

Manufacturing Climate Solutions

Carbon-Reducing Technologies and U.S. Jobs

CHAPTER 7

Recycling Industrial Waste Energy



by

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Summary

The U.S. industrial sector includes many significant opportunities to recycle energy that is currently being discarded. Energy-intensive industrial processes—including refineries and the production of steel, cement, glass and chemicals—often cast off energy in the form of exhaust heat, combustible gases, biomass, and other “waste” energy. These highly recoverable energy resources can be harnessed, with common, well-established technology, to generate electricity. Together, various forms of recyclable waste energy represent an estimated 100 gigawatts (GW) of potential electric capacity—an amount roughly equal to 10% of the current U.S. grid—requiring no or little additional fuel. The resulting reduction in carbon dioxide emissions (CO₂) would be an estimated 400 million metric tons.

The recycling of industrial waste energy is a largely untapped subset of Combined Heat and Power (CHP), or the use of one single process to generate both useful heat and electricity. Four types of job opportunity are associated with energy recycling:

1. Jobs in manufacturing the waste energy recovery equipment
2. Jobs in creating the “energy islands” where industrial hosts’ waste energy is recycled into power
3. Jobs operating and maintaining the on-site energy islands
4. Jobs resulting from higher energy productivity and increased competitiveness

Recycling industrial waste energy, like all CHP, offers considerable potential to save energy, increase productivity, reduce greenhouse gases, and create jobs. The U.S. government in recent years has provided crucial support for the development of CHP, including waste energy recycling. Fully developing these opportunities will require reforming federal and state regulations that inhibit decentralized power production, as well as expanding incentives for renewable energy to include support for these major improvements in energy efficiency.

Introduction

Vast potential for improving U.S. energy efficiency lies in the industrial sector (McKinsey Global Institute, 2007). One important avenue is recovering energy that can be recycled from energy-intensive industries, such as refineries and the making of steel, cement, glass, and chemicals (ICF International, 2007). These manufacturing processes may discard waste energy in the form of exhaust heat or combustible gases, often releasing it to the atmosphere or to a water body, when instead it could be used to generate electricity. Waste heat and combustible gases are among many currently wasted but highly recoverable energy resources, including discarded biomass, changes in pipeline pressure, and selected pollutant emissions such as methane (S. Casten, 2008).

A few U.S. manufacturers have long used waste energy to great advantage, including the pulp and paper industry—which burns wood bark and other wastes to produce both electricity and useful thermal energy. Still, opportunities to recycle industrial waste energy are vast, varied, and remain largely untapped, even though many of them are fully feasible with well-established technologies. Lawrence Berkeley National Laboratory has estimated that energy recycling represents nearly 100 gigawatts (GW) of untapped electrical capacity (Bailey & Worrell, 2005). This figure is roughly equal to 10% of current U.S. electric capacity (Energy Information Administration, 2009) and, as an alternative electricity source, would reduce carbon dioxide emissions (CO₂) by nearly 400 million metric tons (Bailey & Worrell, 2005).

The recovery and recycling of industrial waste energy fits under the umbrella of “co-generation,” or Combined Heat and Power (CHP). CHP makes use of the fact that great energy efficiencies can be achieved by using one single process to generate both useful heat and electricity. CHP achieves much greater efficiencies than a typical power plant, where two-thirds of the energy used to produce electricity is simply discarded in the form of waste heat. Because the vast majority of U.S. power generation does not use the waste heat that is its by-product, the power sector is only about 34% efficient at best, a figure that has not improved since the 1960s (Oak Ridge National Laboratory, 2008). CHP, in contrast, combines the generation of useful heat and power, achieving efficiencies of 60% to 90%, and even higher in some applications of energy recycling (Sears, 2009).

