Toxics Reduction through Energy Efficiency for Boilers

A white paper from the Oregon Environmental Council

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1. Executive Summary

Improving energy efficiency of boilers has two primary beneficial outcomes: it lowers facility fuel costs and it reduces emissions of toxic pollutants and greenhouse gases. Based on findings from a similar study carried out by the Delta Institute in Wisconsin in 2002, the Oregon Environmental Council (OEC) set out to reduce toxic emissions in Oregon by improving the energy efficiency of boilers.

To do this, OEC partnered with Oregon State University's Industrial Assessment Center (IAC), the Oregon Department of Energy (ODOE), the Oregon Department of Environmental Quality (DEQ), and a private consultant to offer free energy efficiency audits and tune-ups to small- to medium-sized industrial and institutional boilers in Oregon.

OEC found opportunities to increase boiler efficiency at almost every single facility visited, with substantial reductions in fuel costs, toxic pollutant emissions, and greenhouse gas emissions. Specifically, this study found that if boiler efficiency improvements were implemented at *all* participating industrial facilities, the *potential annual savings and reduced emission*s would be:

- **$437,406 dollars of fuel cost savings**
- **29,476 metric tons of CO_2 emissions mitigated**
- **1.16 pounds of mercury emissions mitigated**

Furthermore, by offering free boiler tune-ups to participating institutional facilities, the actual savings and reduced emissions were:

- **Saved Oregon public schools a total of $20,106**
- **Prevented 85.3 metric tons of CO_2 from being released**
- **Kept 1.40 grams of mercury out of the air and water.**

Considering that the equivalent of one gram of mercury from atmospheric contamination has the potential to contaminate a twenty acre lake so the fish are unsafe to eat, these results are significant. This study demonstrates the tangible benefits – both for the environment and for the financial bottom line – of improving boiler efficiency. Furthermore, it offers insight into the potential benefits of statewide actions to reduce fuel consumption and use cleaner fuels in better functioning equipment at minimal net cost to business owners and to school districts.

For all of these benefits to be realized, however, the state of Oregon must take an active role in encouraging Oregon businesses, schools, and hospitals to take advantage of the array of financing mechanisms that are available for improving overall facility energy efficiency.

Specifically, Oregon state agencies should organize an integrated program to encourage boiler efficiency. Oregon's varied programs are fragmented and boiler operators do not have the time or motivation to sort through these programs. This means that few operators take advantage of the substantial financing mechanisms available to them. Economic development agencies, DEQ, and other partners interested in these outcomes should be more actively engaged in programs to help identify and highlight other incentives and opportunities to encourage efficiency. Furthermore, Oregon's public agencies should aggressively pursue boiler tune-ups and related efficiency measures because increased boiler efficiency has multiple benefits: energy efficiency, reduced toxic pollutants, and improved economic performance and competitiveness.

2. Introduction

Industrial, commercial, and institutional boilers are a significant source of many persistent, toxic pollutants, including mercury. The objective of this project was to improve the energy efficiency of industrial and institutional boilers in Oregon though tune-ups and energy efficiency audits and other strategies, thereby reducing emissions of toxic pollutants.

Boilers are widely used by almost all segments of U.S. industry to produce hot water and steam by burning fuels such as natural gas, diesel oil, coal, waste products, and wood products. The Oregon Department of Environmental Quality (DEQ) estimates that industrial and commercial/institutional boilers in Oregon emit approximately 196.7 pounds of mercury to the air each year, along with other persistent and toxic pollutants.[1]

The non-profit Delta Institute performed energy efficiency assessments at nine Wisconsin industrial boilers and found that by implementing energy efficiency practices, businesses can realize cost savings and reduce toxic pollution.[2] In addition to immediate mercury pollution prevention benefits, the Delta Institute found that adoption of pollution prevention techniques by industrial boilers reduces emissions of cadmium, PCBs, dioxins, furans, PAHs and hexachlorobenzene, as well as ozone precursors, acid aerosols, particulate matter (PM) and greenhouse gases.

While EPA has issued a new Maximum Achievable Control Technology (MACT) rule for boilers under the Clean Air Act, this rule does not apply to most boilers in Oregon. However, this and a number of other studies suggest that companies could

[1] Oregon DEQ, 2002.
[2] "Sector-Based Pollution Prevention: Toxic Reductions through Energy Efficiency and Conservation Among Industrial Boilers." A Report to the Great Lakes National Program Office (GL97514402). The Delta Institute, July 2002.

prevent mercury pollution and save money, even in the absence of regulatory mandates, by improving efficiency, conserving energy, switching to cleaner fuels, and/or adopting other pollution prevention techniques.

OEC coordinated with Oregon State University's Industrial Assessment Center (IAC), the Oregon Department of Energy (ODOE), and the Oregon Department of Environmental Quality (DEQ) to offer free energy efficiency audits and tune-ups to small- to medium-sized industrial and institutional boilers in Oregon. OEC also promoted an array of financing mechanisms to further encourage Oregon businesses to adopt energy efficiency practices. OEC plans to use the results of these audits to raise awareness among other boiler owners across the state about energy efficiency opportunities.

OEC identified industrial and institutional clients willing to participate in the study. The goal of the project was to conduct a total of 20 audits consisting of 10 industrial and 10 institutional facilities using an array of fuel types. Ultimately, only six industrial facilities were willing and able to participate, and 11 institutional facilities (eight schools and three hospitals) agreed to boiler tune-ups, bringing the total number of audits completed to 17.

Recruiting industrial facilities to participate in this program was more difficult than anticipated. After identifying likely candidates for the program, OEC, ODOE, and DEQ staff contacted the facility by phone, described the program and requested their participation. Unfortunately, more facilities turned down the offer than agreed to participate. There are several possible reasons that a facility declined to participate, some of which are listed below. In some cases, phone calls were simply never returned, so it is difficult to assess the reasons for non-participation.

- Facility did not meet the IAC criteria;
- Facility felt that their boiler was operating well already;
- Facility was suspicious of a program that involved an "environmental" organization;

- Facility was concerned about possible regulatory implications;
- Facility staff were too busy dealing with other concerns;
- Facility staff were put off by the questions posed by IAC.

This report presents the results of the energy efficiency audits program partners were able to conduct, and it provides several recommendations for future efforts aimed at decreasing the release of toxic pollutants from industrial and institutional boilers. The report is organized into the following sections:

Project Background. This section includes an overview of boiler types, the number of facilities using boilers in the state of Oregon, boiler related rules and regulations at the state and national level, existing school energy efficiency programs, and financing mechanisms for boiler upgrades.

Assessment Findings and Implementation. This section includes the findings from industrial and institutional boiler audits and tune-ups conducted for this project as well as a summary of the actions taken by industrial and institutional facilities and the subsequent reductions in toxic emissions.

Conclusions and Recommendations. This section includes a summary of the successes of the project as well as suggestions for future efforts in the area of boiler efficiency and upgrades.

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3. Project Background

3.1. Purpose

The primary purpose of this project was to demonstrably reduce toxic air emissions in Oregon by increasing energy efficiency of industrial and institutional boilers. There are a number of different types of emissions from the combustion of fuels in boilers, including particulate matter (PM), carbon dioxide (CO_2), carbon monoxide (CO), sulfur dioxide (SO_2), nitrogen oxide (NO_X), and mercury.

According to the Natural Resources Defense Council (NRDC), "particulate matter includes a wide range of pollutants -- road dust, diesel soot, fly ash, wood smoke, and sulfate aerosols that are suspended as particles in the air." PM results from the combustion of fossil fuels such as the burning of coal, oil, diesel fuel, gasoline, and wood in transportation, power generation, and space heating. The NRDC also indicates that old coal-fired power plants, industrial boilers, diesel and gas-powered vehicles, and wood stoves are the largest sources, and that people living in areas with high levels of PM are at increased risk for premature birth, respiratory problems, and a variety of other health problems.[3]

In recent years, OEC has focused much of its efforts specifically on mercury reduction efforts due to the element's high toxicity, to the small amounts of mercury needed to contaminate rivers and lakes, and because much of the release of mercury into the environment can be prevented.

