Reverse Ambient Solar Energy Reclamation System

New Environmental Technology for Small Business (NETSB) Project Summary

NETSB, a program developed by the Iowa Waste Reduction Center (IWRC) at the University of Northern Iowa, strives to increase the use of new environmental pollution prevention technology by small business, resulting in measurable environmental and economic benefits.

When choosing which technologies to test, the IWRC recognized three key areas of consideration: environmental criteria, economic measures and small business use feasibility. The equipment should have a positive impact on the environment, such as pollution prevention or energy savings. The technology should be evaluated considering capital costs, operational costs and return on investment. And finally, the equipment should be applicable in a small business environment.

In 2006-2007, the IWRC placed several types of potential pollution prevention technologies at small businesses throughout Iowa including: soy-based metal working fluids, RASERS heat reclamation equipment, Zerowaste wastewater treatment systems and Green Earth® dry-cleaning solvent alternative.

New Environmental Technologies for Small Business, of the Iowa Waste Reduction Center at the University of Northern Iowa, is funded through the US EPA Region 7 grant number X-98753501-0. For more information contact the IWRC at 319-273-8905 or www.IWRC.org/NETSB

Small Business Placement Description

NETSB supplied a Reverse Ambient Solar Energy Reclamation System (RASERS) to a restaurant as a means of recovering ambient heat in the building to help heat water for dish washing. The NETSB program recognized the importance of testing energy recovery equipment applicable to many different small business settings because energy recovery translates to decreased energy usage and related air emissions.

Technology Description

The RASERS system absorbs thermal energy from surrounding ambient air, wastewater, or hot air exhaust. The captured energy is then transferred to a liquid such as water where the energy can be used in various applications such as heating potable water and space heating. The technology is appropriate for many applications such as preheating water in laundry operations, car washes, restaurants, and manufacturing and commercial applications such as facility cleanup, pre-washing for painting applications, etc.

The RASERS system is composed of an evaporator panel, a compressor and a heat exchanger. Evaporator panels can be placed close to any energy source such as in the path of a waste air stream indoors or outdoors, on the roof or sides of buildings or even submerged in a wastewater collection basin. Energy collection is accomplished when the evaporator panels capture thermal energy using refrigeration gases that transfer it to a compressor. When the gas is compressed it in turn causes a substantial increase in the heat of the refrigerant liquid. This heated liquid travels through a heat exchanger where it transfers heat to another liquid such as water.

The amount of energy recovery depends on waste energy temperature, the proximity of the collector plates to the energy source and the temperature difference between waste energy and inlet. The RASERS system is able to operate in ambient temperatures as low as -20°F.

The rate of transfer for the captured energy into water is completed in a way that requires much less work for the compressor when compared to similar compressors in other applications. A typical amperage draw of a single-phase 61,000 BTU compressor used in a RASERS system will draw up to 21 amps of electricity compared to up to 45 amps drawn by a the same rated compressor in a typical air conditioner.

RASERS ability to transfer energy to fluids such as water allows a small business to use less energy. Heating water is more efficient than heating air. The hot water serves as a buffer allowing the business to maintain heat uniformly throughout the space.[1]

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Environmental & Health Background

Reducing energy use not only saves money for business, but also has a positive impact on the environment. Burning fossil fuels such as coal, natural gas and diesel fuel generates greenhouse gases. Therefore reducing energy consumption also reduces air emissions, including greenhouse gas emissions.

Some greenhouse gases occur naturally in the atmosphere, while others result from human activities. Naturally occurring greenhouse gases include water vapor, carbon dioxide, methane, nitrous oxide, and ozone. Human activities like energy production, however, add to the levels of most of these naturally occurring gases. Total greenhouse gas emissions in the United States in 2006 were 7,045.6 million metric tons of CO_2 equivalents ($MMTCO_{2e}$). [2]

Most areas in the United States obtain electricity by burning coal. Carbon emissions from burning coal are one of the leading causes of global warming. Total CO_2 emissions in the United States in 2006 were 5,825.5 $MMTCO_{2e}$, 82% of which were energy related emissions from fossil fuel combustion. [2]

From mining and processing to transporting and burning, coal has more negative environmental impacts than any other fuel source. For example a 500-megawatt coal burning power plant produces enough electricity to power a city of about 140,000 people for a year. But it also produces:

- 10,000 tons of sulfur oxide (SO_x), a main cause of acid rain;
- 10,200 tons of nitrogen oxide (NO_x), a major cause of smog and contributor to acid rain;
- 3.7 million tons of carbon dioxide (CO_2), the main greenhouse gas and leading cause of global warming;
- 500 tons of small particles, a known cause of lung damage;
- 220 tons of hydrocarbons, a major cause of smog;
- 720 tons of carbon monoxide (CO), a contributor to global warming;
- 125,000 tons of ash and 193,000 tons of sludge from smokestack scrubbers, both of which can carry heavy metals;
- 225 pounds of arsenic, 114 pounds of lead, 4 pounds of cadmium and other heavy metals like mercury, known causes of multiple health concerns; and
- trace elements of uranium, radioactive emissions from coal-powered plants are greater than from nuclear powered plants.[3]

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*Table 1: Air Emissions Reduced Due to Electricity (Coal) Use Reduction**

Pollutant	Emission Factor (lb/kWh)	Lbs. Pollutant Reduced/year
Sulfur Oxide (SO_x)	0.006†	76.30
Nitrogen Oxide (NO_x)	0.004†	50.86
Carbon Dioxide (CO_2)	0.82†	10,427.12
Methane (CH_4)	1.05†	13,351.80
Mercury (Hg)	$1.09 \times e^{-8}$†	$1.39 \times e^{-4}$

* The facility saved 6,358 kWh in 6 months. Here we have estimated double savings (12,716 kWh) for a year.

†Emission factors derived from *United States Environmental Protection Agency, Compilation of Emission Factors AP-42, Volume 1, Fifth Edition, 1995.* Contact the IWRC for more detailed information on emission factors used here.

*Table 2: Air Emissions Reduced Due to Natural Gas Use Reduction**

Pollutant	Emission Factor (lb/kWh)	Lbs. Pollutant Reduced/year
Sulfur Dioxide (SO_x)	$5.88 \times e^{-4}$†	0.08
Nitrogen Oxide (NO_x)	0.09†	12.6
Carbon Dioxide (CO_2)	117.65†	16,471.00
Methane (CH_4)	0.002†	0.28
Mercury (Hg)	$2.55 \times e^{-8}$†	$3.57 \times e^{-6}$

* The facility saved 705 therms in 6 months. Here we have estimated double savings for a year. 1,410 therms x 99,976.12 BTU/therm = 140,996,335.52 BTU.

† Emission factors derived from *United States Environmental Protection Agency, Compilation of Emission Factors AP-42, Volume 1, Fifth Edition, 1995.* Contact the IWRC for more detailed information on emission factors used here.

Outcomes

POLLUTANT REDUCTION OUTCOMES

By reducing energy needs and subsequent electricity (coal) and natural gas consumption, the restaurant also reduced air emissions as shown in Tables 1 and 2.

ECONOMIC OUTCOMES

Six months after the restaurant installed the RASERS system it reported significant cost savings. The restaurant reduced its electricity use by 6,358 Kilowatt-hours ($306.14) and natural gas use by 705 therms ($1,040.00). The total savings for six months was $1,346.14.

TECHNOLOGY ACCEPTANCE AND USE OUTCOMES

The restaurant is satisfied with the level of energy savings provided by the RASERS system. As experienced by this facility, the RASERS system can show a significant reduction in energy usage and subsequent pollution prevention.

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ACRONYMS USED IN THE CASE STUDY

BTU .....British Thermal Unit

CO .....Carbon Monoxide

CH_4.....Methane

CO_2 .....Carbon Dioxide

EPA ....Environmental Protection Agency

Hg .....Mercury

kWH .....Kilowatt Hour

Lb .....Pound

MMBTU ....Million British Thermal Units

$MMTCO_{2e}$ .....Million Metric Tons CO2 Equivalent

NETSB..New Environmental Technology for Small Business

NO_x .....Nitrogen Oxide

RASERS ..Reverse Ambient Solar Energy Reclamation System

Scft .....Standard Cubic Foot

SO_x .....Sulfur Oxide

SO_2.....Sulfur Dioxide

References

[1] http://www.watershotinc.com

[2] "Emissions of Greenhouse Gases in the United States 2006." Energy Information Administration, Office of Integrated Analysis and Forecasting, United States Department of Energy. DOE/EIA-0573(2006). November 2007. ftp://ftp.eia.doe.gov/pub/oiaf/1605/cdrom/pdf/ggrpt/057306.pdf

[3] "Clean Energy, How Coal Works." Union of Concerned Scientists. http://www.ucsusa.org/clean_energy/fossil_fuels/offmen-how-coal-works.html

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