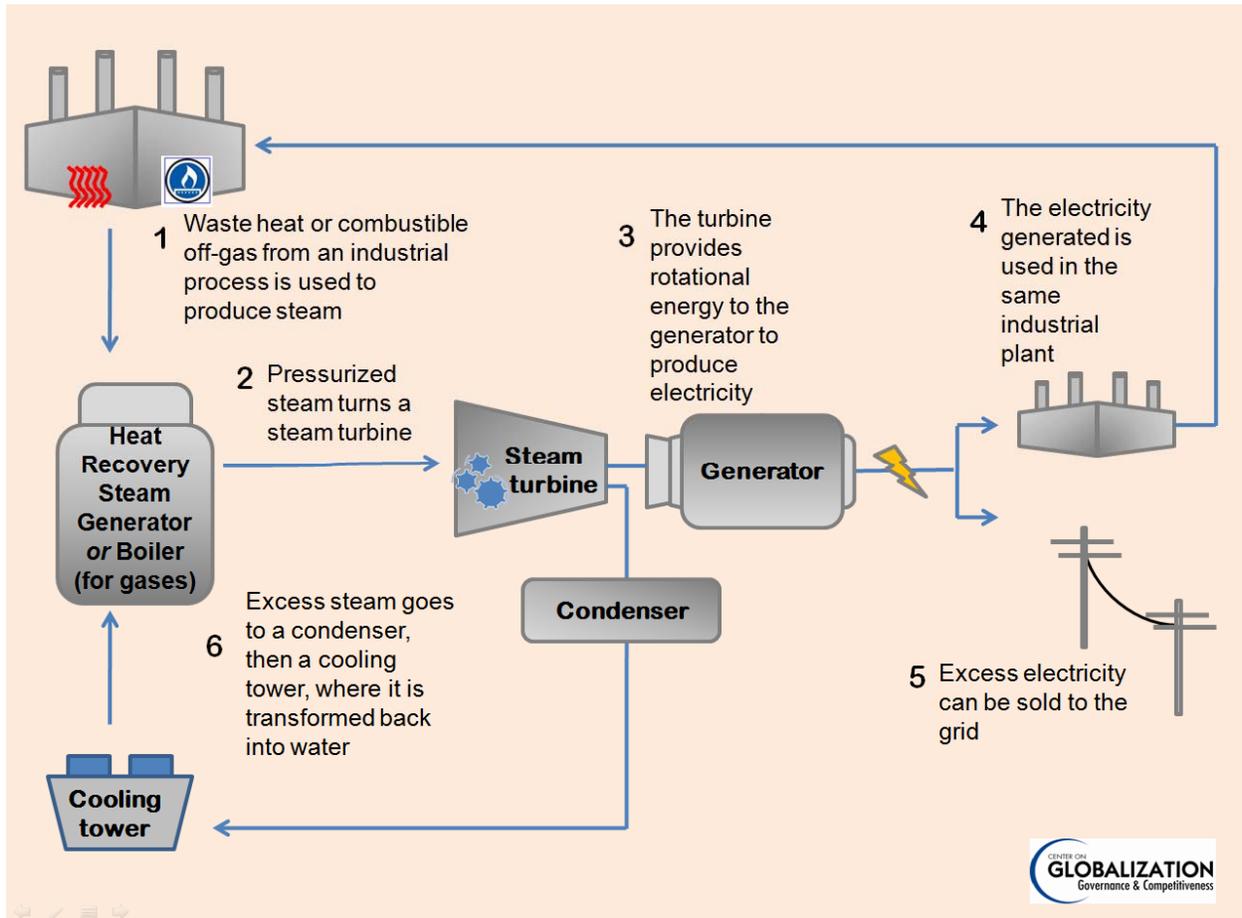
By definition, all CHP constitutes waste heat recovery. To date, most CHP applications have used a fuel source such as natural gas to generate power; thus the recovered waste heat in question is the by-product of electricity generation. By contrast, in CHP projects that recycle industrial waste energy, the waste heat in question (or other waste energy) essentially serves as the “fuel” for electricity generation. In other words, while all forms of CHP drastically improve the energy efficiency of power production, it is worth highlighting this often-overlooked subset of opportunities: those that produce power by recycling existing waste energy that is currently being discarded, requiring no or little additional fossil fuel.

Within current CHP, it is difficult to estimate the share specifically attributable to industrial waste energy recycling. There is general agreement, however, that recycled energy is a vast resource. While many firms involved in waste heat recovery have for years been finding creative ways to recycle energy, this niche within CHP has only in recent years begun to be recognized in wider energy policy circles for its important role in energy efficiency. Many important opportunities remain untapped (Sears, 2009).

This report focuses on recycling industrial waste energy, with particular emphasis on waste heat and combustible gases. The basic process by which these can be recycled into electricity is shown in Figure 1. Existing waste energy from a manufacturing process that would otherwise be discarded—such as exhaust heat from a blast furnace or off-gases from a coke oven—is

instead converted into high-pressure steam. The steam is then connected to a steam turbine, where it provides rotational energy to a generator, producing electricity. This electricity can be used on-site by the manufacturing plant, and any excess can be sold to the local utility.

Figure 1. Industrial Waste Energy Recycling Process



Note: In addition to waste heat and combustible off-gases, the many other forms of recoverable waste energy include discarded biomass, changes in pipeline pressure, and selected pollutant emissions such as methane (S. Casten, 2008).