In December 2001, OEC released a report, "*Mercury on the Road to Zero: Recommended Strategies to Eliminate Mercury Releases from Human Activities in Oregon by 2020*," which provides a useful

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[3] "Breath-Taking: Premature Mortality Due to Particulate Air Pollution in 239 American Cities" (1996). Prepared by the Natural Resources Defense Council.

background of mercury and its prevalence in the environment. The report explains that mercury is a naturally occurring element that has been used historically in a wide variety of industrial and commercial applications. However, mercury is also a "persistent bioaccumulative toxin" or PBT. It is highly toxic, persists for years in the environment without breaking down, and tends to accumulate to higher concentrations as it moves up the food chain. Once mercury enters the environment, it circulates in and out of the atmosphere until it ends up in the bottoms of lakes and oceans.

Depending on its form, mercury may travel long distances before it falls to earth with precipitation or dust, and can remain airborne for up to a year or more.[4] Mercury eventually falls to the ground with rain or snow, and then migrates to lakes and streams. When mercury enters a lake or river, it can enter the food chain, or it can be released back to the atmosphere by volatilization. Mercury can be converted by bacteria to the more toxic methylmercury, and plants and fish easily absorb this form of mercury. Larger fish eat smaller fish and in doing so, they accumulate higher levels of methylmercury. Fish at the top of the food chain, therefore, often contain very high levels of mercury.

A neurotoxin, mercury slows fetal and child development, causes irreversible deficits in brain function, and is a particular risk for children exposed before birth through their mothers. The Centers for Disease Control found that one in 10 women of childbearing age have levels of mercury high enough that a small increase in exposure to mercury while pregnant could jeopardize the neurological development of the baby.[5] Edward Swain of the Minnesota Pollution Control Agency has explained that the equivalent of one gram of mercury from atmospheric

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[4] US EPA & Environment Canada, 1999.

[5] Center for Disease Control and Prevention, 2001. Blood and Hair Levels in Young Children and Women of Childbearing Age – United States, 1999. Morbidity and Mortality Weekly Report, March 2, 2001.

contamination has to potential to contaminate a 20 acre lake so the fish are unsafe to eat.[6]

"In Oregon alone, industrial and institutional boilers release approximately 196.7 pounds of mercury into the environment each year."

In Oregon alone, industrial and institutional boilers release approximately 196.7 pounds of mercury into the environment each year.[7] Given the potency of mercury as a toxin and its prevalence in the environment, OEC believes that a diversity of actions aimed at reducing the release of this toxin into the environment is needed. Improving the efficiency of boilers is one of these actions.

3.2. *Boiler Types and General Efficiency Improvement Methods*

Boilers are widely used by almost all segments of U.S. industry to produce hot water and steam by burning fuels such as natural gas, diesel oil, coal, waste products, and wood products. As summarized by the US EPA,

> [b]oilers are enclosed devices using controlled flame combustion and having the primary purpose of recovering and exporting useful thermal energy in the form of hot water, saturated steam, or superheated steam. The principal components of a boiler are a burner, a firebox, a heat exchanger, and a means of creating and directing gas flow through the unit. A boiler's combustion chamber and primary energy recovery section(s) are usually of integral design (i.e., the combustion chamber and the primary energy recovery section(s), such as waterwalls and superheaters, are usually formed into one manufactured or assembled unit).
>
> Although the exact number of boilers in use is not known, it is likely that tens-of-thousands are currently operating, ranging in size from small residential and commercial units to large electric utility steam generators. A wide range of boiler designs are common, such as bubbling and circulating fluidized beds, cell-tubes, cyclone-fired, dutch ovens, fire-

[6] Email communication between Edward Swain and Laura Weiss, December 19, 2001.
[7] DEQ Emissions Inventory, 2002.

> and water-tubes, stokers, wet and dry bottom units, wall- and tangentially-fired, and package and field-erected units.
> …
> Boilers can emit a wide variety of pollutants, including those pollutants commonly associated with the combustion of fossil fuels. The Environmental Protection Agency is particularly interested in particulate matter, formaldehyde, PAH, POM, carbon monoxide, lead, HCl, mercury, cadmium, and dioxins/furans.
> …
> Various emission controls are used on boilers. Some of the more common devices include electrostatic precipitators and fabric filters for metals and particulates, scrubbers for acid gases and various inorganics, and good combustion practices for dioxins/furans and other products of incomplete combustion.[8]

In the Pacific Northwest region, a large number of industrial boilers use wood scraps, known as hogged fuel, as the primary source of fuel due to its prevalence as a byproduct of the timber industry. Boilers are also widely used in institutional settings such as schools and hospitals. Among institutional facilities, natural gas and oil are the primary fuel types in use. Table 3-1 shows the distribution of boiler fuel types evaluated for this project.

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[8] Eddinger, Jim. "Industrial-Commercial-Institutional Boilers MACT Standards Development." US EPA, http://www.epa.gov/ttn/atw/combust/boiler/boilback.html.

Table 3-1: Count of Boiler Types Evaluated, by Facility Type

	Institutional			Industrial		
Fuel Type	# Boilers Audited	Estimated # Boilers in State	% of Total in State	# Boilers Audited	Estimated # Title-V Permitted Boilers in State	% of Total in State
Anthracite Coal	1	1	0.1%	0	1	0.6%
Hogged Fuel (wood)	0	0	0.0%	6	51	30.5%
Waste Oil	0	0	0.0%	0	0	0.0%
Heavy Oil	0	94	10.8%	0	20	12.0%
#2 Oil (Diesel)	10	87	10.0%	0	17	10.2%
Natural Gas	4	647	74.3%	4	77	46.1%
Propane	1	42	4.8%	0	1	0.6%
Total	16	871	100.0%	10	167	100.0%

Notes
(1) Estimated number of institutional boilers in the state of Oregon derived from facility energy usage data provided by Oregon Department of Energy.
(2) Estimated number of Title-V permitted boilers in the state of Oregon derived from summary analysis and data provided by Oregon DEQ.

"The audits conducted during this study found that almost all of the industrial and institutional boilers at participating facilities could benefit from efficiency improvement measures."

In general, there are several methods for improving the operating and combustion efficiency of boilers:

Boiler Load Management

- Proper sizing of the boiler to meet the steam load (i.e., install several small boilers instead of one large one).

Tune-up and Air/Fuel Ratio Optimization

- Measuring the outflows provides information about how well the boiler is running.
- Maintaining proper air-to-fuel ratio so as to increase the efficiency of burning.

Burner Replacement

- Using a fuel atomizer to add flexibility to fuel choice and improve low load operation.
- Install modulating burner controls.

Stack Heat Losses, Blowdown Control, and Waste Heat Recovery

- Install stack gas heat recovery and/or blowdown head recovery to preheat feedwater and/or boiler intake.
- Minimize "Blowdown."
- Remove deposits on heat transfer surfaces, which reduce efficiency.
- Install barometric dampers in stack.

All of these methods can be used to reduce fuel consumption – which saves money and reduces overall emissions – as well as to increase the ability of the boiler to optimize the conversion of energy stored in the fuel into usable heat energy. The audits conducted during this study found that almost all of the industrial and institutional boilers at participating facilities could benefit from efficiency improvement measures.

3.3. Overview of Oregon Facilities and Emissions

In accordance with Title V of the US Clean Air Act, Oregon DEQ requires that major sources of air pollutants (potential to emit 100 tons of any criteria pollutant) apply for a Title V permit. While this permit does not mandate numerical emissions standards, it does place the responsibility for reporting emissions data on the source facility. Businesses operating under Title V permits are required to report on their compliance with the conditions of the permit at least every six months.

According to DEQ data, Oregon facilities emit a total of approximately 334.3 lbs of mercury per year (Table 3-2). Of this, 196.7 lbs, or 58.9%, is from industrial and commercial boilers.

