.directives.doe.gov/directives-documents/400-series/0413.3-EGuide-04a)

MRLS based on Chapt.2 p.2-2, DOD Manufacturing Readiness Level (MRL) Handbook Version 2.0. (http://www.dodmrl.com/MRL_Deskbook_V2.pdf)

Technology Tracking Database Webtool
Output (screenshots) PNNL Technology Articles

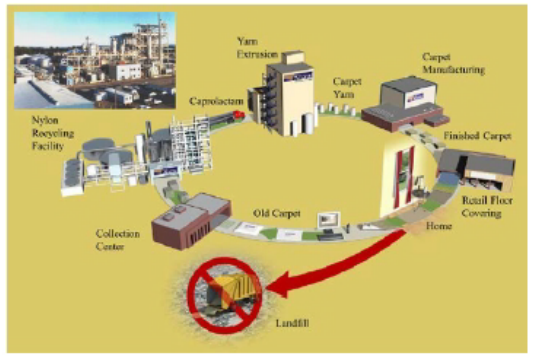
Nylon Carpet Recycling

New Process Recovers and Reuses Nylon from Waste Carpeting Saving Energy and Costs

With a desire to keep materials out of the landfill, Shaw Industries, Inc., has incorporated a novel process developed by Honeywell International, Inc., and DSM Chemicals North America, Inc., into the largest Nylon-6 carpet recycling facility in the United States. The recovery process not only reduces the amount of carpet-based material destined for landfill, but produces virgin quality caprolactam, the monomer building block of Nylon-6 resin used to make carpet fiber.

With proof-of-principal financial assistance provided by AMO, the closed-loop depolymerization and purification process allows Nylon-6 recyclers to recover and reuse a significant percentage of the raw materials used to make carpeting while consuming less total energy compared with the conventional production of caprolactam. In addition to caprolactam recovery, the process can reclaim calcium carbonate used for carpet backing and other polymers used in carpet manufacturing for future use.

Shaw Industries' Evergreen Nylon Recycling (ENR) facility in Augusta GA, is the largest commercial-scale Nylon-6 recycling plant in the world. ENR draws from more than 40 carpet collection facilities across the nation and has kept over 600 million pounds of carpet out of landfills since it began operation. The Cradle to Cradle™ process recovers approximately 23 million pounds of caprolactam each year. Calcium carbonate collected from the process has also been used as alternative material source for another company's cement kiln. ENR efforts have resulted in an annual energy savings of approximately 450 billion Btu.



Shaw Industries' Nylon Carpet Recycling Loop and Evergreen Recycling Plant (inset)

Overview

- Developed by Honeywell International, Inc., and DSM Chemicals North America, Inc.
- Evergreen Nylon Recycling facility owned and operated by Shaw Industries, Inc.
- Produced over 190 million pounds of virgin quality caprolactam since 2007.

U.S. Energy Savings (Trillion Btu)	
Cumulative through 2014	**2014**
3.44	0.42

U.S. Emissions Reductions (Thousand Tons, 2012)			
Particulates	**SOx**	**NOx**	**Carbon**
0.0	0.0	0.0	0.0

Applications

Can be used to recover and reuse the primary constituents of reclaimed carpeting and carpet fibers including caprolactam, calcium carbonate, and other polymers.

Capabilities

- Produces virgin quality pure caprolactam using the closed-loop depolymerization and purification system.
- Enables processing of whole Nylon-6 carpets and eliminates mechanical separation.
- Enables reuse of recovered raw materials in Nylon-6 as carpeting, fibers, and resins.

Benefits

Energy
Reduces energy consumption in the production of Nylon-6 resin and carpet fiber.

Environmental
Reduces land filling of nylon waste carpets and other Nylon-6 based materials and reduces raw material demand for the production of Nylon-6.

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HMAX®: Active Energy Control for Electric Motors

Real-Time Sensing and Control of Electric Motor Operation Optimizes Energy Efficiency

In 2011, the U.S. industrial sector consumed 3.7 quad of electricity, of which an estimated 1.7 quad was used for machine drive and facility heating, ventilation, and air-conditioning. Electric motor-driven systems are used in many of these machine and facility support applications. As energy costs continue to rise, a critical task is reducing electricity consumption of induction motors using advanced power control technologies.

Eaton Corporation, with assistance from the U.S. Department of Energy's Advanced Manufacturing Office, has developed an active energy control using a dynamic energy-optimizing variable frequency drive (VFD) control algorithm to reduce energy consumption and improve energy efficiency of induction motors that drive variable torque loads, such as pumps and fans. Eaton examined the shortcomings of the conventional static and dynamic control techniques, which typically do not take into account the motor's loading condition, do not achieve optimal energy usage, and cause motor instability. Eaton's HMAX active energy control monitors the motor's run-time loading conditions and dynamically adjusts the VFD's output to maximize the motor's power savings. HMAX energy control also includes mechanisms that ensure the stability of the induction motor against load changes and other potential risks, such as catastrophic mechanical failure. The control algorithms use typical motor operational point parameters, e.g., speed and torque, which are monitored by the VFD without additional complexity or cost. During initial test and development and at beta test sites, HMAX routinely demonstrated 2-10% energy savings compared with other conventional static and dynamic motor control techniques. Motor condition change tests also proved that the HMAX algorithm provides superior motor operation stability.

Eaton Corporation's Industrial Control Division successfully commercialized this control technology into its HMAX series product family of HVAC drives in 2011 and has filed a patent application for the technology. Eaton is currently targeting energy savings in the forestry, wastewater treatment, continuous industrial processes, and primary metal industries.



Eaton's HMAX Series Active Energy Control Technology

Overview

- Developed by Eaton Corporation.
- Commercialized in 2011..
- Distributed and marketed by Eaton Corporation

Applications

Can be used to maximize energy savings of induction motors with variable torque loads.

Capabilities

- Achieves optimized energy efficiency for induction motors with variable torque loads.
- Provides onboard proportional–integral–derivative control, input/output programming, and both RS-485 and ethernet communications.
- Provides adaptable and expandable customization to meet specific application needs

Benefits

Durability
Achieves ultra-efficient drive operation with a minimum five-year shelf-life by using a new thin metal capacitor design.

Energy Savings
Achieves optimized energy use, resulting in a net energy savings of 2–10% compared with conventional technologies.

Installation
Provides easy installation, simple startup, and multi-motor control.

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