Source: CGGC based on Recycled Energy Development (RED) website, interviews and industry sources.

Recycled energy projects tend to be highly individualized undertakings between the host facility and an outside party that finds creative ways to recycle energy into power, often with the host facility committing to buy back that power for a future period, for instance, 20 years. A well-established example of industrial waste energy recycling is a series of projects developed in northwest Indiana by Primary Energy/EPCOR USA. Initiated in 1996, the projects serve Arcelor Mittal Steel’s steel-making operation by recycling waste heat and off-gases (which would

otherwise be flared) from several smelters to generate power (Primary Energy/EPCOR USA, 2009). The projects generate 220 megawatts of electricity. Including the Arcelor Mittal and other projects, EPCOR USA has interests in 17 power plants totaling 1,500 MW of electricity capacity and five million pounds per hour of thermal energy. Most of this efficient energy is derived from recycled blast furnace gas, recovered waste heat, coal, tire-derived fuel, wood, and natural gas-fired CHP (Primary Energy/EPCOR USA, 2009).

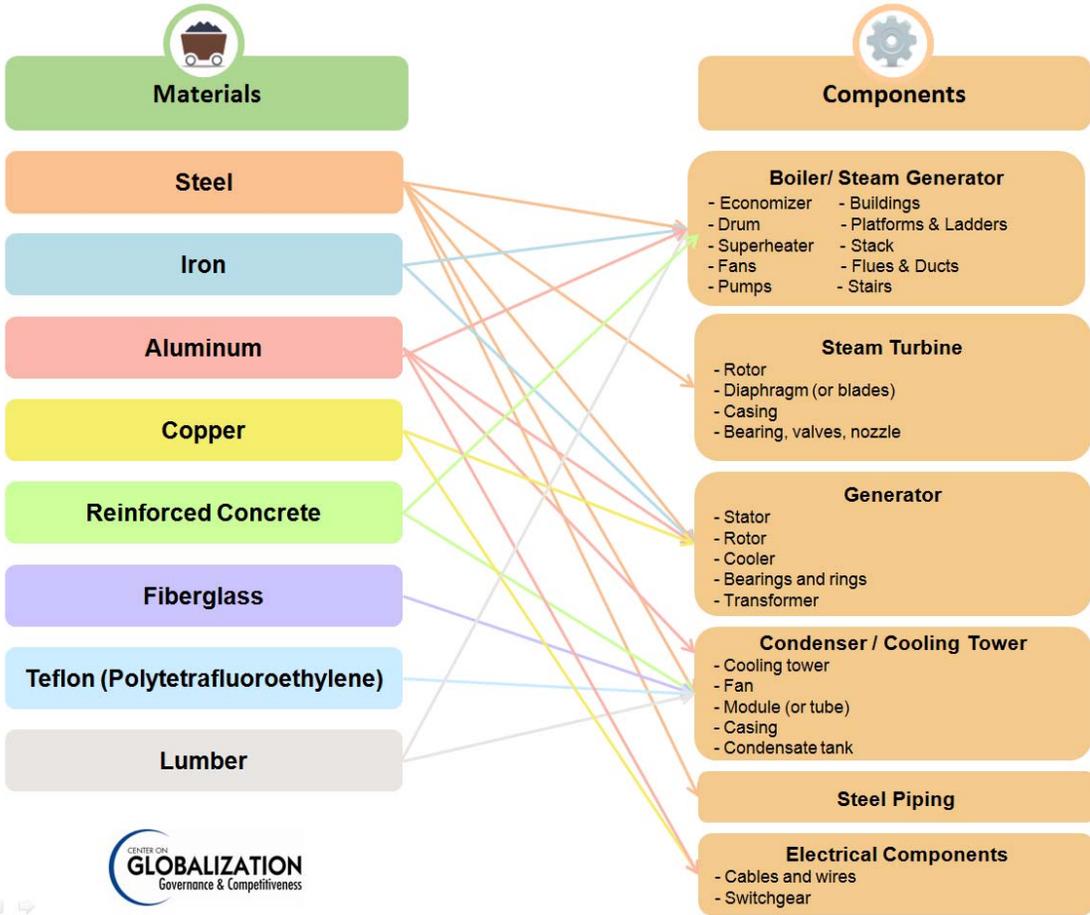
Industrial Waste Energy Recycling Systems: Materials and Components

The equipment required for industrial waste energy recycling can be simplified into six basic components: a heat recovery steam generator (or if recovering combustible gases, a boiler or other combustion device), a prime mover (typically a steam turbine, but lower-heat applications can use an organic fluid to drive the Rankine cycle turbine), a generator, a condenser/cooling tower, piping, and electrical components. Natural gas-fired CHP projects involve largely the same equipment but also require fired prime movers—in other words, engines and gas turbines.

