Final Technical Report

EPA Grant Project Number X9-96589901-0
University of Minnesota CUFS 1707-662-6282
Funding period September 1, 2005 to February 28, 2007

Consolidating Energy Efficiency (E2) with Pollution Prevention (P2) for Minnesota's Industrial Facilities

Submitted to:
U.S. EPA Region V

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May 2007

EXECUTIVE SUMMARY

MnTAP identified metal casting as a high-energy use industry in Minnesota, also having significant pollution prevention potential. Minnesota's metal casting industry is comprised of approximately 56 foundries: ferrous (iron and steel) and non-ferrous (brass, aluminum, etc.), and 38 die cast operations (aluminum, magnesium and zinc).

The metal casting industry has pollution prevention-related issues: casting sand waste disposal, air emissions and regulatory permitting. From a business productivity standpoint, energy use cost containment and production competitiveness are of primary concern.

Buyouts, mergers and equipment auctions are common in the industry. Margins are low on most cast products and financial resources are tight. Facilities seem to fall into two groups, those that are focused on basic survival and those that innovate to maintain a competitive edge.

MnTAP work under this grant used the Accelerated Diffusion of Pollution Prevention Technologies (ADOP2T) model. A foundry industry focus group identified process changes that could improve energy efficiency and prevent pollution. MnTAP evaluated its five top priorities: energy and productivity savings through utility; pre-heating combustion air; centrifugal air compressors, compressed air storage and variable speed drives; computer modeling simulations and stack melting.

Demonstrating technologies and piloting process improvements takes commitment of personnel, resources and time—which are in short supply for most metal casting facilities. Both demonstrations and pilots have been difficult to arrange, but MnTAP continues to pursue them as part of its commitment to the technology diffusion model's practical aspects of familiarity and experience.

As a result of MnTAP's work through this project, over 100 Minnesota metal casters received energy efficiency (E2) and pollution prevention (P2) information, six received E2/P2 assistance. Of these facilities, one reduced energy use by 641 MM BTU, and eliminated 38.5 tons carbon dioxide and 0.02 tons of priority pollutant emissions, saving over $4,400 annually. Additional projected impacts include: energy use savings by 329,000 kWh and 9,600 MM BTU, and eliminating 935 tons carbon dioxide and 1.6 tons of priority pollutant emissions, saving more than $108,200.

BACKGROUND

MnTAP identified metal casting as a high-energy using industry in Minnesota, also having significant pollution prevention potential. This sector in Minnesota uses approximately 8,018,000 MM BTUs per year. Melting is the most energy-intensive operation in the metal casting industry, accounting for about 55 percent of the total energy use in foundries. Seven Minnesota facilities are on the 2005 U.S. Department of Energy (DOE) high energy user list (over $2 million a year in energy costs).

The metal casting industry has pollution prevention-related issues: casting sand waste disposal, air emissions and regulatory permitting. From a business productivity standpoint, energy use cost containment and production competitiveness are of primary concern. Metal casting generates volatile organic compounds (VOCs) as air emissions, and waste sand as a nonhazardous industrial waste. Both pollution prevention and energy efficiency opportunities exist in this sector and new more-efficient technology is available.

Inefficiencies in melting may be found in stack losses, inaccuracies in temperature measurement, conduction and radiation losses, poorly-fitting charge well covers and doors, temperature imbalance when adding cold metal to the molten metal bath and improper handling procedures and planning.

Minnesota's industry is comprised of approximately 56 foundries: ferrous (iron and steel) and non-ferrous (brass, aluminum, etc.), and 38 die cast operations (aluminum, magnesium and zinc). Relative to other casting industry-intensive states, Minnesota's casting industry is small. Three associations represent metal casting companies in Minnesota: the Twin Cities Chapter of the American Foundry Society (AFS), Chapter 16 of the North American Die Casting Association (NADCA) and the Metal Casters of Minnesota (MCM). MnTAP staff membership in the AFS and NADCA provides the opportunity to take advantage of organized gatherings for information sharing, networking and outreach.

