

Industrial Energy Conservation Analysis

Identifying opportunities for industrial energy efficiency

Minnesota Technical Assistance Program



UNIVERSITY OF MINNESOTA

Driven to DiscoverSM

Agenda

- Project overview
- Sector information and opportunities
 - Conservation opportunities
- Benchmarking study and findings
- Next steps and action items

The Project

- Purpose
 - Investigate savings for industrial users
 - Industrial users account for 30% of energy use
 - Help identify opportunities to meet Next Generation Act Goals of 1.5% savings
 - Identify process-specific energy use
 - Identify conservation opportunities and savings potential
 - Technologies identified for energy efficiency
 - Process changes also identified

Completing the Project

Collect utility data

Determine sectors

Identify sub-sectors

Develop savings estimates

Make recommendations

Participating Utilities

- Alliant Energy
- CenterPoint Energy
- Greater Minnesota Gas
- Great Plains Gas
- Minnesota Energy Resources Corporation
- Minnesota Power
- Otter Tail Power Company
- Xcel Energy



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Sectors

Four Primary

- Chemical manufacturing
- Primary metals
- Fabricated metals
- Food processing

Utility-Selected

- Wood Products
- Printing
- Pulp & Paper
- Industrial Drying



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Sector	Recommended Sub-Sectors	
Chemical Manufacturing	Ethanol production Pharmaceutical manufacturing Resin production Shingle manufacturing	Asphalt production Explosives manufacturing Compressed gas production Paint, ink, and adhesive production
Food Processing	Dried dairy products Poultry processing Meat processing Rendering Seafood processing Cheese, whey, and butter processing Sugar manufacturing from beets	Snack chip production Soybean processing Pet food manufacturing Commercial bakeries Fruit and vegetable canning Frozen fruit and vegetable processing
Fabricated Metals	Transportation equipment manufacturing Metal tube manufacturing Stamping and forging operations Industrial equipment manufacturing Coating, plating, polishing, and finishing	Metal can manufacturing Structural metal products Heat treating Machine shops Steel metal fabrication
Primary Metals	Non-ferrous metals operations Steel products Iron feedstock production	Iron operations Precious metal operations Aluminum operations

Sector	Recommended Sub-Sectors	
Printing	Web-fed heat set printers Newspaper printing	Heat set printers
Industrial Drying	Grain elevators with drying operations	
Wood Products	Reconstituted wood products Primary sawmills	Secondary millwork
Pulp and Paper	Pulp and paper mills Board converting (non-heat set)	Extruding and paper coating Multi-wall converting with heat set operations

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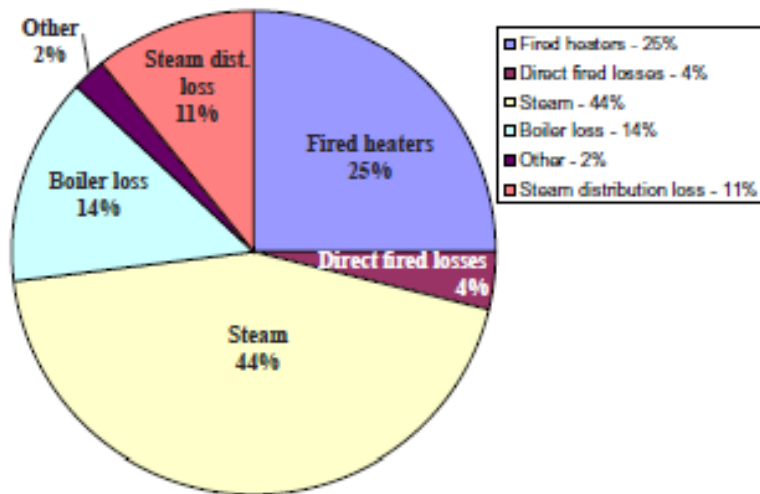
Energy Use by Sector

Sector	Gas Customers			Electric Customers		
	# of facilities	Annual Use (therms)	% of total	# of facilities	Annual Use (kWh)	% of total
Chemical Mfg	126	121,846,681	38.4%	227	508,184,994	12.9%
Food Processing	178	106,129,160	33.5%	733	1,093,818,350	27.7%
Fabricated Metals	693	28,913,817	9.1%	1,681	1,069,876,577	27.1%
Primary Metals	73	17,897,256	5.6%	168	330,988,784	8.4%
Printing	330	12,645,000	4.0%	1,071	450,170,000	11.4%
Industrial Drying	49	1,019,676	0.3%	-	-	0.0%
Wood Products	-	-		71	125,431,928	3.2%
Pulp and Paper	39	28,758,000	9.1%	89	364,166,000	9.2%
TOTAL	1,488	317,209,590	100.0%	4,040	3,942,636,633	100.0%