Table 3-2: Mercury Emissions from Boilers in Oregon, DEQ Emissions Inventory

	Title V Permited			Non-Title V Permited			
Mercury Emissions (lbs/year)	Industrial	Commercial/ Institutional	Electric Generation	Industrial	Commercial/ Institutional	Electric Generation	Total
Coal	2.7	-	137.3	-	-	-	140.0
Distillate Oil	0.7	-	0.3	30.9	39.7	-	71.6
Natural Gas	6.1	-	0.0	13.1	7.9	-	27.0
Process Gas	0.0	-	0.0	-	-	-	0.0
Residual Oil	0.6	-	0.0	2.2	0.3	-	3.2
Wood/Bark Waste	92.4	-	0.0	-	-	-	92.4
Total	102.7	0.0	137.5	46.1	47.9	0.0	334.3

Notes:
(1) Analysis and data collection conducted by Oregon DEQ.
The following notes are applicable for non-Title V facilities:
(2) Industrial and Commercial statewide fuel use was taken from the following Federal Energy Department publications
http://www.eia.doe.gov/pub/oil_gas/natural_gas/data_publications/natural_gas_annual/current/pdf/table_063.pdf
http://www.eia.doe.gov/emeu/states/sep_use/ind/use_ind_or.html
http://www.eia.doe.gov/pub/oil_gas/petroleum/data_publications/fuel_oil_and_kerosene_sales/current/pdf/table4.pdf
http://tonto.eia.doe.gov/dnav/ng/ng_sum_lsum_sor_a_d.htm
(3) The statewide values were apportioned to counties based on the ratio of county to state employees in SIC 20-39 (Industrial) or SIC 50-99 (Commercial) from the 2002 Oregon Covered Employment and Wages publication.
(4) Countywide Title V fuel use was then subtracted from the apportioned amounts to diminish double counting of emissions.

These data illustrate that mercury emissions do not come only from large power plants, as almost half of the mercury emissions come from institutional and industrial facilities. Furthermore, of the mercury released by industrial and institutional facilities, almost half (47.8%) is from smaller, non-Title V permitted boilers.

3.4. *Boiler-Related Rules and Regulations*

On February 26, 2004, the EPA signed the final Maximum Achievable Control Technology (MACT) standard applicable to industrial, commercial, and institutional boilers and process heaters. The EPA estimated that the new MACT requirement would apply to 58,000 facilities nationwide. The MACT standard applies to facilities with annual aggregate Hazardous Air Pollutants (HAP) emissions of greater than 25 tons/year, or individual HAP emissions greater than 10 tons/year. For example, if a facility contains boilers with individual HAP emissions less than 10 tons/year but the facility as a whole has HAP emissions greater than 25 tons/year, all boilers and heaters in use in the facility are subject to the MACT standards.

The MACT regulates boilers based on size, fuel type, and whether the unit is new or existing. As shown in Figure 3-1, the MACT targets four pollutant categories: 1) particulate matter; 2) hydrogen chloride; 3) carbon monoxide; and 4) mercury. Facilities subject to these new standards must demonstrate ongoing compliance through performance tests. Continuous Emissions Monitors (CEMs) are required for boilers and process heaters with heat input capacities greater than 100 MMBtu/hour, and units with capacitates between 10 and 100 MMBtu/hour must conduct annual performance tests to demonstrate compliance with carbon monoxide limits. [9]

In addition to the Boiler MACT, the Plywood and Composite Wood Product MACT has a substantial impact on Pacific Northwest industries due to the size of the lumber industry in the region. The same qualification criteria apply (facility-wide potential to emit greater than 10 tons/year of any individual HAP or 25 tons/year of aggregate HAP), but facilities have three compliance options. Facilities can 1) meet a production-based emission standard; 2) install and maintain add-on control devices; or 3) average emissions across multiple units.[10]

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[9] Pooser, Chirstopher and Tom Wood. "Big MACTs: Boilers & Process Heaters and Plywood & Composite Wood Products MACTS Issued." *Oregon Insider*. Issue #340, March 15, 2004.
[10] Option 3 is available only to existing sources.

Figure 3-1: Units Affected by MACT Standard[11]

Which units are affected?

Affected:

Boilers or process heaters located at a major source of hazardous air pollutants (HAP).

Major source: Potential to emit 10 tons/year of one HAP or 25 tons/year of all HAP combined. Emissions from the entire facility, including non-boiler or process heater sources, count toward major source status.

Hazardous air pollutants: Boilers and process heaters emit HAP such as arsenic, cadmium, chromium, hydrogen chloride, hydrogen fluoride, lead, manganese, mercury, and nickel. Emissions from each boiler or process heater vary. HAP are listed at www.epa.gov/ttn/atw/188polls.html.

Not Affected:

- Solid waste incineration units covered under section 129 of the Clean Air Act
- Units covered by another NESHAP under 40 CFR part 63 (including hazardous waste units, chemical recovery boilers at pulp mills, secondary lead refining kettles, ethylene cracking furnaces, blast furnace gas fuel-fired units)
- Hot water heaters, blast furnace stoves, temporary boilers
- Direct-fired (contact) combustion units (e.g., direct contact dryers) where the combustion gases come into contact with the process materials
- Research and development units

Affected units with no requirements or only initial notification:

- **No requirements:** Existing small units (all fuel types) and new small units (gas fuel) have no emission limits and no requirements: No monitoring, no records, no notifications.
- **Initial notification:** Existing large units (gas and liquid fuel), new small units (distillate oil only or combined with gas fuel) have no emission limits and submit only an initial notification. No other requirements.

Emission limits apply to these boilers or process heaters:

FUEL TYPE	EXISTING UNITS	NEW UNITS
Solid	PM or TSM HCl Hg	PM or TSM HCl Hg CO
Liquid	None	PM HCl CO
Gas	None	CO

Solid: Burns any amount of solid fuel
Liquid: Burns liquid fuel alone or with gas
Gas: Burns only gaseous fuel

Regulated Pollutants

- Particulate matter (PM) or total selected metals (TSM) as surrogate for metallic HAP. TSM: Arsenic, beryllium, cadmium, chromium, lead, manganese, nickel, selenium
- Hydrogen chloride (HCl) as surrogate for inorganic HAP
- Mercury (Hg)
- Carbon monoxide (CO) as surrogate for organic HAP

NEW UNITS: Commenced construction or reconstruction on or after January 13, 2003

EXISTING UNITS: Commenced construction before January 13, 2003

SMALL UNITS: Any firetube boiler (regardless of size) and any other boiler or process heater ≤10 MMBtu/hr

LARGE UNITS: Any watertube boiler or process heater >10 MMBtu/hr

Compliance Alternatives

Units can meet emission limits through a combination of the following:

- Conduct performance testing for units that have new or existing control devices
  - Use emissions averaging (certain units)
  - For HCl (measured as HCl and chlorine) and manganese, demonstrate low public risk
- For HCl, TSM, Hg, limit HAP content of fuel, demonstrate compliance through fuel analysis

The Oregon DEQ estimates that the new boiler MACT standard will affect 50 facilities in Oregon, primarily in the paper and timber industries. Regardless of the number of facilities affected by the new standard, it is clear that one way to minimize HAP emissions from boilers and process heaters is to increase the operating efficiency of this equipment.

3.5. School-Related Energy Efficiency Programs

In 1999, Senate Bill 1149 (SB 1149) introduced competition into the electricity markets of Portland General Electric (PGE) and Pacific Power (PacificCorp). As part of this bill, a public purpose charge of 3% of total revenues is collected by the utilities from their customers. The first 10% of this charge, approximately $7 million over the first 10 years, is specifically distributed to education service districts located within the territory of the local utility for energy efficiency improvements in schools. Therefore, public schools being served by either of the two major Oregon

[11] US EPA MACT Brochure, September 2004. http://www.epa.gov/ttn/atw/boiler/brochure.pdf

electric utilities are eligible for funds for boiler efficiency improvements.

However, public schools not served by either PGE or PacifiCorp are at a disadvantage in this regard because such funds are not readily available to them. One alternative source of financing for such schools, reviewed in more detail in the following section, is an energy loan provided by the Oregon Department of Energy.

Another potential source of funding is the so-called "Williams Funding." The "Williams Funding" is the result of a settlement between the US Department of Justice (DOJ) and the Williams Companies, Inc. and the Williams Energy Marketing and Trading Company. The settlement pays Oregon $15 million over three years and is a result of the Attorney General's investigation of Williams' actions during the 2000-01 West Coast energy crisis.[12] Of the $4.7 million awarded to Oregon in 2004, $1 million will be used for energy efficiency upgrades in Oregon public schools through a program implemented by the Oregon Department of Energy.

3.6. *Financing Mechanisms for Boiler Upgrades*

OEC encouraged the use of existing financing mechanisms and Oregon's carbon offset credit program. Oregon is a leader in the emerging carbon dioxide offset market: a unique state law requires new gas-fired power plants to offset their carbon dioxide emissions. Sale of "offset credits" has already helped finance some school boiler improvements. OEC analyzed the feasibility of financing further improvements in this manner and also promoted other existing programs and tax incentives such as the Business Energy Tax Credit, Pollution Control Tax Credit, and others.

