New Energy Recovery and Carbon Reduction Benefit Streams Improve Industrial Energy Project ROI's

Robert J. Tidona, RMT, Inc.

ABSTRACT

Energy efficiency is fundamental to carbon reduction strategy. Often, it is an economically attractive first step in achieving carbon neutral status. Recognizing this, many industrial firms take the initial steps of determining the technical and economic feasibility of energy conservation/cost-reduction projects; however, they often fall short when implementing their strategies because of the difficulty in balancing stakeholder expectations, financial constraints, and ever-changing regulatory mandates.

Stalled implementation of energy efficiency projects costs companies money both in elevated operating expenses and missed incentives. For example, the Energy Independence and Security Act of 2007 offers significant new incentives for projects that incorporate recoverable waste energy or combined heat and power systems. Companies can receive $10 per Megawatt-hour-electric (MWh_e) for excess electricity produced from waste energy or $10 per 3.412 million British thermal units (Btu) of excess thermal energy recovered and used for any purposes other than its original intent. In states with mandatory carbon emission limits and for firms desiring to register voluntary carbon emission reductions, these projects will result in either an avoided cost of carbon emissions or a revenue from the sale of carbon credits that should also be included in their financial analyses.

Balancing stakeholder expectations, financial constraints, and regulatory mandates, may start with recasting energy savings projects already in the pipeline. By incorporating economic incentives and rebates, and the value of reduced carbon emissions, companies will often realize improved financial results, early success in carbon reduction without large expenditures, reduced operating costs, and improved stakeholder satisfaction. The real-world examples in this paper will provide insight into the benefits of this approach.

Introduction

Producing more with less has been the global mantra of industrial firms for many years. Forthcoming greenhouse gas (GHG) legislation and the recently enacted Energy Independence and Security Act (EISA) of 2007 are creating new incentives to reduce energy consumption and minimize waste in manufacturing processes.

Ecoefficiency is defined as "the ability to manufacture goods efficiently and at competitive prices without harming the environment". Increasing ecoefficiency means reducing the amount of raw material, energy, or waste per unit of production. The benefits of increasing ecoefficiency typically include:

- Reduced energy, water, and waste disposal costs
- Reduced pollutant emissions (SO_2, NO_x, unburned hydrocarbons, PM, CO, trace metals, etc.)
- Reduced carbon emissions

- Increased productivity
- Improved market share
- Improved "green" image
- Documented progress toward meeting sustainability and corporate social responsibility goals

In evaluating the economics of an ecoefficiency improvement project, companies should consider the operating and maintenance cost impacts. The financial analysis should include all of the above benefits. This paper evaluates industrial energy project costs and benefits, and highlights the additional impact of the expected energy incentives associated with EISA and GHG reduction credits.

Energy Independence and Security Act of 2007

On December 19, 2007, President George W. Bush signed the Energy Independence and Security Act (EISA) of 2007, building on the comprehensive energy strategy set forth by the Energy Policy Act of 2005. The EISA is made up of sixteen sections (titles).

Industrial Focus

For industrial companies, Title IV Section 451 of the Act, which addresses industrial energy efficiency, is of particular interest. Title IV directs the United States Environmental Protection Agency (USEPA) to establish a recoverable waste energy inventory program to include:

- An ongoing survey of all major industrial and large commercial combustion sources in the U.S.
- A review of each source for quantity and quality of waste energy produced.

Title IV of EISA also establishes an incentive grant program for projects that successfully produce electricity or thermal energy from waste energy recovery at the rate of \$10 per MWh_e during the first three calendar years of production after December 19, 2007, and \$10 per each 3.412 million Btu of recovered thermal energy utilized. Additional grants are authorized to states that achieve 80 percent or more of the waste heat recovery opportunities identified by this program.

In addition, Title IV requires the Department of Energy (DOE) to develop new processes and technologies to improve the energy efficiency of energy-intensive industries (e.g., IT data centers, consumer product manufacturing, food processing, aluminum, chemicals, forest and paper products, metal casting, glass, petroleum refining, mining, and steel). It also requires improved federal and commercial building energy efficiency, with the ultimate goal of zero net energy use by 2050, and establishes a procedure for states to determine buyback of electricity by regulated utilities.

Impacts and Opportunities

The new provisions and amendments of the EISA took effect one day after enactment—December 20, 2007. The full impact of the Act may not be immediately apparent, but it may require changes—and offer opportunities— for companies now.