Energy Use Footprint²

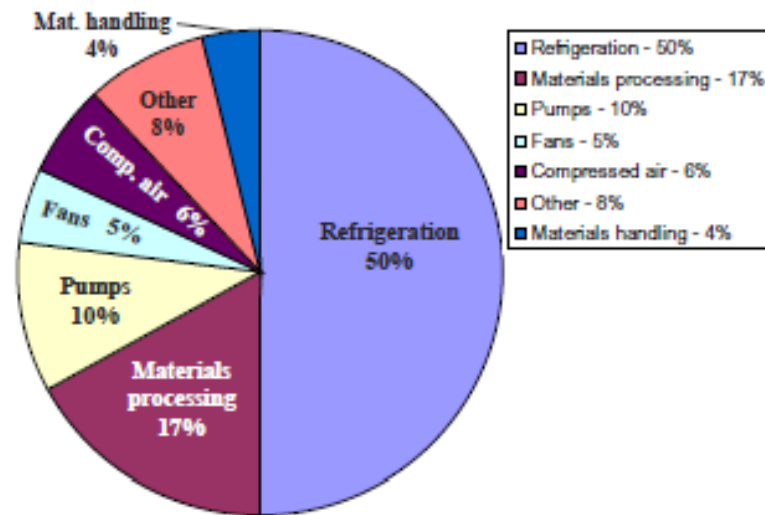
Energy Footprint - Fuel Use

51% of sub-sector's energy use



Energy Footprint - Electricity Use

49% of sub-sector's energy use



Energy Savings Estimates

- Developing savings estimates
 - Reports or case studies with estimates for changes
 - Reports or fact sheets on technologies with estimates
 - DOE Industrial Assessment Center (IAC) recommendations
- Estimated remaining savings
 - 25 million therms
 - 271 million Kwh