Today's domestic metal casting industry needs to add value in terms of design, time and/or quality to its offerings. Without those features customers can easily look elsewhere in an emerging global marketplace. Product, mold and die design are the key first steps to efficient production. After that, preparing, melting and processing metal involves significant energy use and inevitable feedstock and energy losses.

Melt and casting equipment is not 100 percent efficient, the metal feedstock is not completely free of contaminants or melting and handling processes that introduce unwanted oxides or inclusions, procedures are not always carefully followed, and mistakes can be made. Design flaws may only be discovered after several attempts at part production. Many facilities operate using established routines on older, yet functional equipment. Through established process controls, they maintain the productivity required to satisfy the customer. Slight deviations to their set process (temperature, alloying, inoculation, fluxing, transport, molding, etc.) can affect productivity.

Producing castings includes significant reclamation of many process inputs. Inherent to making castings are the pathways in the molds needed to get the metal to the actual shape cavity. Casting pathways, used to release trapped air and channel the metal to the actual shape cavity of the mold, along with any faulty castings are recycled as scrap into the metal charge at the front end of the melt process. Although this activity recovers resources, facilities have an overall cost to efficiency in wasted energy, labor and resources. Faulty castings that have been further processed by coating, painting or modifying with plastics typically cannot be recycled in-house. These rejects need to be sold as low-value scrap to be recycled at smelting facilities with adequate emission controls.

Although mold and core sand is reclaimed, often it is not seen as a valuable resource. Excessive amounts of sand are likely disposed of because of inattention to proper in-facility procedures. Recently the MCM, industry experts and the MPCA along with representatives from U.S. EPA Office of Policy, Economics, and Innovation and Region V held a well-attended seminar outlining information to better manage sand resources inside and outside the casting operation for beneficial reuse.

This grant allowed MnTAP to further integrate energy efficiency (E2) with pollution prevention (P2) into our program activities overall, and to specifically provide E2/P2 assistance as part of site visit assistance to the metal casting industry.

Metal casting was targeted for assistance in the MnTAP industry-opportunities evaluation, conducted every three years, in 2004. This grant helped re-established MnTAP's assistance work for the metal casting industry which had been an underserved industry after losing industry expertise with a staff departure. Four major tasks outline the grant objectives and are described in detail below.

GRANT ACTIVITIES

Task 1: Pilot integration of energy efficiency and pollution prevention in the metal casting sector

The first grant task combined technical assistance focusing on both energy efficiency and pollution prevention opportunities to provide a comprehensive approach to help the metal casting industry. This task used the technology diffusion approach Accelerated Diffusion of Pollution Prevention Technologies (ADOP2T) developed by the Waste Management Research Center (WMRC) at the University of Illinois. This model approach emphasizes:

- Industry-identified technologies and process improvements
- Demonstrating those technologies for interested parties to question, see and experience the advantages first hand
- Piloting useful technologies with early adopters of the technology

Technology diffusion in this model emphasizes industry hands-on exposure and experimenting with improvement ideas, so those ideas (technologies) can be more readily evaluated and quickly adopted by industry, leaders can compel followers to also adopt the improvements by virtue of competitive advantage, and industry overall improves by becoming more efficient and competitive.

The more experiential the exposure to a technology, the more it can be viewed as real-world achievable and risk-acceptable. Reducing uncertainties about a technology can foster its adoption in the marketplace. Ideally, a technology will meet five criteria: relative advantage, compatibility with current processes, experiences and systems, complexity fit, observability and trialability.

During the early months of this grant, numerous opportunities were taken to introduce MnTAP and the technology diffusion strategy to metal casters and their suppliers, and to promote and solicit candidate proposals for the MnTAP intern program. Formal presentations about MnTAP resources and the ADOP2T strategy, along with audience brainstorm participation were made to the AFS and NADCA chapters and to the MCM board. Progress updates have also been provided to the MCM board periodically. Over 100 individuals involved with metal casting have attended and provided input in these meetings.

As a supporting resource and to promote assistance to metal casters, MnTAP added metal casting as an industry on its Web site, <http://mntap.umn.edu/metalcast>.