For example, the USEPA must publish criteria for inclusion in the industrial recoverable waste energy inventory program within 270 days of enactment (September 14, 2008), with the inventory to be established by December 19, 2008. The Act currently calls for at least the following criteria:

- The project must have a simple payback of no more than five years after the date of first full project operation including the Act's incentives.
- The primary purpose of the project cannot be to sell excess electric power; if the project produces excess power and an electric utility purchases or transmits it, 50 percent of the grant money shall be paid to that utility.
- The process must capture at least 60 percent of the total energy value of the fuels used in the form of useful thermal energy, electricity, mechanical energy, chemical output or any combination thereof.

The EISA defines waste energy as any of the following:

- Exhaust heat or flared gas from any industrial process;
- Waste gas or industrial tail gas that would otherwise be flared, incinerated, or vented;
- A pressure drop in any gas, excluding any pressure drop to a condenser that subsequently vents the resulting heat; and
- Such other forms of waste energy as the Administrator may determine.

The EISA formally re-designates the DOE's Combined Heat & Power Application Centers as "Clean Energy Application Centers" within the Office of Energy Efficiency and Renewable Energy (EERE). These Centers build upon existing EERE activities, such as the Industrial Technologies Program, and will be responsible for encouraging deployment of clean energy technologies and for providing assessment and advisory support.

The best opportunities will likely be for companies with high temperature, high flow exhaust streams, and/or significant electricity consumption. Taking a proactive stance by assessing recoverable energy opportunities that may be eligible for incentives can provide a significant boost to project economics and enhance the chances for implementation.

Carbon Markets and the Value of Ghg Reductions

There are several global markets for carbon, some more advanced with higher valuations for carbon dioxide equivalents (CO_{2e}) than others. The term "carbon" in this context refers to carbon equivalents. A CO_{2e} has the same global warming effect as one metric ton of CO_2. The six categories of GHGs that play the most important role in global warming, according to the Intergovernmental Panel on Climate Change (IPCC), are:

- Carbon dioxide (CO_2)
- Methane (CH_4)
- Nitrous Oxide (N_2O)
- Perfluorocarbons (PFCs)
- Hydrofluorocarbons (HFCs)
- Sulfur Hexafluoride (SF_6)

For combustion sources, the first three categories (CO_2, CH_4, and N_2O) are the major emissions. PFCs are emitted by the secondary aluminum industry and are refrigerants. HFCs are also refrigerants. SF_6 is used primarily as a dielectric medium in electrical equipment such as switchgear and circuit breakers, as a tracer gas in ventilation systems studies, and in medical applications.

The "mandatory market" is that which develops when mandatory carbon caps are instituted for GHG emitters. Those organizations that are able to control their GHG emissions to below their allotted amount, or cap, can register their excess reductions with one of several exchanges through a licensed environmental broker. Those who are less able to control their own GHG emissions can purchase allowances from the same exchanges, again, through a licensed environmental broker.

The European Union Emission Trading System (EU ETS) was the first mandatory market for carbon and, as such, has the most volume and the highest prices (approximately \$30 per metric ton of CO_{2e}). California and the Regional Greenhouse Gas Initiative (RGGI) are the first mandatory markets for GHG in the U.S., with others like the Midwest and Western States Climate Initiatives soon to follow. RGGI's first auction, held September 25, 2008, resulted in the sale of 12.6 million carbon allowances for \$3.07 each. More recently, 2009 vintage RGGI allowance prices have been hovering at \$3.50 to \$4.00.

The "voluntary market" for carbon in the US has been governed by the desire of its participants to develop a climate-friendly approach to their operations thereby improving their "green" image or to prepare for future restrictions on emissions. To date, the Chicago Climate Exchange has the highest voluntary carbon trading volume in the world. Prices on this exchange have been hovering between about \$1.75 and \$4.00 per metric ton of CO_{2e}. A number of models have been developed to project future carbon market prices. For the most part, they predict increases over the next 50 years due to the challenge posed by reducing up to 80 percent of GHG emissions to the atmosphere while simultaneously increasing global energy consumption by 20 percent or more.

A logical assumption is that, in a carbon-constrained world where one CO_{2e} has the same impact on global warming anywhere on the planet, the price for emitting that ton will be closely related to the cost of removing it from the atmosphere or preventing it from being released to the atmosphere in the first place. This cost may range from less than \$10 per metric ton of CO_{2e} for reforestation projects to \$100 or more per metric ton projected for carbon capture and sequestration (CCS) when it becomes a commercially available technology. Another factor in the future market price of carbon is the cost of the energy from non-fossil sources that ultimately displace fossil energy sources and their associated carbon emissions. It is generally recognized that, in order for such "fuel switching" to take place, the cost of the new energy source needs to be comparable to the fuel being displaced. Thus, there should be no incremental contribution to the overall average cost per ton of carbon removed due to switching to non-carbon or low-carbon fuels.