"Oregon is a leader in the emerging carbon dioxide offset market . . . [and the] sale of "offset credits" has already helped finance some school boiler improvements."

There are a number of creative financing mechanisms for energy conservation and renewable energy development in the state of Oregon. The opportunities most relevant for the facilities

[12] US DOJ Press Release, March 13, 2003. Available at: http://www.doj.state.or.us/releases/rel031303.htm

evaluated during this project are summarized in the following tables.

Oregon Energy Loans (SELP)

Oregon Energy Loans (SELP)	**Sponsor**	ODOE
	Type	Low-interest, fixed rate, long-term loan
	Amount	Up to $100,000
	Eligibility	Individuals, businesses, schools, cities, counties, special districts, state and federal agencies, public corporations, cooperatives, tribes, and non-profit
	Qualifying Projects	Projects must be in Oregon and generally fall into one of four categories: energy conservation; producing energy from renewable resources such as water, geothermal, wind, solar, or biomass; using recycled materials to create new products; or producing or using alternative fuels
	Contact	Toll-free in Oregon at 1-800-221-8035 or visit www.energy.state.or.us

Business Energy Tax Credit (BETC)

Business Energy Tax Credit (BETC)	**Sponsor**	ODOE
	Type	Corporate tax credit for 35 percent of eligible project costs.
	Amount	The credit has a maximum limit of $10,000,000 per project and is distributed over 5 years (ten percent the first two years and five percent over the remaining years).
	Eligibility	Trade, business or rental property owners who pay taxes for a business site in Oregon.
	Qualifying Projects	Conservation, lighting, recycling, alternative fuels, hybrid vehicles, rental dwelling weatherization, transportation, and sustainable buildings.
	Contact	Toll-free at 1-800-221-8035 or visit www.energy.state.or.us for application forms, administrative rules, information on the tax credit program and examples of businesses that have earned a tax credit for investing in energy efficiency.

The BETC also has a Pass-through Option, which allows a project owner to transfer the 35% Business Energy Tax Credit project eligibility to a pass-through partner for a lump-sum cash payment. A project owner may be an Oregon public entity or non-profit organization with no tax liability or an Oregon business with tax liability who chooses to use the Pass-through Option.

Pollution Control Facilities Tax Credit

Pollution Control Facilities Tax Credit	**Sponsor**	DEQ
	Type	Tax credit (for required upgrades)
	Amount	35% tax credit
	Eligibility	Any taxpayer who has constructed the project in response to a requirement imposed by the EPA, DEQ, or a regional air pollution authority; or for the sole purpose of controlling, preventing, or reducing a substantial quantity of air, land or water pollution.
	Qualifying Projects	Facilities that prevent, reduce or control one of the following: air pollution, water pollution, noise pollution, solid waste, hazardous waste, used oil by recycling or providing for its appropriate disposal. Projects must be completed before January 1, 2008.
	Contact	Toll-free at 1-800-452-4011 or visit www.deq.state.or.us

Carbon Offsets

Carbon Offsets	**Sponsor**	Climate Trust
	Type	Carbon off-set program
	Amount	Payment of $5 per metric ton of CO2 prevented or avoided as a result of a boiler project
	Eligibility	Offset projects must result in a true net benefit to the environment by meeting two essential tests: 1) it must be demonstrated that an offset project would not otherwise occur without the funding provided by the offset purchaser, and 2) results must be rigorously quantified.
	Qualifying Projects	Including but not limited to: increasing energy efficiency in buildings, factories, or transportation, by generating electricity from renewables such as wind or solar, by modifying a power plant or factory to use fuels that produce less GHG, by putting wasted energy to work via cogeneration, and by capturing carbon dioxide in forests and agricultural soils.
	Contact	503-238-1915 or visit www.climatetrust.org

According to the Climate Trust, a non-profit organization dedicated to providing solutions to stabilize climate change, a greenhouse gas (GHG) offset is "a project implemented specifically to reduce the level of greenhouse gases in the atmosphere. Offsets are so named because they counteract or offset the purchaser's GHG emissions."[13]

Building Tune-up and Operations

The Energy Trust of Oregon administers rebate and incentive programs for PGE and Pacific Power, the two major electric utilities in the state of Oregon. The Energy Trust's programs include new building efficiency, building efficiency, multi-family residential support, operations and maintenance, production efficiency, and renewable energy. Specifically relevant to facilities participating in this project is the cash-back incentive on high efficiency condensing boilers, tankless water heaters, infrared gas fryers, and other natural gas equipment.

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13 Climate Trust website, http://www.climatetrust.org/about_offsets.php.

In addition, on October 31, 2005, the Energy Trust launched a new program aimed specifically at helping businesses maintain and tune natural gas fired boilers, called the Building Tune-up and Operations program.

Building Tune-up and Operations		
	Sponsor	Energy Trust of Oregon
	Type	Cash incentive to maintenance contractor
	Amount	Full cost of tune-up, up to $600
	Eligibility	Must be a NW Natural gas customer on a commercial rate schedule and the boiler must be between 300 and 12,000 MBH (thousand Btu per hour).
	Qualifying Projects	The boiler must be between 300 and 12,000 MBH (thousand Btu per hour).
	Contact	1-866-ENTRUST (368-7878) or visit www.energytrust.org/bto/faq_boiler.html

4. Assessment Findings and Implementation

The audits conducted as a result of this project show the potential to reduce toxic emissions, energy usage, and financial costs for participants. In addition, this program provided some insight into the methods for getting industrial facility buy-in for energy efficiency measures, which is discussed in more detail in the final section of this report.

4.1. Industrial Facilities

The goal for this project was to conduct energy audits at 10 industrial facilities using a range of fuel types so as to ensure wider applicability of findings. However, OEC and its partners had difficulty recruiting industrial facilities to participate in the program. As a result, the overall number of audits conducted and the diversity of boiler types was not as great as originally desired, as shown in Table 4-1 below.

Table 4-1: Industrial Energy Efficiency Audit Universe

Fuel Type	# Originally Targeted	# Completed
Coal	1	0 (boiler no longer active)
Heavy Oil	1	0
Waste Oil	1	0
Diesel/Distillate Oil	2	0
Wood	2 to 3	3
Natural Gas	2 to 3	3

OEC partnered with the OSU Industrial Assessment Center (IAC) to conduct energy efficiency audits of the industrial facilities. In accordance with OSU guidelines, OEC and its partners identified industrial facilities having a SIC code for manufacturing 20-39, sales under $100 million, fewer than 500 employees, and utility bills over $100K and less than $2 million a year.

After a list of potential participants was generated using the criteria and these facilities were contacted by either OEC or ODOE, the IAC arranged to conduct the audits. The audits involved a full day site visit, wherein the team toured the facility, identified and discussed potential opportunities with the site manager, and collected data. The IAC then produced a final report of recommendations and plans to follow-up with the facility six to 12 months after the final report was issued to determine which recommendations have been implemented.

Audits were conducted at a total of six facilities in the lumber and wood products, food processing, and industrial laundry industries. The results of these audits are summarized in the following section.

Findings and Implementation

The OSU audits were facility-wide, meaning that they evaluated the energy use of the entire industrial facility, not just the boilers. While not a specific target of this current project, overall facility energy efficiency improvement opportunities were found at all of the industrial facilities, on top of specific boiler related measures. For the purposes of this report, however, the findings have been split into boiler related opportunities and non-boiler related opportunities, and the findings are summarized in Table 4-2.

"Boiler related opportunities represent 90% of total energy savings, have substantially lower overall implementation costs, and have shorter average payback periods."