The six energy recycling components named here, their main subcomponents, and the relevant materials they are made from appear in Figure 2. Each of the major components is principally made of steel. Other important inputs include iron, aluminum, copper, concrete, and fiberglass.

Installing the equipment at the operation site requires extensive construction, from pads of reinforced concrete to entire buildings. Depending on the site-specific configuration, the condenser/cooling tower arrangement may also require various combinations of lumber, fiberglass, stainless steel, and Teflon (PTFE). In large manufacturing facilities that comprise miles of interconnected pipes, wires, and buildings, the size of the equipment required for waste energy recovery can be substantial. For example, Port Arthur Steam Energy LP is a large waste heat recycling project in Port Arthur, Texas that provides 5 MW of power and 400,000 pounds per hour of high-pressure steam. The project involves 2.5 miles of steam pipeline (Deyoe, 2007). See project details on pages 7-8.

Figure 2. Industrial Waste Energy Recycling Components and Materials

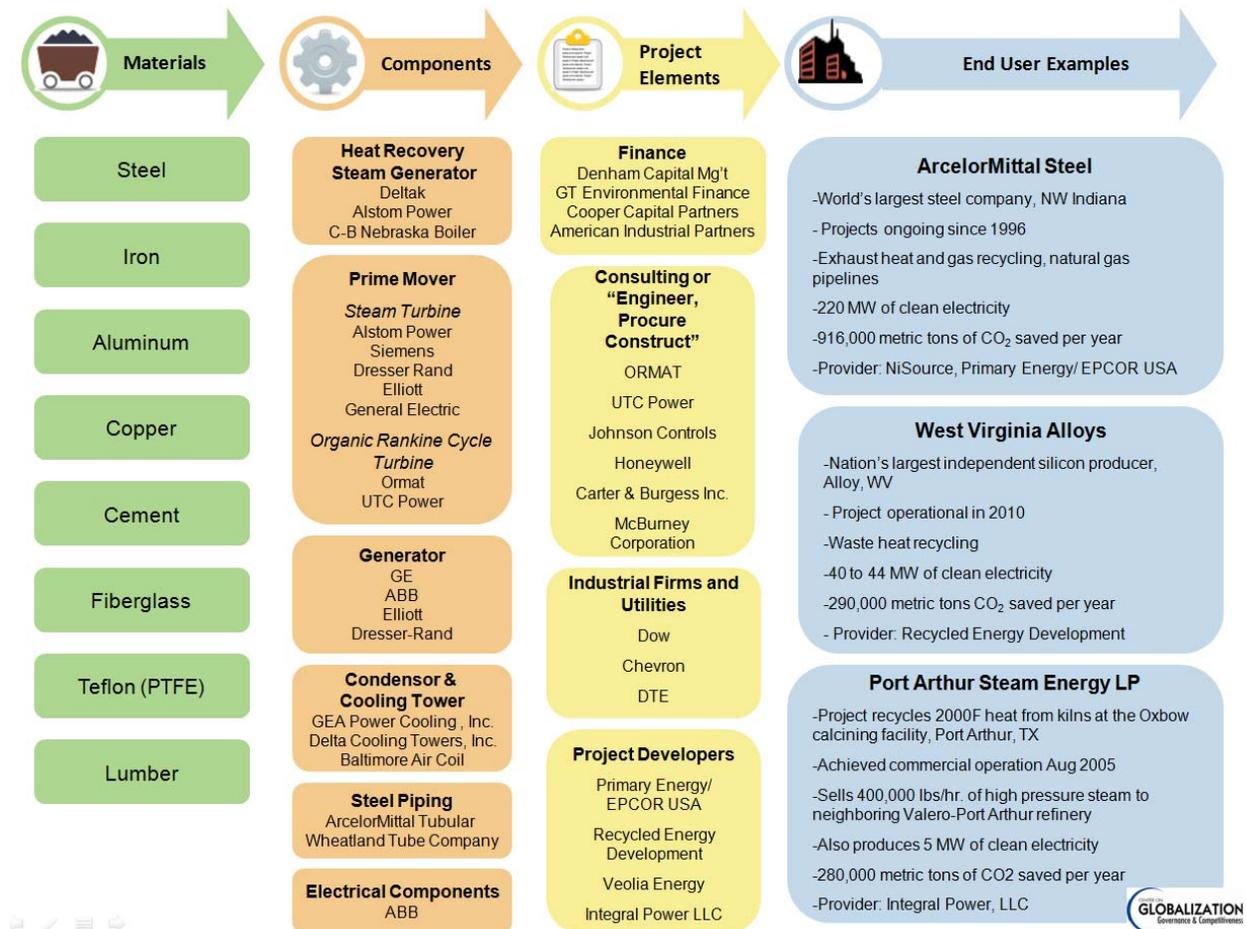


Source: CGGC, based on interviews and industry sources.