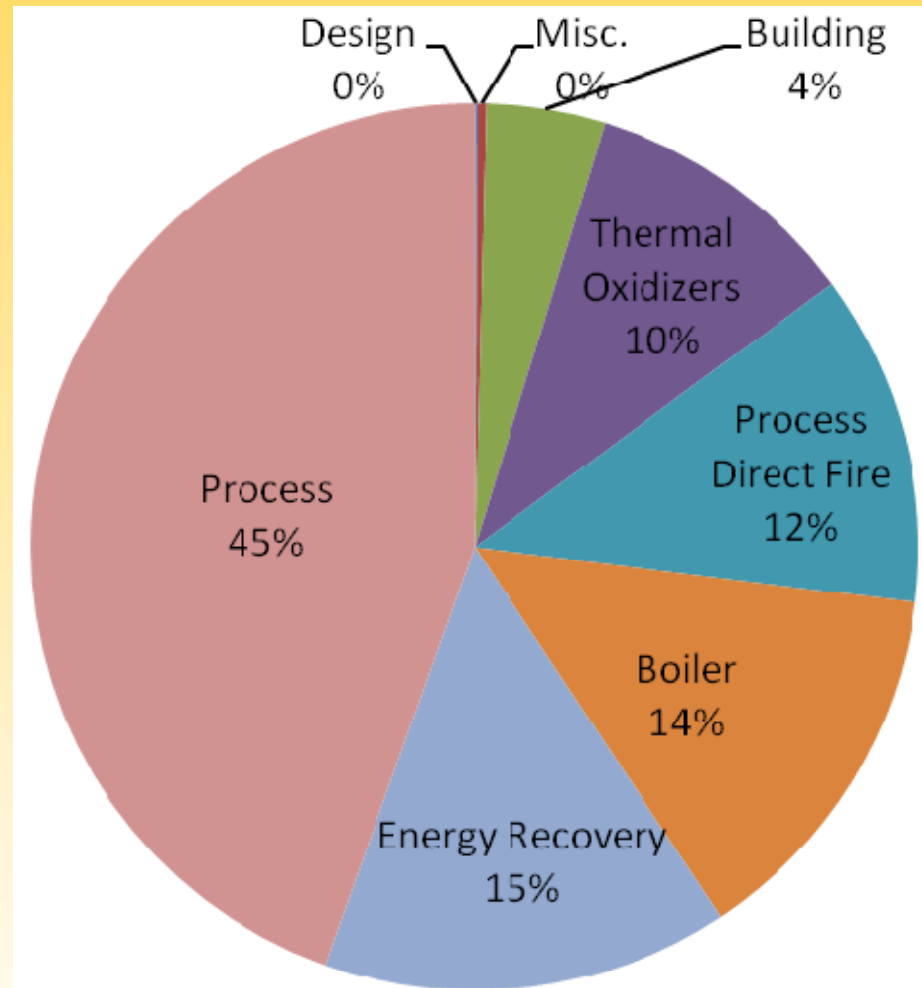
Savings Estimate Limitations

- Energy savings estimates
 - Represent savings over time
 - Based on published reports of implementation
 - For sub-sectors not facilities
 - Macro-economics
 - Rebate information is incomplete

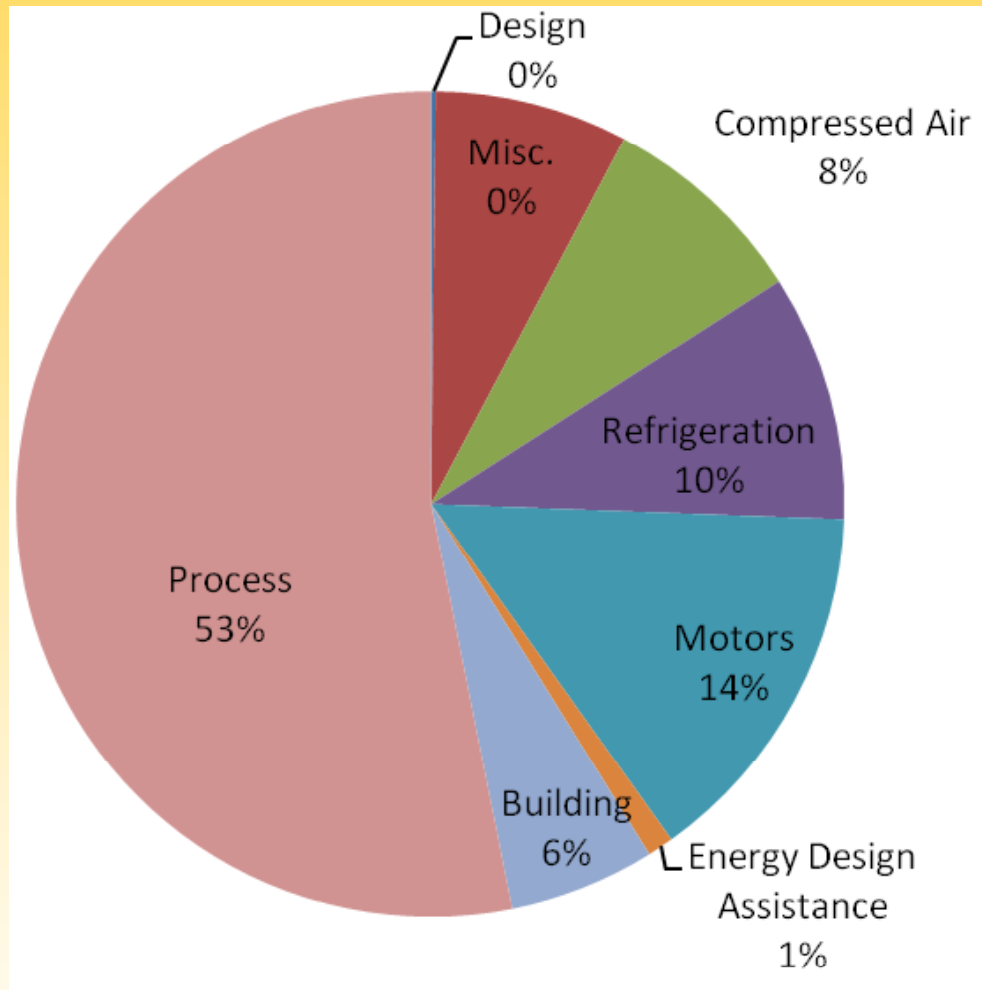
Rebate Analysis

- Used to adjust savings estimates
- Rebates reported savings
 - 29 million therms
 - 206 million kWh
- Technology rebate numbers varied

