Industrial Energy Efficiency Opportunities in North Carolina

Extended Abstract # 157

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INTRODUCTION

Energy efficiency (EE) is growing in importance to the business community for reducing operating costs and to air regulators for providing cost-effective air emissions reduction strategies. Implementation of EE, however, relies on the voluntary actions of decision makers who are often non-technical and have limited capital to invest. Therefore, providing education, direct interaction with energy experts, and site-specific recommendations can be effective approaches to driving action on EE and improving North Carolina's air quality.

METHODS

In 2011, the NC Division of Air Quality (NC DAQ) received a grant from U.S. Environmental Protection Agency (EPA) to educate and assist North Carolina facilities on the benefits of implementing EE. The primary goal of the grant was to encourage facilities to take voluntary actions to reduce energy use through implementing EE measures with short payback periods.

To realize these goals, the NC DAQ partnered with two organizations that have expertise in EE; 1) professors and students from North Carolina State University's Mechanical Engineering Department, and 2) Waste Reduction Partners, a group of retired facility engineers. Our partners provided reduced-cost energy assessments and EE workshops for facilities of all types and sizes over a period of four years (2011-2015).

Energy assessments are a proven method to encourage implementation of EE.[1] In an energy assessment (EA); a trained engineer evaluates energy use and costs for the energy consuming equipment operated by a facility. The assessor develops a set of recommendations on how to lower the use and/or cost of electricity and fuel. For each recommendation, the capital cost, the annual cost savings, and payback period are estimated to assist facility management prioritize projects. Lastly, the decrease in emissions of air pollutants is estimated.[2, 3]

Shortly after the grant was awarded, the U. S. EPA promulgated the National Emission Standards for Hazardous Air Pollutants for Area Sources: Industrial, Commercial, and Institutional Boilers, also called the Boiler General Available Control Technology (GACT) rule.[4] It requires subject facilities to complete an energy assessment on the boiler system as a work practice standard to reduce emissions of Hazardous Air Pollutants (HAPs). The rule does not require implementation of the recommendations. The rule relies on the identified cost-savings as incentive for improving boiler efficiency. To encourage participation in our assessments, the NC DAQ sent letters to about 300 facilities in March 2012 that were potentially subject to this rule.

RESULTS

A total of 77 assessments were conducted at manufacturing and institutional facilities throughout North Carolina, including 51 facility-wide assessments and 26 equipment specific assessments. Forty-five of these facilities are subject to the Boiler GACT rule. The assessments resulted in more than 500 individual recommendations. The NC DAQ and its partners placed the recommendations into three major categories - electricity, boilers and measures that involve multiple energy sources - and twelve subcategories to delineate the targeted equipment as shown in Table 1.

Table 1. Energy Assessment Recommendations

Type of Recommendation		Descriptions
Boilers	Stack Loss & Heat Recovery	Reducing stack temperature, improving heat transfer
	Steam Recovery	Improving steam recovery: condensate return and steam trap maintenance
	Boiler Tune-up	Improving combustion efficiency by adjusting fuel to air ratio
	Gauges	Installing monitoring gauges for pressure, temperature and makeup water flow
Electricity	Lighting	Installing energy efficient lighting, ballasts and occupancy sensors
	Compressor	Repairing leaks and reducing pressure
	Motors	Installing variable frequency drives and premium efficiency motors
	General - Electric	Reducing use of various manufacturing and office equipment
Multi-Energy	HVAC/Chiller	Improving HVAC or chiller efficiency
	Heat Recovery	Recovering compressor waste heat
	Combined heat & power (CHP)	Utilizing excess steam to produce electricity
	Fuel Switching	Changing to a less costly fuel source

Table 2, summarizes the energy savings and reductions in both energy costs and air emissions identified by the assessments. Note this table represents the potential savings, i.e., assuming all recommendations were implemented. The average cost savings in electricity and fuel use per facility assessment is $100,000 per year. Implementation of all recommendations would reduce greenhouse gas emissions by 67,000 tons per year.

Research indicates that the response to EE is based largely on investment costs, not energy savings.[1] Therefore, assessors focus on recommendations with low capital costs such as lighting and equipment maintenance. Table 3 shows the average capital cost per recommendation was $20,000 with a corresponding average payback time for the investment of 20 months. This average excludes CHP, which generally involves significant capital investment and technical difficulty.