1.1 Identify opinion leaders for this sector

Opinion leaders were chosen based on number of employees (>50); sales (>$10M); and/or active association membership or established MnTAP relationship. These criteria were presumed to properly represent facilities interested, well-positioned, and able to innovate and implement E2 and P2 improvements. Minnesota has industry-recognized leaders, including the 2006 metal casting facility of the year and two facilities awarded castings of the year in 2005 and 2007. The foundry focus group coincidentally included representatives from all three of these facilities.

1.2 Convene stakeholder focus groups to identify energy efficiency and pollution prevention technologies needs of the sector

The industry was split into two sectors for the purpose of convening focus groups. The foundry focus group was held in January 2006 and is described in detail below. Based on the success of the foundry focus group, a second meeting with die casters facilities was scheduled for late February. Fourteen die casters were invited. After repeated attempts to enlist participation only two facilities committed to attend, so the idea of a focus group for die casters was abandoned.

The foundry focus group of 13 participants representing seven foundry facilities, one utility and one consultant was convened January 26, 2006, to identify relevant technologies fitting the ADOP2T model. The meeting began with an overview of the MnTAP program, an explanation of definitions (P2 and E2) and the concept of technology diffusion. The group was asked about desired industry objectives relative to technology evaluation. Feedback included cost, labor and energy savings, improved operations, environmental protection, beneficial reuse of molding sand, more-efficient equipment, alternative chemistries and no compromise to safety.

Participants were instructed about criteria that drive successful solutions to problems including relative advantage, compatibility with current processes, experiences and systems, complexity fit, observability and trialability. The group was then asked to brainstorm the production efficiency problems they faced as well as proven, workable solutions to those problems. Voting identified the top seven solutions listed in Table 1.

Table 1 Foundry Focus Group Priorities to Evaluate

1.	Energy and productivity savings through utility
2.	Pre-heating combustion air (heat exchanger)
3.	Centrifugal air compressors, compressed air storage and variable speed drives
4.	Simulations
5.	Stack melting (preheat charge)
6.	Employee comfort
7.	Alternative alloys

Employee comfort and alternative alloys were deems too vague or constrained and were not chosen to be addressed. The top five of these priorities were addressed and are briefly presented below.

1. <u>Energy and productivity savings through utility</u>

Utility account managers play an integral part in MnTAP's energy efficiency work. Utilities offer energy supply-specific expertise to reduce operation cost and will calculate a potential rebate for suggested energy improvements. Both of the major southern Minnesota utilities that service a majority of metal casting facilities in the state played a significant role in this grant.

- Xcel Energy (natural gas and electricity): Participated in the foundry focus group providing utility experience and also attended an iron foundry demonstration of scrap drying, offering improvement idea rebate information.
- CenterPoint Energy (natural gas): Assisted in utility costing and offering potential rebate information for the 2006 MnTAP intern project at a die cast facility.

MnTAP continues to work with utilities to strengthen our working relationships and understanding of each others' capabilities.

2. Pre-heating combustion air (heat exchanger)
Fuel-fired combustion losses are a major energy conservation opportunity in metal casting. Fuel savings increase when higher exhaust gas temperatures can be used to preheat combustion input air. This opportunity requires furnace adaptability and/or major capital investment in technologies like recuperators or regenerators in order to capture flue gas heat loss and return it to the furnace intake combustion air.

During a site visit to a brass and aluminum foundry, MnTAP identified the potential to reuse waste heat from aluminum crucible furnaces to preheat combustion air for a core oven or makeup air unit. Because of the significant capital investment needed install a preheated air system conversion, no action has been taken although according to the Department of Energy, temperatures above 1000°F, a significant number of hours of operation and fuel cost generally may justify a cost-effective payback.

Other companies have expressed interest in this technology in 2007 intern project proposals and this technology will become the subject of future assistance work.

3. Centrifugal air compressors, compressed air storage and variable speed drives
Compressed air needs are critical to both foundry and die cast operations. Compressed air is used to transport mold sand, pressurize die cast machines, spray die lubricant, and operate other machinery and hand tools.

New, more-efficient compressors can improve a system, but any compressed air system new or old, can have various energy and performance shortcomings. Without sophisticated pressure and electronic controls, preventive maintenance and monitoring, system size and complexity make operation efficiency a challenge. Leaks, inadequate on-line storage and inappropriate end uses reduce the work energy available. In many instances, electric motor-driven appliances and tools are much more efficient at doing the same work as air-driven apparatuses.