Gas Rebate Information



Electric Rebate Information



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Develop savings estimates



Make recommendations

Food Processing Energy Savings

Sub-sector	# of Facilities	Gas			Electricity		
		Total Use (therms)	Remaining Savings * (therms)	Est. Savings (%)	Total Use (kWh)	Remaining Savings * (kWh)	Est. Savings (%)
Cheese and Butter Proc.	22	11,348,282	1,017,200	9.0%	76,246,307	10,510,200	13.8%
Poultry Processing	24	10,903,658	903,200	8.3%	108,000,000	16,200,000	15.0%
Rendering	4	10,766,071	1,155,300	10.7%	24,948,375	1,532,800	6.1%
Dried Foods	10	9,506,837	110,000	1.2%	6,357,072	833,700	13.1%
Fruit and Vegetable Can	14	7,126,977	372,500	5.2%	26,910,996	2,703,900	10.0%
Soybean Processing	2	3,304,160	450,000	13.6%	21,509,620	1,112,100	5.2%
Meat Processing	19	1,437,624	26,200	1.8%	83,622,144	8,942,000	10.7%
Margarine Manufacturing	1	422,316	65,700	15.6%	10,182,948	441,800	4.3%
Bakeries	31	341,488	64,400	18.9%	51,000,000	7,650,000	15.0%
Food Proc. w/ Water Heat	44	330,416	42,200	12.8%	-	-	-
Seafood Processing	3	-	-	-	14,323,582	459,700	3.2%
Citric Acid Production	1	-	-	-	4,534,200	324,300	7.2%
Sunflower Seed & Rice	2	-	-	-	13,521,747	943,600	7.0%
Snack Chip Manufacturing	1	-	-	-	10,951,560	876,100	8.0%
Pet Food Manufacturing	1	-	-	-	10,654,189	625,700	5.9%
TOTAL	179	55,487,829	4,206,700	7.6%	462,762,740	53,155,900	11.5%

Gas Opportunities

Opportunity	Savings Range	Sub-Sectors									
		Bakeries	Fruit & Veg Canning	Rendering	Dried Food Products	Meat Processing	Soybean Processing	Poultry Processing	Margarine Mfg.	Cheese & Butter Proc.	
Boiler improvements / best practices	1-8%	✓	★	★	✓	★	✓	✓		★	
Direct fired improvements /best practices	0.1-1%	✓			✓	✓	✓	✓		✓	
Process equipment heat recovery	0.5-13%	★		★	★	✓	✓	★		★	
Facility HVAC improvements	1-8%	✓	✓								
Improved process equipment	0.5-4%	★	★	✓	✓	✓	✓	✓	✓	✓	
Product wash improvements	1%		✓								
Steam best practices and improvements	0.5-11%		✓	✓	✓	✓	✓	✓	✓	✓	
Water heating improvements	2-10%			★		★		★		★	

Electric Opportunities

Opportunity	Savings Range	Sub-Sectors													
		Bakeries	Fruit & Veg Canning	Rendering	Dried Food Products	Meat Processing	Soybean Processing	Poultry Processing	Margarine Mfg.	Cheese & Butter Pr	Seafood Processing	Citric Acid	Seed & Rice Proc.	Snack Chip Mfg.	Pet Food Mfg.
Improved process equipment	9.7%	★	✓	✓	✓	✓	★	✓	✓	✓	✓	✓	✓	★	★
Process design improvements	2-4%		✓	✓	✓	✓			✓			✓	✓		
Refrigeration improvements	2-10%	✓	✓		✓	★		★	✓	★	★				
Compressed air improvements	0.5-3%	✓	★	★	★	✓	★	★	✓	★	✓	✓	✓	✓	✓
Motor improvements incl. pumps and fans	1-1.5%	✓	✓	★	★	✓	✓	✓	✓	✓	★	✓	★	★	★
Facility HVAC Improvements	0.5-2%	✓	✓		✓	✓		✓	✓	✓	✓			✓	✓
Lighting	0.5-2%	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

Success Story: Process Changes

- Cheese processing plant
- Extract water at beginning of process
- Impact
 - 1.6 million kWh

Food Processing

- Food processing was 2nd largest sector
- Cheese & Poultry sub-sectors were big
- Refrigeration is important to the sector