With an expected mix of renewable "replacement" energy sources and CO_2 mitigation measures such as CCS, it is not unreasonable to project that the overall average cost per ton of CO_2 removal will be close to the EU ETS's current price, or \$30 per metric ton of CO_{2e}.

Putting It All Together – Economic Impacts of Incentives and Emission Credits

To properly determine the cost-benefit ratio of a specific project or grouping of projects, the potential value of avoided carbon emissions should be considered along with the benefits of applicable energy incentives. Although it is too early to know exactly which projects will qualify for EISA-mandated benefits, it is certainly possible to estimate their value based upon the explicit language in the Act.

The three examples below provide simplified economic analyses of industrial energy projects that were originally developed without the value of carbon credits or energy incentives in mind. These projects all involve the combustion of recycled wastes from one or more manufacturing processes and the substitution of biomass fuel for a portion of the remaining thermal input necessary to generate steam for process and facility heating uses. Two of the three projects are also designed to generate electricity primarily for internal plant consumption, with sale of the excess electricity back to the grid. Each project results in calculated GHG emission reductions, as well as energy and other operating cost savings. The original analyses have been updated with the expected value of avoided carbon emissions (assumed as \$30 per metric ton of CO_{2e}), as well as the economic incentives for thermal energy recovery and/or additional electricity generation at the rates specified in the EISA (i.e., \$10 per each 3.412 million Btu and \$10 per MWh_e, respectively), as applicable. Care was taken to avoid double counting the benefits for cases involving simultaneous electricity generation and thermal energy recovery. Excess electric power was not the primary goal of these projects; thus, all of the electric incentive was applied toward the project.

Project Descriptions

Paper Recycling Mill

When the recent surge in natural gas prices significantly increased utility costs, this paper recycling mill needed to develop a strategy to reduce electricity, natural gas, and waste disposal costs, as well as the financial risk associated with them. To maximize fuel flexibility and minimize energy and waste disposal costs, the selected design concept included a boiler capable of burning various mixes of alternative fuels, including mill process wastes, carpet waste, wood, and coal.

RMT, Inc.'s preliminary system design included the boiler and associated ductwork, fans, fuel and ash handling, air pollution control, and backpressure turbine to generate electricity, primarily for onsite use. The design provided a system steam capacity of 200,000 pounds per hour (lb/hr) at 900 pounds per square inch gauge (psig) and 900 degrees Fahrenheit (°F), plus an 8-MW_e backpressure steam turbine.

Pressure Sensitive Tape Manufacturing Plant

RMT helped this tape manufacturing facility evaluate the installation of a 40,000 lb/hr multi-fuel-fired steam boiler to replace two existing coal-fired boilers. A design was developed that provided for the use of the plant's own manufacturing solid waste materials, as well as purchased wood wastes, to supplement coal fuel. The system was designed to produce 250 psig saturated steam for process use with no electricity generation.

Tissue Mill

The tissue mill is an integrated paper mill with paper making capacity of 270 tons per day. RMT conducted a feasibility study to determine the cost to install and operate a wood biomass and de-inking sludge-fueled combined heat and power (CHP) system to help meet the facility's future steam and electricity needs. The new boiler was designed to generate up to 120,000 lb/hr of steam at 700 psig and 750 F.

The CHP facility would be installed in parallel with the mill's existing steam generation equipment – two older packaged boilers that would continue to be available as backup units. The existing boilers fire natural gas but also have the capability to fire No. 2 fuel oil. Steam header conditions are saturated at 250 psig. A 5-MW_e backpressure steam turbine was included in the new system design.

Economic Analysis Accounting for Carbon Value and Energy Incentives

First, the impact of the value of avoided carbon emissions can be considered as an additional cost of fossil fuels that release CO_2 to the atmosphere upon combustion. For a conventional fossil fuel with established chemical analysis, the amount of CO_2 generated per pound is fixed. Figure 1 illustrates the effect of including the value of CO_2 emissions, at $30/ton CO_{2e}, as part of the absolute fuel cost. Figure 2 shows the relative impact of carbon value on fuel cost on a percentage basis. This graph reveals the much greater sensitivity of coal fuels to carbon value relative to gas and oil fuels. In general, the lower the "quality" of fuel, the higher its carbon content and, therefore, the greater the impact of carbon value on its cost. Replacing a high-carbon fossil fuel with a low-carbon fossil fuel or carbon neutral biomass fuel reduces carbon emissions. Due to their biomass origins, the manufacturing and mill process waste fuels were considered to be carbon neutral for the purposes of this analysis.