Industrial Waste Energy Recycling Value Chain

The value chain for U.S. applications of industrial waste energy recycling is depicted in Figure 3. For this report we have divided the value chain into four segments: materials, components, project elements—an umbrella that includes finance, consulting or “engineer/procure/construct,” and product development—and finally, end user examples.

Figure 3. Value Chain for U.S. Industrial Waste Energy Recycling Systems, with Selected Company Examples



Source: CGGC, based on interviews, company websites, and (Deyoe, 2009; Primary Energy/EPCOR USA, 2009; Recycled Energy Development, 2008b).

Materials. The United States is a major producer of all the main materials identified here for a waste energy recovery system, including steel, iron, aluminum, copper, and others. However, many of the large equipment manufacturers operate global supply networks in order to source the materials at the least cost. Prices for steel, aluminum and several other materials are volatile,

increasing with global economic growth, energy price hikes, rising demand in China and other emerging economies, and fluctuating exchange rates (Datamonitor, 2008).

Components. A heat recovery steam generator—a network of steel tubes boiling water—is central to recovering waste heat, while a combustion device such as a boiler is needed to recover waste gases. These devices are closely coupled with a prime mover, which provides rotational energy to the generator. Typically, in projects that recover high-grade waste heat such as that from steel or cement making, the prime mover is a steam turbine. Steam turbines are recognized as the most cost-effective, and they have the advantage of flexibility in choice of fuel source. However, for less heat-intensive processes (under 700 degrees F) an organic Rankine cycle turbine is very effective (Leibowitz, 2007). This technology is currently more widely applied in Europe than in the United States, although growing U.S. attention to energy recycling suggests that increasing support is likely in the near future. This may help bring costs more in line with traditional approaches (Neveu, 2009).

Project elements. Recycling industrial waste energy typically requires several outside parties to put together a project, encompassing design, financing, construction and engineering, and in some cases, operation and management of the on-site power plant. A wide range of companies offer one or more of the elements required to develop a CHP project on behalf of a business, university or industrial client. These include, but are not limited to, the following:

- *Finance providers* – Examples include Denham Capital Management; GT Environmental Finance; Cooper Capital Partners; American Industrial Partners
- *Consulting/engineering* or “*Engineer Procure Construct*” firms – These companies do turnkey installations (performing all necessary design, engineering and construction). Examples are Carter & Burgess Inc., McBurney Corporation, Johnson Controls, and ORMAT Technologies Inc., a company that specializes in recovering energy with lower heat values than is typical of steam turbine applications.
- *Industrial firms and utilities* – Some large industrial firms including BP, Dow, and Chevron develop projects for their own operations and for clients. Also, some utilities have non-regulated arms that add alternative energy-derived power to their portfolios by recycling waste energy. Examples include DTE Energy and NRG Energy.
- *Project developers* – firms that, in addition to performing the “Engineer Procure Construct” role described above, do all the other complex steps necessary to complete a project, including acquiring land if necessary, securing the waste energy source, applying for environmental and local permits, negotiating power purchase agreements, and presenting the project at community hearings if needed (Ganga, 2009). Project developers include Primary Energy/EPCOR USA, Recycled Energy Development (RED), Veolia, and Integral Power LLC (see value chain in Figure 3).

End user examples. The largest current U.S. example of industrial waste energy recycling is a series of seven integrated projects serving Arcelor/Mittal Steel in northwest Indiana, built between 1996 and 2004, described on pages 4-5. Another large project, expected to be operational in 2010, is for silicon producer West Virginia Alloys. Waste heat from the silicon process will produce 40-44 MW of electricity, offsetting one-third of the host facility's electricity needs. An additional notable project is Port Arthur Steam Energy LP, a redevelopment project in Port Arthur, Texas. This project captures high temperature flue gas heat from a petroleum coke calcining operation to produce high pressure steam, much of which is then sold to a neighboring refinery for its processes. Steam sold to the refinery displaces natural gas firing in boilers, saving both fuel and emissions. Part of the steam is also used to produce 5 MW of electricity, supplying power for both the calcining and heat recovery operations, with excess sold to the grid (Deyoe, 2009).