Fabricated Metals Energy Savings

Sub-sector	# of Facilities	Gas			Electricity		
		Total Use (therms)	Remaining Potential Savings* (therms)	Est. Savings (%)	Total Use (kWh)	Remaining Potential Savings* (kWh)	Est. Savings (%)
Plating, Polishing, Finish	29	4,248,501	806,500	19.0%	882,455	154,400	17.5%
Ordnance & Ammo Mfg	6	3,363,437	553,600	16.5%	-	-	-
Machine and Tool/Die	611	2,447,014	736,900	30.1%	188,072,875	32,638,500	17.4%
Metal Tube Manufacturing	4	1,026,337	381,600	37.0%	-	-	-
Metal Can Manufacturing	7	1,182,037	264,600	22.4%	47,876,568	5,266,400	11.0%
Sheetmetal Products	21	546,435	129,700	23.7%	4,622,495	832,000	18.0%
Computer Components	55	131,498	26,300	20.0%	141,860,215	14,186,000	10.0%
Stamping & Forging	7	-	-	-	32,788,741	4,329,500	13.2%
Boat Manufacturing	21	-	-	-	8,256,004	1,733,300	21.0%
Medium Duty Equipment	48	-	-	-	15,565,003	1,665,300	10.7%
TOTAL	809	12,945,259	2,899,200	22.4%	439,924,356	60,805,400	13.82%

Gas Opportunities

Opportunity	Savings Range	Sub-Sectors									
		Sheetmetal Products	Plating, Polishing, Finishing	Ordnance and Ammo Manufacturing	Metal Tube Manufacturing	Metal Can Manufacturing	Machine and Custom Tool/Die Shops	Computer Components and Hardware	Stamping and Forging Operations	Boat Manufacturing	Medium Duty Equipment Mfg.
Process heat system optimization	1-20%	✓	✓		✓	✓	✓	✓	✓		
Heat recovery	2-59%			✓	✓	✓	✓		✓		
Facility HVAC improvements	5-35%	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

Electric Opportunities

Opportunity	Savings Range	Sub-Sectors							
		Sheetmetal Products	Plating, Polishing, Finishing	Metal Can Manufacturing	Machine & Die Shops	Computer Components	Stamping and Forging	Boat Manufacturing	Medium Duty Equipment Mfg.
Process improvements and optimization	2-9%	✓	✓		★		★		
Facility HVAC and lighting improvements	1-6%	✓	★	✓	✓	★	★	★	
Pumps and fans	2-6%	✓	✓	✓	✓	★	✓	✓	
Compressed air	1-9%	★	★	★	★	★	★	★	★
Process motors	1-4%	★	✓	★	★			✓	★
Fan and paint ventilation	1%	✓						★	✓
Electrochemical process	10%		★						
Welding system controls	1%	★		★				✓	★

Fabricated Metals

- Largest potential gas savings: Plating
 - Tank heating and make-up air
- Largest potential electric savings: Machine and custom metal shops
 - Compresses air, motors, and process changes
- Cross sub-sector opportunities
 - Compressed air improvements, welding power supplies, motor and HVAC optimization.

Chemical Manufacturing Energy Savings

Sub-sector	# of Facilities	Gas			Electricity		
		Total Use (therms)	Remaining Savings (therms)	Est. Savings (%)	Total Use (kWh)	Remaining Savings* (kWh)	Est. Savings (%)
Ethanol Production	21	115,564,147	13,599,954	11.8%	164,501,409	3,818,200	2.3%
Pharmaceuticals	15	2,191,809	344,400	15.7%	-	-	-
Resin Production	1	834,758	51,472	6.2%	-	-	-
Compressed Gas	6	21,212	2,758	13.0%	20,288,592	5,072,148	25%
Explosives Mfg.	1	77,327	12,300	15.9%	-	-	-
Shingle Mfg.	1	-	-	-	33,829,875	11,826,900	35%
TOTAL	45	118,689,254	14,010,874	11.8%	218,619,876	20,717,248	9.5%

Gas Opportunities

Opportunity	Savings Range	Sub-Sectors				
		Ethanol Production	Pharmaceutical Mfg.	Resin Production	Explosives Mfg.	Compressed Gas
Corn fractionation	5-15%	★				
Preheat drying combustion air	4-8%	✓				
Cold cooking	5-10%	★				
Steam system optimization	1-17%	★				
Process heat system optimization	1-14%		★		★	★
Heat recovery	4-10%	✓	★		★	
Facility HVAC improvements	0-5%		★		✓	★
Boiler system improvements	3-8%	✓	✓	★	✓	
Burner upgrades/improvements	0-10%			★	★	