Table 2: Potential Average Cost Savings and Emission Reductions Identified

	Type of Recommendation (Rec.)	Number of Rec.	Average: Average Cost Savings[b] ($/yr)	Average: Average Capital Cost ($)	Average: Average Payback Period in Months	Total: [a]Energy Reductions: Electricity kWh/yr	Total: [a]Energy Reductions: Fuel Use MMBtu/yr	Total: [a]Air Pollution Reductions: NO_X ton/yr	Total: [a]Air Pollution Reductions: SO_2 ton/yr	Total: [a]Air Pollution Reductions: CO_2e ton/yr
Boilers	Stack Loss & Heat Recovery	36	$25,000	$30,000	20	0	436,000	56	26	18,500
	Boiler Tune-up	35	$15,000	$8,000	20					
	Steam	77	$7,000	$6,000	16					16,000[c]
	Gauges	10	$3,500	$2,500	12					
Electricity	Lighting	122	$13,000	$22,000	24	30,400,000	0	13	42	16,300
	Compressor	48	$5,400	$3,500	8					
	Motors	28	$16,000	$17,000	26					
	General - Electric	30	$10,000	$3,100	5					
Multi-Energy	HVAC/Chiller	11	$60,000	$130,000	20	34,000,000	-15,000[d]	23	63	16,200
	Heat Recovery	8	$60,000	$30,000	22					
	Fuel Switching	12	$83,000	$116,000	29					
	Combined Heat & Power (CHP)	4	$48,000	$112,000	49					
Total for All Facilities		**421**				**64,400,000**	**421,000**	**92**	**131**	**67,000**
Facility Average			**$100,000**	**$20,000**	**20**					

[a] kwh/yr: kilowatt-hour/year; MMBTU/yr: Million British Thermal Unit/year; NO_X : Nitrogen oxides; SO_2: Sulfur dioxide; CO_2e: carbon dioxide equivalent

[b] Seven facilities did not track waste wood use; therefore energy and cost savings could not be estimated.

[c] CO_2 emissions from biomass combustion are reported separately per U.S. EPA GHG reporting rules.[5]

[d] Fuel switching and CHP are cost-saving measures that may result in a fuel use increase.

To find out which recommendations were actually implemented by facilities, phone surveys are conducted about one year after the EA. At this time, 55 surveys have been completed. Three facilities that received an assessment have shut down and one was sold. The NC DAQ calculated the implementation rate as the number of implemented recommendations divided by the total number of recommendations. Table 3 presents the implementation rate for our program and compares it to a historical U.S. average prior to 2012, 48%.[6] The NC DAQ also calculated an average implementation rate of 60% for the subset of facilities subject to the Boiler GACT.

Table 3: Implementation Rates for Energy Assessment Recommendations

U.S. Historical Average [6]	48%
NC DAQ EA Program Average	54%
NC DAQ EA Program Average for Boiler GACT Facilities	60%

Table 4 presents the savings resulting from implemented or planned EE measures from the surveyed facilities. These data only includes recommendations where energy savings could be quantified by the assessors. It represents actual cost savings to businesses and emissions reductions for North Carolina. In addition, EA projected the total savings expected to be realized from our EA program using the implementation rates for each energy source.

Table 4. Total Realized Energy Savings and Air Pollution Reductions Due to Implemented EE Recommendations at Participating Facilities

	Type of Recommendation	Number Implemented	Total				
				Energy Reductions		Air Pollution Reductions	
			Cost Savings ($/yr)	Electricity Savings (kWh/yr)	Fuel Savings (MMBtu/yr)	NO_X (ton/yr)	GHG Reduced (ton/yr as CO_2e)
Boilers	Stack Loss & Heat Recovery	4	$24,876	0	87,987	14	7,961
	Boiler Tune-up	20	$135,767				
	Steam	33	$324,977				
	Gauges	9	$4,067				
Electricity	Lighting	68	$949,276	21,467,615	7,058	8	12,136
	Compressor	30	$225,842				
	Motors	13	$177,817				
	General- Electric	5	$159,521				
	HVAC/Chiller	5	$53,297				
Actual Savings Realized to Date		187	$2,055,441	21,467,615	95,045	22	20,097
Potential Energy Savings & Emission Reductions			$7,000,000	64,000,000	450,000	91	67,000
Projected Energy Savings & Emission Reductions			$3,220,000	31,360,000	162,000	30	36,180

Table 4 shows that lighting upgrades were the most common recommendation to be implemented (36%) due to its fast payback per time, and the availability of utility rebates. The second most common recommendations deal with recovering steam and decreasing compressor use with basic maintenance and operational changes. Note that the reductions in oxides of nitrogen (NO_X) from implementing EE on boilers, 14 tons per year, were higher than the reductions estimated for EE related to electricity use, 8 tons per year. This is due to NO_X controls on North Carolina's electricity generating units which lowers the emissions factor for indirect offset of electricity purchased from the utility grid.