MnTAP continues to refine staff capabilities and plans to provide resource information and walk-through air-compressor system assessments as a way to alert facilities to equipment or operational deficiencies. MnTAP has a working draft assessment document (Appendix A) to provide staff with a reference for providing uniform assessments. A flyer promoting this assistance was also developed for industry outreach efforts (Appendix A).

4. Simulations
Simulation software provides modeling of mold design, casting flow, potential defects and setup parameters for foundry pouring and die cast machine operation. Computer simulation can help reduce prototyping design flaws and trial-and-error casting and labor waste in developing an acceptable casting.

Almost all facilities use some type of simulation software. MnTAP has learned that software performance, features and usefulness for any particular application can be directly related to the software cost. The most-comprehensive software products cost in the tens of thousands of dollars, some even in the hundreds of thousands of dollars. A software investment of this magnitude also requires staff trained and dedicated full-time to using these products to make the most of the software investment and its capabilities. For companies that develop few new casting dies, ownership of expensive software is not practical.

MnTAP evaluated facilitating shared access to basic software for smaller die casting companies that lack simulation resources. MnTAP learned that companies needing simulation can contract with the software company to directly do the modeling for the project rather than make the investment in the software and personnel training. Shared-access software was determined to be insufficient or unnecessary for most companies needs. Companies either have the resources or can contract the work to experienced software modeling professionals.

MnTAP has recontacted the foundry focus group participants to gain clarification of its original interest in this topic, but no new feedback or clarification has been offered.

5. Stack melting (preheat charge)

Aluminum foundries and die casters can use waste heat to raise the temperature of the furnace metal charge materials to off-set energy used to melt the scrap or ingots. Ferrous foundries need to dry their furnace charge materials in order to avoid moisture and potential safety hazards with reactions and explosions when loading the furnace. While ferrous foundries do not necessarily consider their drying process a preheating step, the scrap drying does increase the scrap charge temperature and reduces the melt energy needed. Table 2 outlines the initiatives undertaken during this grant period.

Table 2 Stack Melting (Preheating Charge) Initiatives

Facility	Initiative	Results
Iron foundry	MnTAP temperature survey and energy savings calculations	Potential annual energy reduction of over 329,000 kWh Potential annual cost savings of over $23,000 Findings being discussed by facility
Aluminum die caster	MnTAP 2006 intern project	Two intern recommendations to be implemented • Modify main breakdown furnace to add a stack melter feature • Fabricate an apparatus to use over crucible (open top) furnaces to preheat and melt scrap
Iron foundry	MnTAP 2007 intern project	Part of the project proposal aims to use furnace cooling water waste heat to dry and preheat the scrap in the furnace loading system nearby. Intern work will conclude in August 2007.

MnTAP will continue to work with facilities on the above five focus group priorities, as well as provide assistance on any newly emerging issues or concerns. At some future date, it may also be appropriate to reconvene another foundry focus group or retry an effort with the die casters to address changes in the industry.

1.3 Identify and establish two to three energy efficiency and pollution prevention technology demonstration sites at vendor or company sites to showcase technologies

Demonstrating new technologies is a key element in the technology diffusion model. Both AFS and NADCA have strong interest in technical information and member education. The foundry association makes a point of conducting tours at member facilities at least once during its meeting season (September to May) and both AFS and NADCA bring training events to their local membership. This sharing mindset is useful in facilitating technology demonstrations. Demonstrations need to fit into busy schedules and have wide relevance. One scrap drying demonstration was conducted and is described in 1.2 (5) above. Two additional demonstrations are pending. The 2006 MnTAP intern project at an aluminum die caster will show the modifications made to the main furnace to increase energy and production efficiency and will also show its use of sealed holding furnaces. A second facility has agreed to a discussion and tour of its melt area with a focus on its three stack melters.

For additional information exchange, MnTAP will encourage facilities that have made other process improvements to share their experiences and information through a tour or to present their improvement projects a chapter membership meeting.