Table 4-2: Breakdown of Savings, Costs, and Payback Periods for Industrial Facilities

	Energy Savings (MMBtu)	Cost Savings ($)	Implementation Cost ($)	Average Payback Period (years)
Boiler Related Opportunities (1)	337,644	$419,881	$150,600	0.83
Non-Boiler Related Opportunities	36,890	$673,005	$982,320	1.14
% boiler related	90%	38%	13%	

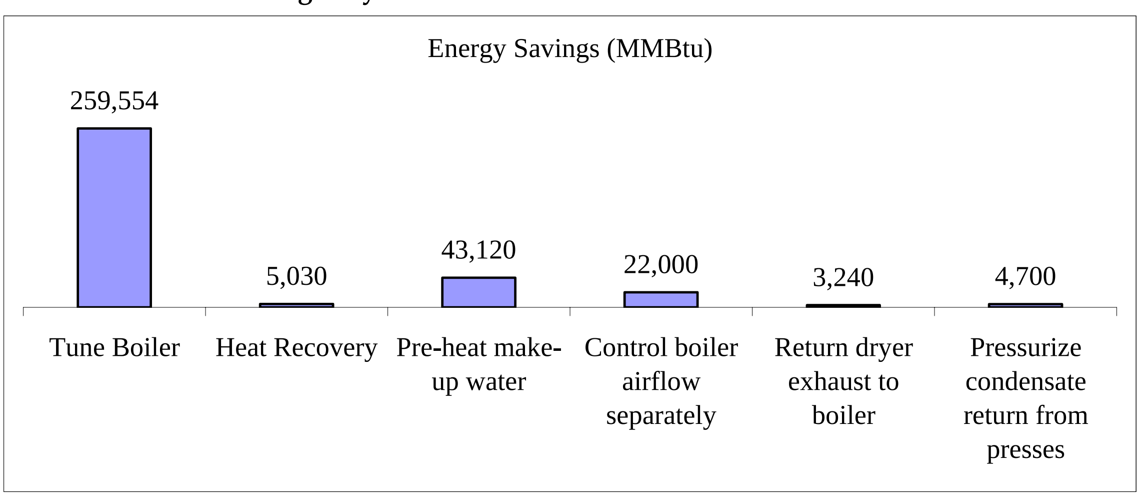
Notes:

(1) Almost 80% of these total boiler-related energy savings are achieved by tuning a single boiler. For this single boiler, the cost savings are four times greater than the implementation costs, with an expected payback period of 2.4 months

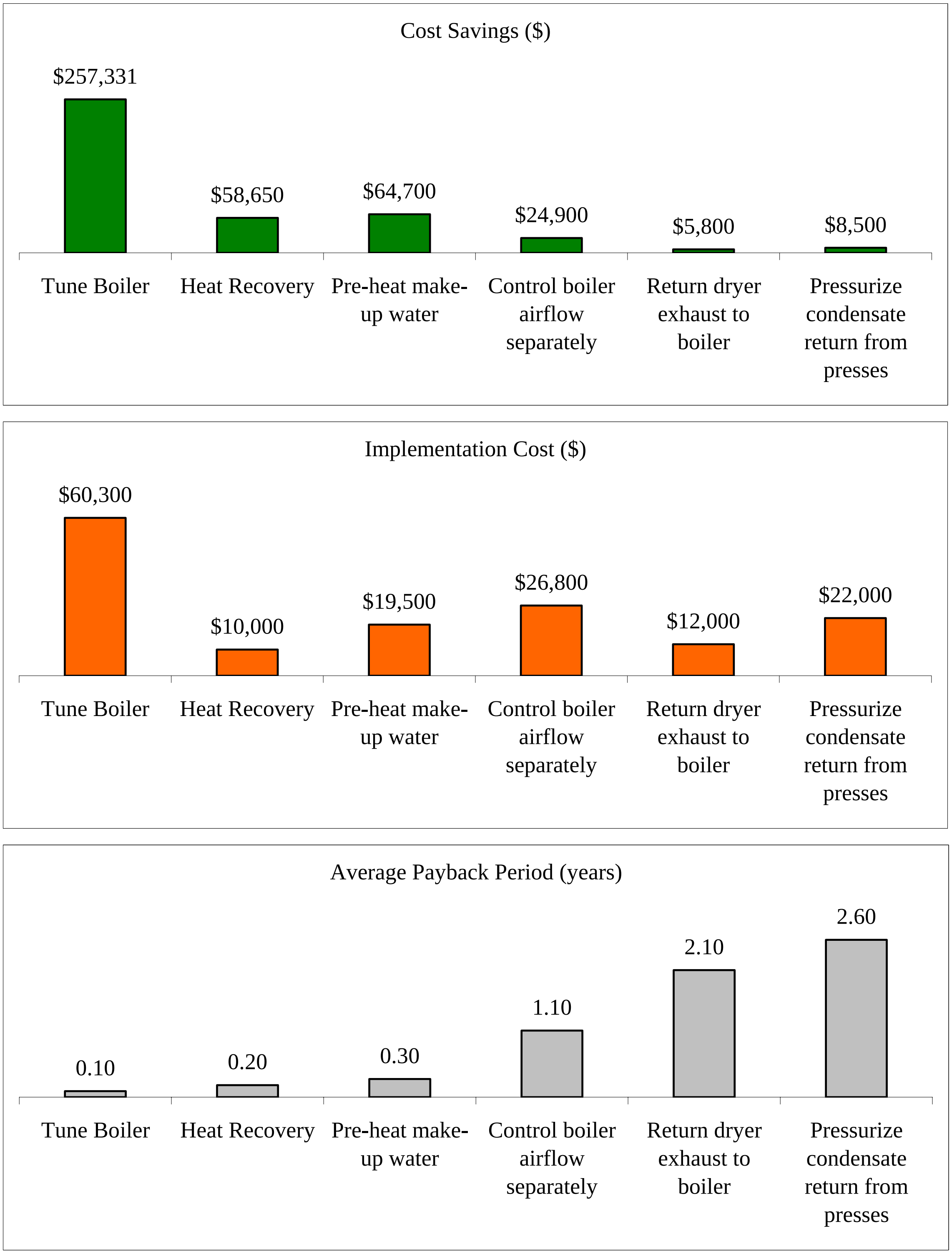
Audits found boiler efficiency opportunities in all but one of the facilities. In fact, boiler related opportunities represent 90% of total energy savings, have substantially lower overall implementation costs, and have shorter average payback periods.

As shown in Figures 4-1, boiler related opportunities include tuning boilers, preheating the makeup water, controlling boiler airflow, and returning exhaust from a veneer dryer to the boiler.

Figures 4-1: Potential Energy and Cost Savings, Implementation Costs, and Average Payback Periods for Industrial Boilers



Figures 4-1 (cont): Potential Energy and Cost Savings, Implementation Costs, and Average Payback Periods for Industrial Boilers



In summary, implementation of the audit findings concerning boiler performance would cost approximately $150,600, would result in cost savings of approximately $419,881, and would reduce energy consumption by 337,644 MMBtu's/year. With an overall payback period of approximately 9.9 months, these savings are substantial.

In addition to the financial benefits, these improvements at just six industrial facilities would reduce mercury emissions by 1.16 lbs/year and prevent the release of 29,476 metric tons of CO_2 into the atmosphere.[14]

At the time of this paper's preparation, IAC was still in the process of conducting follow-up surveys with several of the participating facilities. Of those facilities that have implemented boiler efficiency improvements to date, the results will prove to be significant. As Table 4-3 shows, the implementation of recommendations from IAC audits done for this study will result in the reduction of over 40 grams of mercury and almost 2,300 metric tons of CO_2 emissions through reduced fuel usage.

[14] All emissions reductions presented in this report are calculated using US EPA emissions factors for respective fuel types as published in the *AP 42, Fifth Edition, Compilation of Air Pollutant Emission Factors, Volume 1: Stationary Point and Area Sources*, available at http://www.epa.gov/ttn/chief/ap42/index.html. For example, the mercury emissions factor for wood fuels used in industrial boilers, according to the EPA, is 3.5×10^{-6} lbs/MMBtu. Therefore, the potential mercury emissions reductions value included here is (Natural Gas MMBtu savings x Mercury Emissions Factor for Natural Gas) + (Wood MMBtu savings x Mercury Emissions Factor for Wood).

Table 4-3: Fuel and Emissions Reductions from implementations at Industrial Facilities

	Anticipated Fuel Reductions (MMBtu)	Metric Tons CO_2 reduction	Mercury Reduction (grams)
Hogged Fuel (wood)	25,240	2,232.5	40.07
Natural Gas	1,160	61.9	1.58
Total	26,400	2,294.4	41.65

Notes:
(1) Anticipated fuel reductions based on findings from IAC audits

(2) CO_2 and Mercury emissions reductions calculated by taking fuel reductions (in MMBtu) and multiplying by US EPA emissions factors for respective fuel types.

4.2. *Institutional Facilities*

Working with the ODOE, OEC focused on recruiting institutional facilities outside of the SB 1149 service area, primarily in Eastern Oregon and the coast.[15] Facilities with high fuel usage representing an array of fuel types were selected, and the audits and tune-ups were conducted by an independent contractor. Overall, audits were conduced at eight schools and three hospitals (Table 4-4). The auditor identified opportunities for efficiency improvements, actually made changes to improve combustion efficiency during his visit, and educated boiler managers about additional actions which would further increase combustion efficiency.