In order to estimate the impact of the EA program, the NC DAQ calculated the percent reduction in greenhouse gas (GHG) and NO_X emissions due to the EA program from the total emissions of permitted electric generating units (EGUs) and industrial, commercial and institutional (ICI) boilers in North Carolina.[7, 8] The results are given in Table 5.

Table 5. Air Quality Impacts from Energy Assessment Program

Parameter	**NO_X (tons)**	**GHG (tons)**
Statewide Emissions - EGUs & ICI Boilers (2011, 2012)	63,950	58,234,000
Total Reductions Identified by EA Program	90	67,000
Projected Actual Reductions from EA Program	30	36,000
Percent Reduction in Emissions from EA Program	0.05%	0.06%
Projected Reduction in Emissions due to Statewide Implementation of Low Cost EE Measures	**1.7%**	**2.0%**

The participating facilities represent less than 3% of the permitted facilities in North Carolina. These facilities were able to achieve a 0.06% reduction in GHG s and 0.05% reduction in statewide NO_X emissions from EGUs and ICI Boilers. The NC DAQ estimates that expanding this voluntary program to all 2,600 permitted facilities in North Carolina could result in approximately a 1.7% decrease in GHG emissions and a 2% decrease in NO_X emissions from these sectors.

As stated above, 45 of the participating facilities are subject to the Boiler GACT rule. These facilities represent a unique subset of the data collected since 34 of the boilers fire waste wood, available on site or at low cost. Seven of the boilers did not track fuel use; therefore energy savings could not be estimated. The assessors did not identify low cost EE for two boilers. Nonetheless, the response of these facilities has been very high, with 86% of the facilities implementing at least one recommendation. This is due to the expertise and hands-on approach of our assessors and the focus on low investment cost recommendations.

At this time, the NC DAQ has documented implementation results for 29 facilities subject to the Boiler GACT rule. Table 6 summarizes the HAP reductions from EE measures implemented by these 29 facilities. NC DAQ also projected the emissions on the population of point and non-point boilers potentially subject to the Boiler GACT Rule. The NC DAQ projects total HAP reductions from implementation of low capital cost EE identified by EAs conducted under the Boiler GACT Rule as 3.06 tons per year.

Table 6. HAP Emission Reductions from Boiler GACT Rule:
NC EA Program Actual Reductions and Projections for NC GACT Boiler Population

HAP Category	GACT Boilers that Conducted an EA through NC DAQ Program			NEI HAP Emissions from Boilers Subject to GACT			North Carolina GACT Boilers
	NEI HAP Emissions	Actual HAP Reductions	Reductions from EA Process	NEI Point	NEI Non-Point	Total	Projected HAP Reductions from EA Process
	ton/yr	ton/yr	(%)	ton/yr	ton/yr	ton/yr	ton/yr
Acid Gases	14.5	0.56	3.8%	46.5	0.004	46.49	2.34
Metals	1.3	0.038	2.9%	0.7	1.25	2.00	0.10
Organics	45.3	0.35	0.8%	35.7	0.78	36.49	0.63
Total	**61.1**	**0.94**	**1.5%**	**82.9**	**2.03**	**84.98**	**3.06**

SUMMARY

Energy assessments provide an effective roadmap for the business community to implement EE. The NC DAQ EA program has been very successful and compares favorably to similar programs. The high implementation rate shows both the effectiveness of the outreach program and the usefulness of the reports that were generated. Barriers in our program to more substantial energy reductions are similar to historical evidence, where low investment cost drives action rather than the energy and cost savings achieved.

The NC DAQ found that the projected outcome of the EA program on all permitted facilities would have a slight impact on North Carolina's air quality; including a decrease of 1% to 2% in NO_X and GHGs, respectively. The high implementation rate for facilities subject to the Boiler GACT rule indicates that voluntary EE was implemented in North Carolina due to the rule, even though many of the participating facilities use waste wood fuel. The EA assessment process required by the Rule reduced HAP emissions in North Carolina by an estimated 1.45 ton per year.

ACKNOWLEDGMENTS

Special thanks to the EPA for giving the NC DAQ an opportunity to explore a voluntary program which works with the regulated community in finding solutions that make good business sense and help the environment. We also extend our appreciation to all the energy assessors and students who performed the assessments and the companies who elected to participate. This ongoing effort will hopefully lead to increased sustainability in the industrial sector and improved air quality in North Carolina.

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