1.4 Perform three to five site assessments

Ten facilities had at least one MnTAP site visit. Six of those facilities had technical assessments. The six facilities included one brass and aluminum foundry, an iron foundry, an aluminum smelter, an aluminum die caster, and two facilities working in both iron and aluminum—one a foundry operation and the other a foundry and die cast operation.

1.5 Conduct one to two pilots or trials
The casting industry as a whole seems to be currently in a struggle between production and quality goals and innovating. Technology piloting (innovating) is seen as an opportunity of the well-positioned and well-supported, larger facility. Piloting takes the commitment of personnel, resources and time, which are in short supply for many shops.

No pilots occurred during the course of the grant although two pilots are pending at the 2006 MnTAP intern project die cast facility. One will be to design and implement an ingot melter on an open-top crucible holding-furnace as proposed in the intern project agreement. MnTAP will document the effectiveness of this device in aiding the aluminum melt and reducing energy. The other pilot proposed will involve design and construction of additional modifications to the large melt furnace. A stack will be constructed to redirect the exhaust flue gas through the aluminum scrap load to use waste heat to assist melting. Both of these pilots are pending, but expected to be implemented in 2007. Neither pilot was derived from technology demonstrations as the technology diffusion model predicts.

The 2007 intern project company is expecting to pilot a pouring ladle design improvement. As MnTAP continues to develop professional relationships with facilities, vendors and suppliers, pilot projects will continue to be proposed and documented for case studies.

1.6 Assist in technology implementation using MnTAP interns or financial support
MnTAP uses its summer student intern program as a way to pilot technologies at facilities. The 2006 metal casting intern project provided resources to reach cost-justified recommendations and facilitate improvement implementation. MnTAP has another intern project at a metal caster for 2007 and will work with others that expressed interest to develop additional projects in the future.

MnTAP metal caster contacts were all encouraged to review the 2006-2007 DOE Energy Efficiency and Renewable Energy (EERE) solicitations for the Save Energy Now program’s Energy Savings Assessments. Utility rebate opportunities were also emphasized. When appropriate, referrals were made to the Minnesota Pollution Control Agency (MPCA) grant and loan programs.

Task 2: Support one MnTAP student intern for energy efficiency/pollution prevention project implementation

A natural-gas energy-focused intern project was completed in 2006 at a Twin Cities aluminum die casting operation. The company’s project goal was to reduce energy costs by ten percent. The main focus areas were aluminum melting (two reverberatory furnaces) and metal holding (four crucible-style and three closed cabinet-style holding furnaces).

The intern began by participating in discussions already underway related to structural and operational modifications to the large reverberatory furnace. The furnace volume was reduced by 50 percent and two of the four natural gas burners were permanently set on pilot (low fire). This initial change and other process modifications at the start of the project resulted in a substantial improvement—a 76 percent increase in finished product per dekatherm (10 therms or 1 MM BTUs).

<u>Intern project findings</u>
Nine ideas were identified and investigated by the student. Seven simple modifications along with some capital-intensive options were justified and recommended by the student’s work. One idea was left unresearched. Those recommendations with capital investment paybacks over two years qualify for gas utility rebates (Table 3). The intern also identified preventative maintenance and procedural training and information awareness as important elements to future success at the company.

Table 3 2006 MnTAP Intern Project Findings Summary

Energy reduction option	Annual energy reduction	Implementation cost	Annual cost savings	Payback period	Status (date)
1) Burner tune up	variable	$500 one time cost	Variable	variable	Implemented
2) Covering charge wells	424 MM BTUs	$0	$2,970	0	Implemented
3) Crucible furnace covers	217 MM BTUs	$1,400	$1,520	11 months	Implemented
Total implemented	641 MM BTUs	--	>$4,490	--	--
4) Placement of ingot melters on crucibles	variable	$0	$0.27 per ingot melted	0	Planned
5) Addition of insulation to back door of large furnace	671 MM BTUs	$0	$4,700	0	Recommended
6) Replacement of #1 and #11 crucible furnaces with energy efficient ones	3,600 MM BTUs	$66,000	$33,000	2.23 yrs.	Recommended
7) Replacement of all crucible furnaces with energy efficient ones	5,300 MM BTUs	$113,000	$47,500	2.74 yrs.	Under study
Total additional potential	9,600 MM BTUs	--	$85,200	--	--
8) Small furnace relining					Identified but unresearched
9) Recuperative burners on small furnace	2,300 MM BTUs	$110,000 - $125,000	$14,700	~ 8 yrs.	Not recommended now, but suggest study later

The intern project was presented at the February 2007 NADCA chapter meeting. MnTAP staff provided an overview of the program, the student presented the findings, and the company president offered positive comments on the value of local assistance and internships.