[15] "The Oregon Legislature passed Senate Bill 1149 which introduces competition into the retail electricity market of Oregon´s two largest utilities, Portland General Electric and PacifiCorp. The bill went into effect on March 1, 2002. It provides that PGE and PacifiCorp must collect a public-purpose charge from consumers within their service areas that is equal to 3 % of the total revenues from electricity services. Ten percent of these public purpose funds must go towards energy efficiency efforts in the public schools within their service areas. The administration of the school public purpose funds is being facilitated by the Oregon Department of Energy in cooperation with the Education Service Districts and individual school districts." Source: http://www.oregon.gov/ENERGY/CONS/SB1149/Schools/

Table 4-4: Institutional Energy Efficiency Audit Universe

Fuel Type	Education	Healthcare
Coal	1	0
Heavy Oil	0	0
Waste Oil	0	0
Diesel/Distillate Oil	4	2
Wood	0	0
Natural Gas	2	1
Propane	1	0

Findings and Implementation

Audits found opportunities for efficiency improvements at all of the 11 institutional facilities (a total of 16 systems) visited during this project. As a result of these tune-ups, average combustion efficiency increased by approximately 7.15%, saving these schools more than $20,000 a year, reducing CO^2 emissions by 85 metric tons and mercury emissions by 1.4 grams. The bulk of these savings stem from efficiencies instituted for diesel-powered boilers (see Table 4-5).

In addition to these emissions reductions, the project also realized reductions in Carbon Monoxide (CO), Nitrogen Oxides (NO_X), and Sulphur Dioxide (SO_2) in the following amounts:

Reduction of Carbon Monoxide (CO)	Reduction of Nitrogen Oxides (NOX)	Reduction of Sulphur Dioxide (SO2)
4262 PPM	413 PPM	103 PPM

Table 4-5: Summary of Results from Institutional Boiler Tune-ups

	Average Efficiency Increase from Tune-ups	Cost Savings	Fuel Reductions Realized (MMBtu)	CO_2 Emissions Reduction (metric tons)	Mercury Emissions Reduction (grams)
	(a)	(c)	(b)	(d)	(e)
Diesel	13.84%	$17,354	972	70.2	1.32
Natural Gas	1.96%	$1,412	141	7.5	0.08
Propane	2.63%	$1,340	123	7.6	0.00
Coal*	0.00%	$0	0	0.0	0.00
Total	7.15%	$20,106	1236	85.3	1.40

Notes:

Data based on 2003 fuel usage by facility. Data provided by Oregon Department of Energy.

(a) Increases in efficiency were averaged by fuel type across low, mid, and high boiler firing rates. Total average efficiency increase calculated by averaging increases in efficiency across all participating facilitites.

(b) Fuel reductions realized were calculated by taking annual fuel consumption for facility and multiplying by average increase in efficiency for that facility.

(c) Cost savings were calculated by taking fuel reductions and multiplying by fuel cost. Diesel savings = fuel reduction (gallons) x $2.50/gallon; natural gas savings = fuel reduction (therms) x $1.00/therm; propane savings = fuel reduction (gallons) x $1.00/gallon; coal savings = fuel reduction (tons) x $39.30/ton. Propane fuel cost based on average US spot price for last 3 months. Coal price based on 2004 US average delivery price for industrial facilitites (http://www.eia.doe.gov/cneaf/coal/page/acr/table34.html)

(d) CO_2 emissions reductions calculated by taking fuel reductions (in MMBtu) and multiplying by US EPA emissions factors for fuel types.

(e) Mercury emissions reductions calculated by taking fuel reductions (in MMBtu) and multiplying by US EPA emissions factors for fuel types.

* One facility is still using a coal-fired boiler. This boiler has reached the end of its useful life and is beyond repair. However, it remains currently in use and was not tuned during the audit conducted during this program.

The audits also revealed consistent opportunities for efficiency improvements and safety precautions that applied in many cases and may be applicable more broadly to all institutional boilers:

- Seal tube access doors by placing silicone on the door edge and covering with paper while still pliable. Closing the doors will form a permanent gasket that will not have to be replaced every time the system is opened.

> *"Audits of just 17 facilities identified 1.16 lbs of mercury reduction potential and over 29,500 metric tons of CO^2 reduction potential if all audit recommendations were implemented."*

- When the system is shut down for the season, hose the boiler out while it is still warm and pliable. It will be much easier to clean.
- When it is time to close and fill the boiler, hose it out first to remove the dried material from tube surfaces. This will eliminate the bouncing and surging effect from the materials floating on the surface.
- Establish a written procedure that will require at least weekly water column blowdown to the point of main burner extinction. This is a vital safety process that should be conducted frequently.
- At least once during the heating season, turn off the feed pump while operating and watch the water level carefully to see that the system will shut down naturally. Do not allow the water level to go out of sight in the gauge glass.

Overall, the audits conducted at institutional facilities were successful in multiple ways. First, the tune-ups led to actual toxics and GHG emissions reduction. Second, the tune-ups led to actual dollar savings for participating facilities by reducing fuel consumption. Third, the audits provided a way for boiler managers to learn additional maintenance and operating procedures which will help keep boilers running at optimum performance levels.

4.3. *Summary of Findings*

The purpose of this project was to demonstrate reductions in toxics emission by increasing energy efficiency in boilers. This project was successful in this regard; audits of just 17 facilities identified 1.16 lbs of mercury reduction potential and over 29,500 metric tons of CO_2 reduction potential if all audit recommendations were implemented.

Overall, then, the findings as a result of this project were quite positive. Every facility inspected had savings opportunities associated with increased boiler efficiency, and many had additional opportunities resulting from non-boiler related efficiency improvements. The audits conducted during this project identified over $437,000 of potential savings. Of this total reduction potential, approximately $274,000 or about 62%, can be achieved simply by regularly maintaining and tuning industrial and institutional boilers.

The audits conducted during this project identified over $437,000 of potential savings; 62% of which can be achieved by regularly maintaining and tuning boilers.

5. Conclusions and Policy Recommendations

"Increasing the energy efficiency of boilers saves money and reduces emissions."

The conclusions of the current study are clear: *increasing the energy efficiency of boilers saves money and reduces emissions*. This study identified efficiency improvements at almost all participating facilities, regardless of fuel used, boiler make or model, or industry or sector.

In almost all cases, the costs could be recouped by the future cost savings from reduced fuel usage, meaning that reducing toxic and GHG emissions may be achieved at no net cost to Oregon school districts or business owners. Although additional financing mechanisms may be needed to cover the upfront costs of improvements, there are a number of resources in the state of Oregon for just this purpose. These range from public purpose funds to tax incentives to selling GHG offsets in secondary worldwide offset markets.

The audits of institutional facilities found that, on average, efficiency increased by 7.15% as a result of simple tune-ups and maintenance. Extrapolating to all institutional facilities in the state, if every public school performed tune-ups of its boilers, total savings to the state of Oregon in reduced fuel usage would be $832,604, with 3,859.9 metric tons/year of CO_2 emissions avoided, and 42.9 grams/year of mercury kept out of the environment (Table 7-1, Appendix I).

The potential reductions for industrial facilities are likely far greater. For example, assume that combustion efficiency of wood-fired industrial boilers could be increased by 8% and natural gas-fired boilers by just 1%.[16] Extrapolating to all Title-V and non-Title-V industrial facilities in the state, these efficiency gains would yield 14 lbs of reduced mercury emissions and over 350,000 metric tons of CO_2 emissions reductions! (Table 7-2, Appendix II). Over 99% of the mercury reductions are from the wood-fired boilers.

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[16] This assumption is based on the IAC audits conducted for this study.

5.1. Recommendations

- **Oregon agencies and NGO's should organize an integrated program to encourage boiler efficiency.** Oregon has a range of incentives and technical assistance programs that can help boiler owners. However, these programs are fragmented, with different coverage areas and eligibility requirements, and are not well integrated. Boiler operators do not have the time or motivation to sort through these programs. Program operators (ODOE, ETO, the Climate Trust, etc.) should work closely with stakeholders such as the OSU Industrial Assessment Center, the Oregon Boiler and Pressure Vessel Association, Oregon school districts, OEC and other project partners to develop an integrated program to highlight savings opportunities, success stories, and assistance programs, both in print materials and via hands-on workshops.