Geography. Although the largest concentrations of existing CHP capacity are in California, Louisiana, New York, and Texas, the technical potential exists all over the country (Oak Ridge National Laboratory, 2008). Midwestern and Gulf states that are home to energy-intensive industries such as steel, glass, cement, and petrochemicals have the highest energy recovery potential—including heat and other wasted energy sources—particularly in Texas and Louisiana (Sjoding, 2007).

Government and NGO support. The U.S. government in recent years has provided crucial support for the development of CHP. The U.S. Department of Energy (DOE) and Environmental Protection Agency (EPA) have collaborated with the U.S. Clean Heat and Power Association (USCHPA) and the International District Energy Association (IDEA) with the aim of doubling CHP capacity nationwide from 46 gigawatts (GW) in 2001 to 92 gigawatts by 2010. This effort has closely involved stakeholders from industry, academia, non-government organizations and all levels of government. Today the goal has nearly been reached; over 85 GW of CHP has been installed at over 3,000 U.S. sites (Smith, 2008).

Other positive developments include a section in the Energy Efficiency Improvement Act of 2007, calling for the EPA to compile an inventory of recoverable waste energy from large U.S. industrial and commercial sources. Funding for this effort is included in the \$789 billion American Recovery and Reinvestment Bill of 2009, along with provisions for industrial efficiency and incentives for clean heat and power generation and recovered waste energy.

Job Opportunities in Recycling Industrial Waste Energy

The Oak Ridge National Laboratory summarizes the U.S. potential of CHP as follows:

If the United States adopted high-deployment policies to achieve 20 percent of generation capacity from CHP by 2030, it could save an estimated 5.3 quadrillion Btu (Quads) of fuel annually, the equivalent of nearly half the total energy currently consumed by US households. Cumulatively through 2030, such policies could also generate \$234 billion in new investments and create nearly 1 million new highly-skilled, technical jobs throughout the United States. CO₂ emissions could be reduced by more than 800 million metric tons (MMT) per year, the equivalent of taking more than half of the current passenger vehicles in the US off the road. In this 20 percent scenario, over 60 percent of the projected increase in CO₂ emissions between now and 2030 could be avoided (Oak Ridge National Laboratory, 2008).

Because industrial waste energy recycling systems are highly individualized and vary widely in scale, size of equipment, length of piping, and other features, it is difficult to estimate the number of associated job opportunities. In the Oak Ridge scenario described above, the job potential would reach 1 million new highly-skilled, technical jobs throughout the United States. Looked at another way, the following four layers of employment can be associated specifically with projects to recycle industrial waste energy:¹

1) Jobs in the manufacture of waste energy recovery equipment. These employers range from large multinational corporations to small, specialized firms. Most have complex supply chains that can branch all over the world, although many of the skills and materials needed are readily available in the United States.

2) Jobs in creating on-site “energy islands” in host facilities. These jobs include welders, pipefitters, design engineers, and construction workers. Waste energy recycling systems are not simply manufactured, but rather custom designed and implemented; thus installation services, including engineering, typically represent about 50% of project costs (Elliott, 2009). These are all local jobs. Many of the design/engineering skills needed in this part of the value chain are increasingly in short supply, making it difficult for firms to find the skilled labor they need (Case, 2009). Much of the required traditional engineering expertise is more typical of today’s graying workforce. Hence, an important future challenge is to train enough new engineers with the skills and creativity necessary to create these individualized systems (S. Casten, 2009).

3) Jobs in operating on-site energy islands. In the West Virginia Alloys plant for example, (see value chain diagram) 15-20 new workers are required to run the steam plant/power facility.

4) Jobs resulting from increased competitiveness. The industrial host facility can improve its margins substantially through lower energy costs and higher productivity. For example, in addition to the above-mentioned jobs to run the West Virginia Alloys energy island, an estimated

¹ This four-point job discussion is based on (S. Casten, 2008).

20-30 jobs, or 20% of the plant workforce, are attributable to the resulting cost savings and increased competitiveness with overseas silicon producers (Recycled Energy Development, 2008a).

Industrial Waste Energy Recycling Market

According to Oak Ridge National Laboratory (ORNL), the current generating capacity of all U.S. CHP systems is 85 gigawatts (GW) or nearly 9% of total electric capacity. However, because it has a higher utilization factor, CHP in 2006 (the latest year data are available) accounted for almost 12% of total U.S. power generated. While this is a significant achievement, several other countries derive a much higher share of their energy portfolios from CHP. Those that have actively encouraged CHP in their energy and regulatory policy include Denmark, where CHP accounts for 51% of electricity production, Finland, (39%), Russia (31%), and the Netherlands (29%) (International Energy Agency (IEA), 2008).