Electric Opportunities

Opportunity	Savings Range	Sub-Sectors			
		Ethanol Production	Pharmaceutical Mfg.	Compressed Gas	Shingle Mfg.
Corn fractionation	5-15%	★			
Increase screen size on hammer mill	0-8%	✓			
Not drying stillage	3%	★			
Optimize dust collection system	6-12%	★			
Replace hammer mills with roller mills	4%	✓			
Motor optimization	1-2%	✓		★	★
Pump optimization	0-1%	✓		★	✓
Insulate heaters	1%				
Air compressor system optimization	0-2%		✓	✓	✓
Process control improvements	0-2%		✓	★	✓
Process heat system improvements	1-2%				★
Facility HVAC improvements	0-3%		★	✓	★
Lighting improvements	0-3%		★	✓	✓

Chemical Manufacturing

- Diverse products, processes, energy mixes, and energy use
- Ethanol is the key sub-sector
 - 93% of energy is gas
- Top opportunities:
 - Fractionation/cold cooking
 - Not drying stillage
 - Boiler system improvements

Primary Metals Energy Savings

Sub-sector	# of Facilities	Gas			Electricity		
		Total Use (therms)	Remaining Potential Savings* (therms)	Est. Savings (%)	Total Use (kWh)	Remaining Potential Savings* (kWh)	Est. Savings (%)
Aluminum Operations	37	11,407,286	572,200	5.0%	100,652,913	14,266,200	14.2%
Heat Treating Operations	15	3,027,292	73,000	2.4%	36,436,318	3,643,600	10.0%
Iron Operations	22	2,305,370	381,400	16.5%	135,599,741	20,323,900	18.0%
Iron Feedstock Prod.	1	-	-	-	9,604,800	856,300	8.9%
TOTAL	75	16,739,948	1,026,600	6.1%	282,293,772	39,090,000	13.8%

Gas Opportunities

Opportunity	Savings Range	Sub-Sectors			
		Aluminum Operations	Heat Treating Operations	Iron Operations	Iron Feedstock Production
Fired heaters upgrades/optimization	6-10%	✓		✓	
Furnace optimization	2-24%	★	★	★	★
Process heat optimization	2-16%	✓			
Waste heat recovery	0.5-5%	★	★		

Electric Opportunities

Opportunity	Savings Range	Sub-Sectors			
		Aluminum Operations	Heat Treating Operations	Iron Operations	Iron Feedstock Production
Process heat system optimization	1-5%	★			
Materials processing improvements	1-2.3%	✓		✓	★
Pump and fan optimization	1-7%	✓			
Existing furnace optimization	9-18%	✓	★	★	
Compressed air optimization	1.6%	★			★
Facility improvements	1.5%	✓		✓	✓

Primary Metals

- Energy saving opportunities focused on furnaces and ovens
 - Existing melt equipment and melt process steps- including casting design improvements
- High temperature waste thermal energy
- Materials handling
 - Motors, compressed air systems

Printing Energy Savings

Sub-sector	# of Facilities	Gas			Electricity		
		Total Use (therms)	Remaining Potential Savings * (therms)	Est. Savings (%)	Total Use (kWh)	Remaining Potential Savings * (kWh)	Est. Savings (%)
Heat Set Printers	56	10,477,677	1,251,397	11.9%	65,234,908	8,508,000	13.0%
Non-Heat Set Printers	181	927,338	138,000	14.9%	312,128,662	43,814,000	14.0%
Newspapers, Periodicals, & Books	261	550,911	80,000	14.5%	57,616,843	7,695,000	13.4%
TOTAL	498	11,955,926	1,469,397	12.3%	434,980,413	60,017,000	13.8%

Gas Opportunities

Opportunity	Savings Range	Sub-Sectors		
		Heat Set Printers	Non-Heat Set Printers	Newspapers, Periodicals, & Books
Replace gas oxidizer with more efficient equipment	3-13%	★		
Replace obsolete dryers with more efficient ones	4-22%	★		
Recover heat from dryer exhaust	6-30%	★		
Integrate dryers and recuperative gas oxidizer		✓		
Make facility HVAC improvements	0-5%	✓	★	★