- **Incentive programs should recognize multiple benefits.** Most current incentive and financing programs are focused on energy efficiency as the goal, whether directly or indirectly (e.g., as in the Climate Trust's offset programs). As outlined here, however, boiler efficiency has multiple environmental benefits, reducing mercury and other toxic pollutants – and improves economic performance and competitiveness, as well. Economic development agencies, DEQ, and other partners interested in these outcomes should be engaged in the program outlined above to help identify and highlight other incentives and opportunities to encourage efficiency.

- **Oregon's public institutions should aggressively pursue boiler tune-ups and related efficiency measures.** Our analysis shows that Oregon school systems alone could save over $800,000 annually through a series of basic efficiency measures (Table 7-1 in Appendix 1). Financially strapped schools need to prioritize efficiency measures as a way to reduce their operating costs.

Furthermore, since we found that most of the emissions reductions resulted from tune-ups conducted on diesel-fired boilers, schools using diesel to run their boilers need to pay particular attention to efficiency opportunities. Other public institutions with boilers would likely achieve comparable savings.

- **Oregon needs to systematically collect data regarding operating efficiency, fuel use, and emissions for both industrial and institutional facilities**. Detailed and specific information about boilers is not maintained by any one agency in Oregon. OEC relied on DEQ's Emissions Inventory for our estimates, but these data are based on aggregated data from the U.S. Department of Energy. While the DEQ regulates some aspects of some Oregon boilers, the Department of Business and Consumer Services is responsible for licensing and inspecting boilers for safety. A cooperative effort by these two agencies would allow for a much improved data set on Oregon boilers. With more specific data about efficiency, fuel use and emissions, regulatory agencies and others would be better positioned to target technical assistance and other programs to improve efficiency.

6. Additional Resources

Mercury Resources

Mercury on the Road to Zero: Recommended Strategies to Eliminate Mercury Releases from Human Activities in Oregon by 2020. December 2001. Oregon Environmental Council.
Available online at:
http://www.oeconline.org/kidshealth/roadtozero/download

Boiler Related Efficiency Studies

Sector-Based Pollution Prevention - Toxic Reductions through Energy Efficiency and Conservation Among Industrial Boilers: A Report to the Great Lakes National Program office (GL97514402). July 2002. The Delta Institute.
Available online at: http://delta-institute.org/publications/pubs.php#7.

Financing Resources

Oregon Energy Loans (SELP)
Information online at:
http://egov.oregon.gov/ENERGY/LOANS/selpqa.shtml

Business Energy Tax Credit (BETC)
Information online at:
http://egov.oregon.gov/ENERGY/CONS/BUS/BETC.shtml.

Pollution Control Facilities Tax Credit
Information online at:
http://www.deq.state.or.us/msd/taxcredits/factsheets/txcfact.pdf

The Climate Trust – Carbon Offsets
Information online at: http://www.climatetrust.org/

The Energy Trust of Oregon
Information online at:
http://www.energytrust.org/bto/faq_boiler.html.

Emissions Calculations Resources

AP 42, Fifth Edition, Compilation of Air Pollutant Emission Factors, Volume 1: Stationary Point and Area Sources. United States Environmental Protection Agency.
Available online at
http://www.epa.gov/ttn/chief/ap42/index.html.

Other Resources

Oregon Environmental Council (http://www.oeconline.org/)
US EPA, Air Quality Division
(http://www.epa.gov/ebtpages/air.html)
Oregon DEQ, Air Quality Division
(http://www.deq.state.or.us/aq/)
Oregon Department of Energy
(http://www.oregon.gov/ENERGY/)
Oregon State University Industrial Assessment Center
(http://me.oregonstate.edu/iac/)
Oregon Boiler and Pressure Vessel Association
Oregon Department of Business and Consumer Services
(http://www.oregon.gov/DCBS/)

7. Appendices

7.1. Appendix I: About OEC and Project Partners

About OEC

Founded in 1968, OEC has played a leadership role for nearly four decades in creating Oregon's reputation as a national leader in environmental protection. OEC is a non-profit, non-partisan charity, guided by a volunteer board of directors from throughout Oregon, with a paid staff of 14. OEC helps Oregonians be part of the solution to environmental problems via programs such as the Bottle Bill, curbside recycling and pollution reduction partnerships with businesses and other organizations across the state.

OEC's work focuses on environmental issues that most affect people's health. Current OEC priorities include protecting kids' health from toxic pollution, cleaning up Oregon's rivers, and protecting our climate by curbing vehicle pollution. Major projects include securing cleaner car emission standards and accelerating the development of sustainable agriculture. With various business partners, we are working to create "eco-friendly" auto insurance, reduce mercury pollution, and promote biofuels as an economic opportunity in Oregon. Via our Tiny Footprints™ Healthy Baby project and our Eco-Healthy Childcare project, we help parents and caregivers create safer living environments for Oregon's children.

We bring together business, government, agricultural and health leaders to craft solutions to complex problems. OEC emphasizes collaboration and communication over litigation; in fact, OEC hasn't filed a lawsuit in more than a decade. OEC gets advice and input from advisory committees made up of members of the business, agricultural and health care communities who live and work in all regions of Oregon. Based on that input, OEC works to ensure that the Oregon Legislature and state agencies protect Oregonians from environmental harm. We also empower people to take action on their own behalf to create a healthier environment. Our work is supported by individual donations, event sponsorships, and foundation and government grants (www.oeconline.org).

About Project Partners

Oregon Department of Environmental Quality (DEQ)

The Oregon DEQ is the state regulatory agency whose job is to protect the quality of Oregon's environment. DEQ is responsible for protecting and enhancing Oregon's water and air quality, for cleaning up spills and releases of hazardous materials, and for managing the proper disposal of hazardous and solid wastes. DEQ staff use a combination of technical assistance, inspections and permitting to help public and private facilities and citizens understand and comply with state and federal environmental regulations. (http://www.deq.state.or.us/)

Oregon Department of Energy (ODOE)

The mission of the ODOE is to ensure Oregon has an adequate supply of reliable and affordable energy and is safe from nuclear contamination, by helping Oregonians save energy, develop clean energy resources, promote renewable energy, and clean up nuclear waste.
(http://www.oregon.gov/ENERGY/)

Oregon State University Industrial Assessment Center (IAC)

The OSU-IAC is one of 26 centers supported by the U.S. Department of Energy at universities across the country. The IAC provides no cost energy, waste and productivity assessments to small and medium-sized manufacturers primarily in Washington, Oregon and Idaho. Engineering and business students and faculty conduct the assessments and provide a report to summarize their findings and recommendations.

The Industrial Assessment Center at OSU has been commended by the US Department of Energy (DOE) for its work. The IAC also contributed to a national award for Environmental Sustainability presented to DOE by Renew America, Inc. IAC

teams have visited more than 400 Northwest manufacturers, and have made recommendations totaling more than $67 million in annual savings.
(http://me.oregonstate.edu/iac/)

Oregon Boiler and Pressure Vessel Association (OBPVA)

The Oregon Boiler and Pressure Vessel Association is dedicated to safety in ownership, operation, and repair of boilers and pressure vessels in the state of Oregon. The association meets quarterly and has an annual conference.