MnTAP will follow up with the 2006 intern project company for at least two years after the project's conclusion, to monitor the status of all viable recommendations and offer additional assistance. The company is currently reorganizing its manufacturing and business strategies, as a result other objectives like the demonstrations are on hold.

Promotion of the MnTAP's 2007 summer intern program resulted in queries from seven metal casters. A waste heat reuse project at an iron foundry is scheduled to begin in late May 2007.

Task 3: Purchase energy measurement equipment

MnTAP committed $1,000 to a cost-share for the purchase of energy measurement equipment under this grant. Staff responsible for energy assistance discussed and prioritized the equipment that would best facilitate MnTAP's energy assistance work. The equipment ranging in cost from $125 to $290 included:

- Infrared thermometer used for temperature measurements of furnace, ladle and charge bucket radiation heat losses;
- Flow meters, pressure gauge, and an ultrasonic leak detector used for evaluation of compressor system operations.

This equipment, along with additional equipment that has been acquired, will continue to be valuable for data collection and assistance delivery. When activities that contribute to heat loss can be effectively measured and documented, metal melt procedures can be streamlined.

Use of compressed air in casting operations may represent the largest end-use of electricity in the facility. Assessing compressor system performance can highlight important energy saving opportunities for metal casters. MnTAP is targeting assessment opportunities for the remainder of 2007.

Task 4: Train one staff to be a Certified Energy Manager

This grant covered the cost for one MnTAP staff for the Certified Energy Manager (CEM) training from the Association of Energy Engineers (AEE) in September 2005. MnTAP now has five CEM-trained staff.

MnTAP has integrated energy assistance with pollution prevention assistance. All MnTAP technical assistance staff are expected to incorporate energy knowledge into their assistance work. MnTAP also offers energy assistance through Web site resources and partnering relationships.

DISCUSSION

This EPA Region V grant enabled MnTAP to successfully reintroduce assistance and integrate P2 and E2 outcomes for the metal casting industry, as well as purchase energy measurement equipment and receive energy training.

MnTAP has expanded work in energy and technology-related objectives with metal casters and other high-energy using industries in Minnesota by leveraging two additional grants from U.S. DOE[1] and the U.S. EPA[2]. Activities from those grants and additional MnTAP commitment are showing the success of this synergy through the metal casting industry's awareness of and use of MnTAP assistance for pollution prevention and energy assistance. In addition, MnTAP's metal casting knowledge-base has expanded through broad links to industry and association expertise. Energy competence at MnTAP is growing and we are adding pollution prevention perspectives to utility expertise and partnering with utilities to leverage industry assistance needs and interests.

Energy efficiency improvements conserve resources and complement the objectives of pollution prevention. Assistance activities that combine energy with pollution prevention provide a broader package of improvement opportunities to busy industries and help maximize limited assistance resources (e.g. during a comprehensive site visit).

While energy has been a primary issue for metal casters, foundry sand beneficial reuse has also been a topic. Casters that clean and coat castings have wastewater issues. Air emission issues might be addressed through exploring heat recovery opportunities. MnTAP will continue to provide a multi-media perspective in its assistance to the metal casting industry.

E2-P2 Impacts

MnTAP has developed an emission estimate calculator for internal use that translates electric or natural gas energy savings into tons of emissions avoided, based on EPA's <u>AP 42 Compilation of Air Pollutant Emission Factors</u> and other sources of fuels use in Minnesota. Table 4 summarizes the E2 and P2 improvements made as a result of MnTAP assistance through this grant.