Within CHP, the picture for industrial waste energy applications is not well documented, although there is general agreement that it is vastly underused in the United States and elsewhere. Many manufacturers are aware that their processes are wasting recoverable energy, but capturing these opportunities requires a complex set of steps that lie outside most industrial facilities' core activities (see "Project Elements" on page 8). Perhaps most important, these energy projects require substantial capital investment. While they promise an attractive, steady return, it is only after a multi-year period, and many firms and investors require a much shorter return timeframe. The current global financial crisis makes it even more difficult to raise sufficient capital.

An additional important barrier to all applications of CHP is the web of U.S. regulatory policies that favor inefficient centralized power production and penalize or block decentralized alternatives such as CHP. For example, the sale of electricity presents a challenge; in many states, an entrepreneur who generates power for a host facility is forbidden to sell the power to a third party (Sears, 2009). Even well-intentioned environmental legislation can be a barrier. The Clean Air Act, for instance, inadvertently penalizes investments in efficiency. Many environmental regulations, by ignoring how much useful energy a plant produces, fail to reward efficiency (T. R. Casten & Munson, 2009).

Government steps to provide financial incentives and to remove regulatory and other policy barriers are crucial to expanding the market for waste energy recycling systems so that they can take their place among other promising energy technologies. A useful example of expanding energy markets is the wind energy industry. Total U.S. wind power generating capacity grew by a full 50% in 2008—to 25 GW—injecting \$17 billion into the economy. The share of domestically manufactured wind turbine components also grew to about 50%, up from 30% just three years before, creating 13,000 new direct jobs in just one year (American Wind Energy

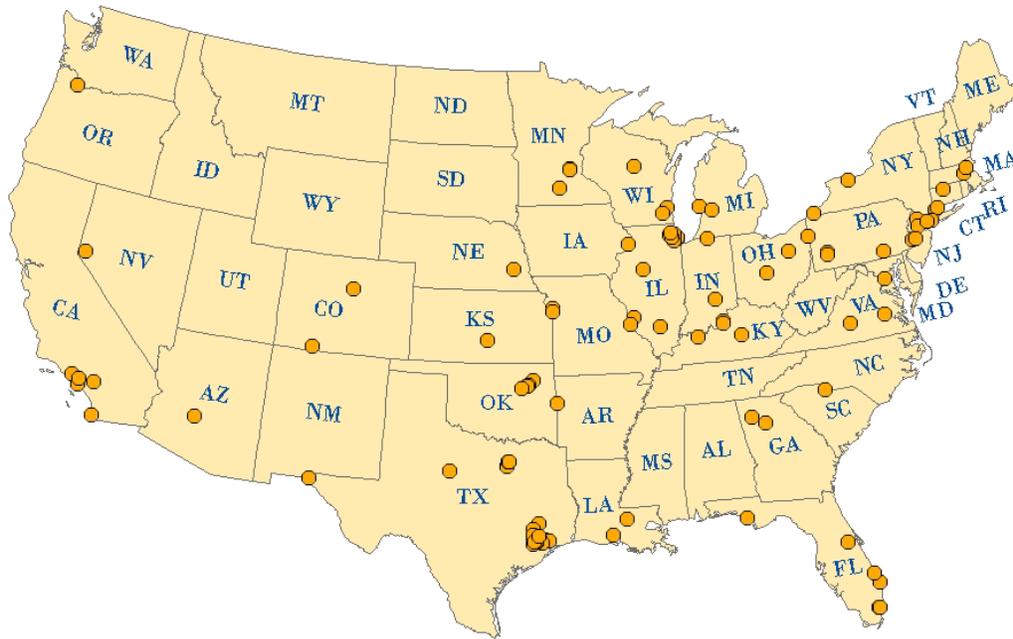
Association, 2009). Energy efficiency, including energy recycling, is as clean as solar or wind power, yet it does not receive the same financial incentives. Going forward, developing energy efficiency as well as renewable energy requires continued, well-targeted government incentives, especially in the face of the current economic downturn.