Second, the grid-purchased electricity consumed by any facility has associated carbon emissions. CO_2 emission data from power plants is readily available for every region of the U.S. in the USEPA's eGRID database. To the extent that a facility's grid purchases are offset by onsite electric generation from low-carbon or carbon-neutral fuels or from the recovery of waste heat, the net CO_2 emissions from the facility will be reduced.

Table 1 provides the total installed capital cost for the three projects, along with the total achievable CO_2 reductions and the capital cost per metric ton of reduction. Table 2 summarizes the fuel and electricity savings from implementation of the projects as determined in the traditional manner, but also shows the impact of a $30 per metric ton value for avoided CO_2 emissions. The value of the avoided carbon cost ranges from 25 to 30 percent of the original total savings.

The projected additional impacts of the forthcoming EISA incentives are illustrated in Table 3. The thermal and electricity components combine to add another 18 to 25 percent of the original total project benefits. Table 4 shows the anticipated results accounting for the avoided carbon and both EISA incentive components. Inclusion of all three benefits adds approximately 50 percent to the original savings.

Figure 1. Impact of Carbon Value on Fuel Cost Per Unit Energy August 2007 Fuel Costs

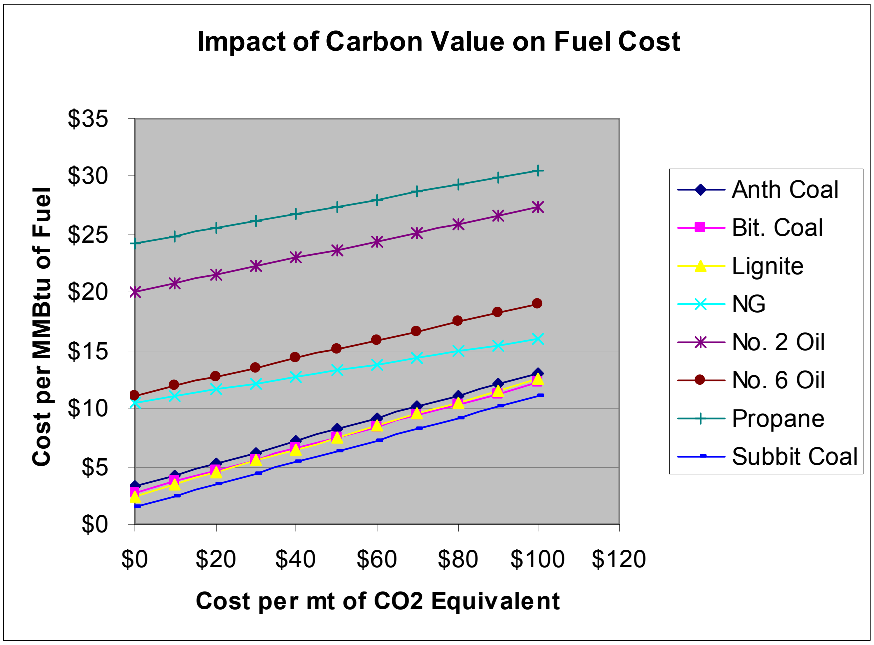

Figure 2. Impact of Carbon Value on Percent Fuel Cost Increase August 2007 Fuel Costs