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[1] DOE grant *Energy Efficiency and Pollution Prevention for Minnesota's Energy Intensive Industries* focused on compressed air system efficiency for metal casting, mining, and pulp and paper industries.
[2] U.S EPA grant *A Regional Pilot to Promote Pollution Prevention Technology Diffusion* focused on technology diffusion.

Table 4 E2-P2 Impact Results

Benefit	Actual	Additional Projected
Energy reductions	641 MM BTUs	9,600 MM BTUs 329,000 kWh
Cost savings	> $4,490	>$108,200
Carbon dioxide ($C0_2$) emissions reduction	38.5 tons	935 tons
Priority pollutant emissions reduction	0.02 tons	1.6 tons

Technology Diffusion Model

The technology diffusion model framed aspects of MnTAP's assistance efforts under this grant. We learned about the industry priorities from industry members directly and provided assistance on several priority areas.

The listening and learning approach of the focus group and stakeholder input of the technology diffusion model was an ideal setting for entering into assistance with a newly targeted industry. Brainstorming with experienced personnel led to significant insights for MnTAP as well as useful sharing within the group. These focus group members have proven over time to be industry leaders in Minnesota.

A focus group represents a time-sensitive snapshot of issues and has limitations. Getting a group together once does not guarantee committed, on-going input. Metal casters in Minnesota, as elsewhere, have production and efficiency priorities that make it difficult for them to stay in touch, hold technology demonstrations that take away from production attention, or commit to piloting different technologies.

Commercial technologies being employed by metal casters are capital-intensive expenditures usually requiring regulatory permit modifications, production planning, substantial budgeting commitments and facility modifications. Process improvements or procedure changes with equipment already in place better fit the technology diffusion model for this industry.

Table 5 evaluates the priorities identified at the foundry focus group stakeholder meeting using the five criteria for success (relative advantage, compatibility, complexity, observability, trialability) of the model.

Table 5 Focus Group Priorities vs. Successful P2 Characteristics

Technology	Relative advantage	Compatibility	Complexity	Observability	Trialability	Success Factor
1. Energy and productivity savings through utility	High (0)	Med (0)	Low (0)	Low (0)	Low (0)	0
2. Pre-heating combustion air (heat exchanger)	High (+1)	Low (-1)	High (-1)	Med (0)	Low (-1)	-2
3. Centrifugal air compressors, variable speed drives and storage	High (+1)	Med (0)	Med (0)	High (+1)	Low (-1)	+1
4. Simulations	Med (0)	Med (0)	High (-1)	High (+1)	Med (0)	0
5. Stack melting (preheat charge)	High (+1)	Low (-1)	High (-1)	High (+1)	Low (-1)	-1

As can be seen in Table 5, the interest level of the stakeholders for a given technology did not necessarily correlate with the overall favorability of the technologies compared to success characteristics. While energy and productivity savings through utility was on the list, it is not a technology or a process change. It is a means to support a change and does not fit the diffusion model. Because we were inexperienced at using the model, we did not learn this distinction until well into the project. Below is a brief discussion of how each prioritized focus group topic related to the successful pollution prevention characteristics.

Relative Advantage

Energy improvements in metal casting (preheating combustion air, air compressor systems, stack melting) provide relative advantage due to the volumes involved and the high cost of both electricity and natural gas. Being more efficient in energy per product produced makes a facility more competitive.

Simulation software may provide some advantage based on the functionality of the software and the skill of the design and process engineer using the software. It is unclear whether relative advantage of software plays a significant role in securing initial business. The only direct advantage would be where software would allow a caster to quickly get up to production speed with fewer mis-casts.

Compatibility

New technologies of interest are not necessarily compatible with current facility equipment. Yet, they can be seen as an important competitive advantage. Heat exchangers, compressor improvements, or preheating melt charges likely require major design evaluation and process modifications. Simulation software could require computer system and training, or at least modifications and possibly a substantial learning curve for the user to learn the program and remain proficient. The software will likely require a dedicated trained staff person to operate it effectively.

Complexity

Issues with compatibility are also reflected in problems with complexity. Combustion air preheating or heat exchangers in metal casting operations are waste heat applications that require high temperature, high abrasion/abuse and reactivity resistance, and/or special performance materials or equipment adapted to current equipment. Stack melters can be furnace modifications, but are more likely new or replacement furnaces that provide better energy efficiency.