Electric Opportunities

Opportunity	Savings Range	Sub-Sectors		
		Heat Set Printers	Non-Heat Set Printers	Newspapers, Periodicals, & Books
Improve compressed air system	1-5%	★	★	✓
Make motor improvements including VFDs, proper sizing, etc.	3-11%	★	✓	★
Optimize pump systems	0-2%	★		
Install high efficiency LED lighting	2-7%	✓	★	★

Printing

- Primary differentiating factor: Heat set
 - Characterized by higher quality media, higher volume, or longer runs
 - Industry codes not reliable
- Top opportunities
 - Dryers
 - Thermal oxidizers
 - Compressed air, lighting, building envelope

Cross-Sector Opportunities

Electric

- Compressed air
- Motor & drives
- Pumps & fans
- Process controls
- Refrigeration

Gas

- Burners & burner controls
- Heat recovery
- Steam system best practices
- Thermal oxidizer

Compressed Air Improvements

- Repair leaks in piping and equipment
- Reduce the compressor output pressure
 - Correct large system pressure drops
 - Set up remote air receivers
 - Increase air storage volume
- Use a cold-air intake
- Replace air-driven uses with other sources
- Reduce inappropriate uses

Motors & Drives

- Maintain motor system – align, lubricate, clean
- Develop motor replacement plans
 - Understand how to cover for failed equipment
- Use direct-drives to transfer power to end uses
- Use cog-belt drives instead of vee-belts
- Install adjustable speed drives (ASD, VSD, VFD)
- Optimally design motor-powered systems

Pumps & Fans

- Properly size pumps, fans, and motors
 - Oversized equipment leads to unstable operation and increased wear
 - Ideally operate at 75% to 100% load.
- Use a smaller impeller with the capability of adding a large one later
- Match supply and demand
- Install adjustable speed drives – avoid throttled flow

Refrigeration

- Implement best practices
- Reduce head pressure
- Increase suction pressure
- Utilize thermosiphon oil cooling
- Improve compressor sequencing
- Use multiple levels of compression
- Utilize cool outside temperatures

Burners & Burner Control

- Select burners with stable flame throughout firing range at low excess air.
 - Try for close to 3% excess air at high fire
 - A 1% reduction in O₂ yields a 1% improvement in operating efficiency.
- Install O₂ trim
 - O₂ control is required to operate boilers at less than 3% O₂ and can achieve levels below 1%
 - Requires a burner that can operate stably within the desired control range

Heat Recovery

- Boiler heat recovery
 - Use stack economizers to recover boiler heat
 - Preheat combustion air, generate low grade steam, preheat returning condensate and boiler feed water, or heat or pre-heat process or domestic water
 - Evaluate condensing economizers
- Process heat recovery
 - Possible where ever waste heat is released
 - Best opportunities are where the waste heat temperature and total amount of heat is high
 - Possible uses of waste heat include process or domestic water heating, product or raw material pre-heating, process or ventilation air heating.

Steam System Best practices

- Boiler tuning
- Steam trap inspections
- Steam leaks
- Insulation



Thermal / Electrical Issues

- Perception of utility role
 - Appearance of increased use
 - Loss of customer
 - Mixed effects
- Customer sub-optimization

Benchmarking Study

- Provide means for comparison
- Industrial benchmarks haven't existed
- Previous MnTAP effort: ethanol only
 - Metric: annual production
- Current MnTAP effort: many industries
 - Metrics: facility area, employees, and sales

Benchmarking: How to Use

- How to use guide has been prepared
- Example: heat set printer with 10,000 sq. ft., employs 150, uses 1,200,000 kWh and 72,000 Th annually.

$\text{kWh/employee} = \frac{1,200,000}{150} = 8,000$	$\text{therms/employee} = \frac{72,000}{150} = 480$
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	Most efficient 25% (Q1)	More efficient 25% (Q2)	Less efficient 25% (Q3)	Least efficient 25% (Q4)
kWh/employee	< 6,635	6,635 - 10,085	10,085 - 15,329	> 15,329
therms/employee	< 454	454 - 982	982 - 2,121	> 2,121

Benchmarking: Constraints

- Benchmark metric uncertainty
 - Variable uses
 - actual or estimated?
- Customer uncertainty
 - False matches
 - correct industry codes?
- Incomplete facility metric data
 - Smaller facilities not represented
 - Substandard population sizes
- Use with caution!

Upcoming Data Uses

- Identify opportunities for future projects
- Partner with utilities to address industrial energy efficiency



Thank you!

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- Reports:
www.mntap.umn.edu/resources/DOC/index.html