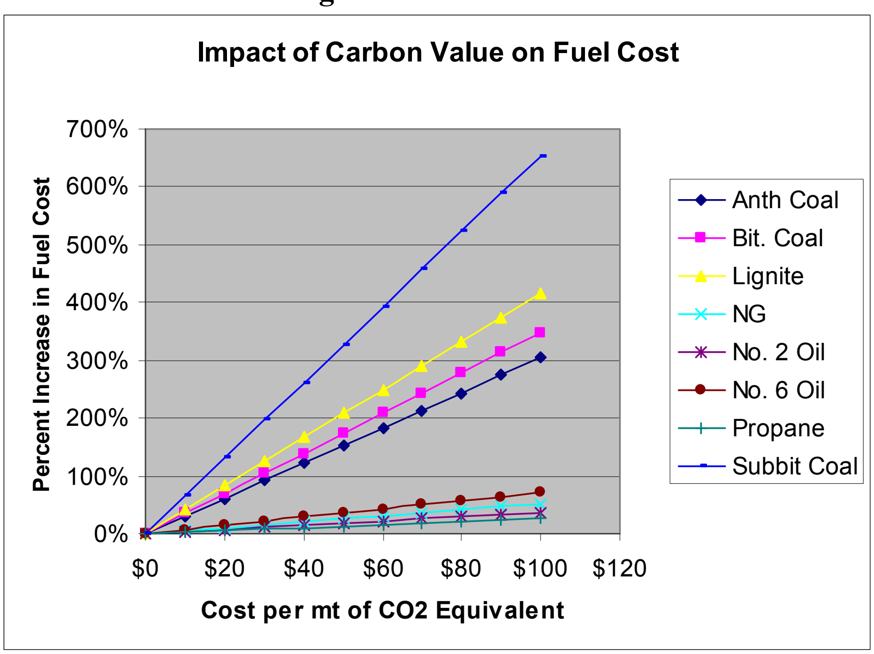

Table 1. Capital Costs of CO_2 Reduction Projects (2007 USD)

APPLICATION	PROJECT	INSTALLED CAPITAL COST	CO_{2e} REDUCTION Metric Tons (MT)	\$/MT CO_{2e}
Recycle Paper Mill	Biomass/Mill sludge CHP boiler - 200 klb/hr + 8 MW steam turbine	$39,000,000	130,000	$300
Tape Manufacturing Plant	Tape mfg waste + coal + biomass boiler	$7,700,000	16,700	$461
Tissue Mill	Biomass/Mill sludge CHP boiler - 120 klb/hr + 5 MW steam turbine	$31,400,000	98,192	$320

Table 2. Economic Impact of a Voided Carbon Emissions Savings in Millions of (2007 USD)

APPLICATION	EQUIPMENT	ANNUAL FUEL SAVINGS $	ANNUAL ELECTRIC SAVINGS $	CO_2 SAVINGS @ \$30/MT $	% SAVINGS INCREASE DUE TO AVOIDED CARBON
Recycle Paper Mill	200 klb/h BFB boiler + 8 MW turbine cogen	13.2	1.1	3.9	27.5%
Tape Manufacturing Plant	40 klb/h multi-fuel boiler	2.0	0	0.5	25.5%
Tissue Mill	120 klb/h stoker boiler + 5 MW turbine cogen	5.6	4.1	2.9	30.3%

Table 3. Economic Impact of EISA Incentives Savings in Millions of (2007 USD)

APPLICATION	ANNUAL HEAT RECOVERY POTENTIAL MMBtu	ANNUAL ELECTRICITY GENERATION POTENTIAL MWh	EISA THERMAL INCENTIVE @ \$10/3.4 MMBtu $	EISA ELECTRICITY INCENTIVE @ \$10/MWH $	% SAVINGS INCREASE DUE TO EISA INCENTIVES
Recycle Paper Mill	757,000	84,408	2.2	0.8	21.4%
Tape Manufacturing Plant	170,000	-	0.5	-	24.9%
Tissue Mill	472,000	34,915	1.4	0.3	17.9%

Table 4. Combined Impact of Avoided Carbon And Energy Incentives Costs and Savings in Millions of USD (2007)

APPLICATION	CAPITAL COST $	TOTAL ANNUAL ENERGY SAVINGS (TABLE 2) $	CARBON AND EISA INCENTIVES (TABLES 2 AND 3) $	TOTAL POTENTIAL BENEFIT $	GRAND TOTAL BENEFIT IMPROVEMENT (REDUCTION IN SIMPLE PAYBACK) %
Recycle Paper Mill	39.0	14.3	6.9	21.2	48.9%
Tape Manufacturing Plant	7.7	2.0	1.0	3.0	50.4%
Tissue Mill	31.4	9.7	4.6	14.3	48.2%

Summary and Conclusions

The economic evaluation of an ecoefficiency improvement project has traditionally considered its operating and maintenance cost impacts versus the project capital costs. When the financial analysis is expanded to include avoided carbon emissions, as well as anticipated thermal and electrical energy incentive payments from the EISA, the benefit streams may increase by as much as 50 percent.

Many ecoefficiency projects have been studied in recent years, yet have not been implemented. When the cost-benefit evaluation of such projects is recast to account for carbon, energy efficiency, and other benefits, the financial case for implementation may now be convincing. Faced with record fossil fuel prices, expected double-digit increases in electric rates, and the need to demonstrate progress in the area of climate change, many firms are now casting a wider net to identify promising ecoefficiency projects by accounting for these ancillary benefits.

In the final outcome, the recycled paper mill project is nearing completion and is to begin operation Q2 2009. The pressure sensitive tape manufacturer did not implement the multi-fuel boiler concept, but did install modular natural gas fired boilers ultimately improving efficiency and reducing carbon emissions. The tissue mill made a similar decision to utilize a more efficient natural gas fired boiler that became available when a neighboring cogeneration plant shut down.

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