Compressor system improvements can include simple procedures (fixing leaks) to complex modifications (controllers, piping, storage) so complexity varies with the application.

Observability

Many of the technologies could be seen, but the specific impact of their operation might not be observable. In the case of combustion air, preheating maybe inferred without complicated measurement.

Trialability

Melt process modifications (combustion air preheating, stack melting) require major retrofits or equipment replacement and are not easily trialable. Simulation software would be trialable, but it did not have enough interest to be pursued. Compressed air improvements continue to be a target activity for this industry due in part to MnTAP expertise and available and applicable resources to address a wide range of opportunities.

Barriers

Barriers will continue to exist for some segments of this industry. Equipment auctions for buyout, merged and shuttered facilities seem to be common across the country. Even some of the most established casters have concerns about staying competitive and in business. Currently, production throughput and quality are key, demanding issues for metal casters. These concerns will compel some casters to avoid any ideas that are out of their routine (including assistance, experimentation or pilot trials)—the very ideas that could help drive improvement.

National and international research work is extensive, everything from alloying innovations to energy optimization, casting control and metallurgical quality. This research often points to materials or equipment that are cutting-edge, expensive, high-temperature, high-abrasion/abuse and reactivity resistance, and/or special performance. Capital investment can be substantial, hampering all but the largest, most adaptable operations. Older, large and expensive equipment takes significant capital to replace. Facilities are not willing to give up their current investment for a modest payback. Any new technology comes with a degree of implementation risk so these leading-edge advances can be slow to reach commercialization, much less be easily and quickly diffused throughout the industry, except as competition drives improvement and equipment wears out and requires replacement.

Future MnTAP work

Waste heat energy opportunities are emerging in the metal casting industry as a priority. Many of the proposed intern projects for 2007 had a waste heat component. Staff assistance or intern projects in 2008 and 2009 will attempt to address those opportunities. Other energy use-reduction opportunities should continue to be of interest to the metal casting industry and will be MnTAP assistance objectives as our E2 and P2 integration efforts for metal casters mature.

MnTAP will continue an emphasis on demonstrating and sharing information on process improvement technologies. Education and information sharing reflects the Minnesota metal casters and suppliers culture. Engaging experienced workers in analyzing how their jobs can reduce waste or improve energy efficiency is an integral part of how MnTAP will continue to approach assistance to the metal casting industry. Pilots will continue to be explored. MnTAP plans to facilitate a demonstration tour of improvements made to compressed air system at an iron foundry.

Follow up with the 2006 intern project company will continue to assist it with potential implementation. We plan to partner with a vendor and a foundry customer to document performance testing of a transfer ladle using a high-tech insulation and design change.

CONCLUSION

MnTAP assistance work for the metal casting industry in Minnesota was renewed in September 2005 through the support of this grant and is now re-established as an industry assistance service sector at MnTAP. MnTAP efforts have been aimed at the local association chapters; the national casting associations and industry partner affiliations, word of mouth; and statewide, regional, and national networking and information gathering within the industry.

Metal casters call MnTAP for a variety of information: MnTAP program updates, requests for resources and input, site visit and intern project requests, and other technical assistance. The 18 months of this grant have helped to firmly establish MnTAP service to this industry and develop beneficial relationships.

Energy and resource conservation are now linked together in MnTAP assistance to this industry. Energy costs and competitive advantage issues are compelling the metal casting industry to reprioritize opportunities that were overlooked or undervalued in the past. Support functions like compressed air are being seen as opportunities ripe and accessible for improvement without directly impacting production line operations. Improving efficiency used per unit of production or per unit of energy are priorities that MnTAP can assist with.

MnTAP can provide assistance in finding overlooked procedures or in evaluating the waste, energy and process balances that can benefit both the struggling and the productive facility. Our continuing outreach on compressed air system operations will aim to provide that assistance. MnTAP's relationship-building and presence with the metal casting industry addresses the program's competency and intent while at the same time strengthening trust and the ability for MnTAP and the casting industry to work together on problem-solving and improvement opportunities. Important partnerships with energy utilities help to provide assistance synergy and economic benefits for metal casters.