The Climate Trust

The sole mission of The Climate Trust is to promote climate change solutions by providing high quality greenhouse gas offset projects and advancing sound offset policy. The Climate Trust focuses on providing greenhouse gas offsets and on advancing sound offset policy. The organization's success is a result of its business-oriented approach. Through partnership and understanding, The Climate Trust has offset more than 1.6 million metric tons of carbon dioxide from $4 million invested into offset projects – making it one of the largest and most experienced offset buyers in the U.S. and world markets.
(http://www.climatetrust.org/about_us.php)

Department of Consumer and Business Services (DCBS)

DCBS is Oregon's largest regulatory agency. The department administers state laws and rules and protects consumers and workers in the areas of workers' compensation, occupational safety and health, financial services, insurance, building codes, and targeted contracting opportunities for small businesses.
(http://egov.oregon.gov/DCBS/index.shtml)

7.2. *Appendix II: Extrapolated Statewide Energy Use and Toxics Reduction*

Table 7-1: Estimated Potential Dollar Savings and Emissions Reductions from Efficiency Increases at Oregon Public Schools, Statewide

	Estimated Actual Fuel Costs ($/year)	Estimated Actual CO_2 Emissions (metric tons/year)	Estimated Actual Mercury Emissions (lbs/year)	Estimated Potential Annual Savings	Estimated Potential CO_2 Reductions (metric tons/year)	Estimated Potential Mercury Reductions (grams/year)
	(a)	(b)	(c)	(d)	(e)	(f)
Diesel	$3,612,775	104,410.3	4.33533	$499,888	2,022.6	38.09
Natural Gas	$16,737,746	89,319.0	0.42665	$327,781	1,749.2	3.79
Propane*	$285,423	1,618.3	0.00666	$4,307	46.9	0.09
#5 Oil	$2,627,837	17,482.2	0.79886	$0	0.0	0.00
Coal*	$629	41.2	0.00208	$629	41.2	0.94
Total	**$23,264,409**	**212,871.0**	**5.56959**	**$832,604**	**3,859.9**	**42.9**

Notes:
Data based on 2003 fuel usage by facility. Data provided by Oregon Department of Energy.

(a) Fuel costs were estimated using annual fuel use data multiplied by fuel costs for diesel, natural gas, propane, #5 Oil, and Coal ($2.50/gallon, $1.00/therm, $1.00/gallon, $1.50/gallon, $39.3/ton, respectivly). Propane fuel cost based on average US spot price for last 3 months. Coal price based on 2004 US average delivery price for industrial facilitites (http://www.eia.doe.gov/cneaf/coal/page/acr/table34.html)

(b) CO_2 emissions calculated by taking fuel use (in MMBtu) and multiplying by US EPA emissions factors for respective fuel types.

(c) Mercury emissions calculated by taking fuel use (in MMBtu) and multiplying by US EPA emissions factors for respective fuel types.

(d) Fuel savings were estimated by taking average increase in efficiency realized from the audits conducted during this project and extrapolating to all facilitites using similar fuel types. For example, the audits realized an average increase in fuel efficiency for diesel boilers of 13.84%. Estimated fuel reductions based on this increase in efficiency were calculated for all Oregon public schools using diesel boilers, and then estimated fuel reductions were multiplied by fuel costs for diesel to calculate total cost savings. This process was repeated for each fuel type.

(e) CO_2 emissions reductions calculated by taking estimated potential fuel reductions (in MMBtu) and multiplying by US EPA emissions factors for fuel types.

(f) Mercury emissions reductions calculated by taking estimated potential fuel reductions (in MMBtu) and multiplying by US EPA emissions factors for fuel types.

* One facility is still using a coal-fired boiler. This boiler has reached the end of its useful life and is beyond repair. However, it remains currently in use. The estimated savings and emissions reductions for coal and for propane assume that the boiler is retired and is replaced with propane-fired units. The anticipated increase in propane usage is reflected in the values for dollar savings and emissions reductions for propane in this table.

Table 7-2: Estimated Potential Fuel and Emissions Reductions from Efficiency Increases at Title-V and non-Title-V Industrial, Commercial, Institutional, and Electric Generation Facilities, Statewide

	Total Fuel Consumption (MMBtu)	Potential Increase in Efficiency from Tune-ups	Potential Decrease in Energy Use (MMBtu)	Potential Decrease in CO_2 Emissions (metric tons)	Potential Decrease in Mercury Emissions (lbs)
	(a)	(b)	(c)	(d)	(e)
Coal	59,025,260	0.00%	0	0	0.00
Distillate Oil	11,495,260	0.00%	0	0	0.00
Natural Gas	10,186	1.00%	102	5	2.60E-05
Process Gas	14	0.00%	0	0	0.00
Residual Oil	3,419,848	0.00%	0	0	0.00
Wood/Bark Waste	49,849,184	8.00%	3,987,935	352,735	13.96
Total	123,799,752		3,988,037	352,740	14.0

Notes:

(a) Represents aggregate fuel consumption for Title-V and non-Title-V industrial, commercial, institutional, and electric generation facilitites.

(1) Initial analysis and data collection conducted by Oregon DEQ.

The following notes are applicable for non-Title V facilities:

(2) Industrial and Commercial statewide fuel use was taken from the following Federal Energy Department publications:

http://www.eia.doe.gov/pub/oil_gas/natural_gas/data_publications/natural_gas_annual/current/pdf/table_063.pdf

http://www.eia.doe.gov/emeu/states/sep_use/ind/use_ind_or.html

http://www.eia.doe.gov/pub/oil_gas/petroleum/data_publications/fuel_oil_and_kerosene_sales/current/pdf/table4.pdf

http://tonto.eia.doe.gov/dnav/ng/ng_sum_lsum_sor_a_d.htm

(3) The statewide values were apportioned to counties based on the ratio of county to state employees in SIC 20-39 (Industrial) or SIC 50-99 (Commercial) from the 2002 Oregon Covered Employment and Wages publication.

(4) Countywide Title V fuel use was then subtracted from the apportioned amounts to diminish double counting of emissions.

(b) Values for Potential Increase in Efficiency from Tune-ups column are based on average potential efficiency gains by fuel type resulting from audits conducted by IAC for this study. These averages are from a very small sample size of one natural gas boiler and three wood-fired boilers.

(c) Equals (a) x (b)

(d) CO_2 emissions calculated by taking fuel use (in MMBtu) and multiplying by US EPA emissions factors for respective fuel types.

(e) Mercury emissions calculated by taking fuel use (in MMBtu) and multiplying by US EPA emissions factors for respective fuel types.

7.3. Appendix III: Conversion Table and Emission Factors

Table 7-3: Fuel to Energy Conversions

Source	Value	Unit of Measurement	Energy Equivalent (btu)	MMBtu
Natural Gas	1	therm	100000	0.1
No. 2 oil (diesel)	1	gallon	140000	0.14
No. 6 oil	1	gallon	152000	0.152
gasoline	1	gallon	128000	0.128
propane	1	gallon	91600	0.0916
dry wood	1	pound	8600	0.0086
bone dry wood	1	ton	17200000	17.2
wood sawdust	1	unit (2244 dry pounds)	19300000	19.3
wood savings	1	unit (1395 dry pounds)	12000000	12
hogged wood fuel	1	unit (2047 dry pounds)	17600000	17.6
coal	1	ton	28000000	28
	1	therm	100000	0.1
	1	MMBtu	1000000	1
	1	10^6Btu	1000000	1
	1	kWh	3413	0.003413
	1	MWh	3413000	3.413

Table 7-4: Emissions Factors

	CO_2 (lbs/MMBtu)	Mercury (lbs/MMBtu)	Emission Factors (EF) Notes
Diesel	159.2857143	3.00E-06	CO_2 based on EPA EF of 22300 lbs per 10^3 gallons. EF = ((22300/1000)/.14). Mercury based on EPA EF of 3 lbs/1012 btu. EF = (3/(1012/1000000)).
Natural Gas	117.6470588	2.55E-07	CO_2 based on EPA EF of 120000 lbs per 10^6 scf. EF = 120000/1020. Mercury based on EPA EF of $2.6x10^{-4}$ lbs per 10^6 scf. EF = ($2.6x10^{-4}$/1020).
Propane	136.4628821	2.55E-07	CO_2 based on EPA EF of 12500 lbs per 10^3 gallons. EF = (12500/1000)/.0916). Mercury EF unavalable. EPA EF for natural gas was used.
Wood	195	3.50E-06	CO_2 based on EPA EF of 195 lbs per MMBtu. Mercury based on EPA EF of $3.5x10^{-6}$ lbs per MMBtu.
#6 Oil	144.7368421	3.00E-06	CO_2 based on EPA EF of 22000 lbs per 10^3 gallons. EF = ((22300/1000)/.152). Mercury EF unavalable. EPA EF for diesel, a similar fuel, was used.
Anthracite Coal	202.8571429	4.64E-06	CO_2 based on EPA EF of 5,680 lbs per ton. Mercury based on EPA EF of $1.3x10^{-4}$ lbs per ton.
All calculations assume a conversion factor of 2,204.62 lbs to 1 metric ton, or 1 lb to 00045359237 metric tons.			
Emmisions Factors from EPA publication *AP 42, Fifth Edition, Compilation of Air Pollutant Emission Factors, Volume 1: Stationary Point and Area Sources* , available at: http://www.epa.gov/ttn/chief/ap42/index.html.			