Industrial Waste Energy Recycling Equipment Manufacturers

Table 1 provides a list of selected global and U.S. firms involved in equipment manufacture for waste energy recycling and gas-fired CHP. Relevant manufacturers of the six identified components include several large multinational companies, including GE (U.S.), Siemens (Germany), Alstom (France), ABB (Switzerland), and Mitsubishi (Japan). These components may or may not represent a significant portion of these large firms' portfolio (Elliott, 2009). In contrast, a number of U.S. firms manufacture one or more major components domestically, including Babcock & Wilcox Company (headquarters in Lynchburg, VA), Dresser-Rand (headquarters in Houston, TX), and C-B Nebraska Boiler (headquarters in Milwaukee, WI). Depending on their area of specialty, some of these smaller firms may play a larger role in manufacturing a given component than the large multinational firms.

The geographic distribution of the headquarters of U.S. firms that manufacture or supply waste heat and gas recovery equipment is found in Figure 4. These headquarters are spread over the eastern and Midwestern United States, with the highest concentrations in Texas, industrial states such as Illinois and Pennsylvania, and New York. Notable manufacturing locations include Texas (Rentech), Georgia (C-B Nebraska Boiler), Ohio (Babcock & Wilcox), and New York (Alstom Power, Dresser Rand).

Figure 4. U.S. Industrial Waste Energy Recycling Equipment Manufacturers and Suppliers: *Company Headquarters*



Source: CGGC, based on company websites and annual reports, interviews and other industry sources.

Table 1. Selected Equipment Manufacturers, Waste Energy Recycling and Gas-Fired CHP

Component	Company	Headquarters Location	Employees	Sales (USD million)
Heat Recovery Steam Generator Manufacturers	Alstom Power USA, Inc.	Windsor, CT	3,000	\$408
	C-B Nebraska Boiler	Milwaukee, WI	228	\$60
	AESYS Technologies, LLC York-Shipley Global	York, PA	155	\$36
	Babcock & Wilcox Company	Lynchburg, VA	8,000	\$1,750
	Caterpillar Energy Products Group	Peoria, IL	101,333	\$44,958
	Chanute Manufacturing Company (Optimus)	Tulsa, OK	160	\$36
	CMI EPTI, LLC	Erie, PA	3,281	N/A
	Deltak	Plymouth, MN	300	\$75
	Emerson Boiler	Peoria, AZ	11	\$6
	English Boiler & Tube, Inc.	Richmond, VA	48	\$8
	Express Integrated Technologies	Tulsa, OK	50	\$32
	G C Broach Co.	Tulsa, OK	N/A	N/A
	Hitachi Power Systems America Ltd.	Basking Ridge, NJ	106,994	\$35,682
	Johnston Boiler Company	Ferrysburg, MI	N/A	\$11
	McBurney Corporation	Norcross, GA	80	\$50
	Steam Turbine Manufacturers	Nooter/Eriksen, Inc.	Fenton, MO	150
RENTECH Boiler Systems, Inc.		Abilene, TX	200	\$115.8
Siemens Boiler Technology Services		Orlando, FL	83,500	\$28,872
Alstom Power		France	76,000	\$21,690
Alstom Power USA, Inc.		Windsor, CT	3,000	\$408
Dresser-Rand		Houston, TX	5,998	\$1,665
Elliott		Jeannette, PA	1,800	\$1,000
General Electric		Fairfield, CT	327,000	\$172,738
Hitachi Power Systems America Ltd.		Basking Ridge, NJ	106,994	\$35,682
Shin Nippon	Tokyo, Japan	368	\$282.7	
Siemens Boiler Technology Services	Orlando, FL	83,500	\$28,872	
Vapor Power International, LLC "Iron Fireman"	Franklin Park, IL	26	N/A	

Component	Company	Headquarters Location	Employees	Sales (USD million)
Generator Manufacturers	ABB (U.S.)	Norwalk, CT	11,250	\$5,247
	Baldor Electric	Fort Smith, AZ	8,083	\$1,824.9
	Elliot	Jeannette, PA	1,800	\$1,000
	Generac Power Systems, Inc.	Waukesha, WI	1,600	\$72
	General Electric	Fairfield, CT	327,000	\$172,738
	Gillette Generators, Inc.	Elkhart, IN	40	\$30.5
	National Electric Coil	Columbus, OH	250	\$39
	Siemens Boiler Technology Services	Orlando, FL	83,500	\$28,872
Condenser & Cooling Tower Manufacturers	Baltimore Air Coil	Jessup, MD	N/A	N/A
	Delta Cooling Towers, Inc.	Rockaway, NJ	9	\$1.7
	GEA Power Cooling, Inc.	Lakewood, CO	20	\$3.8
Steel Piping Manufacturers	ArcelorMittal Tubular Products	Chicago, IL	311,466	\$105,216
	Berg Steel Pipe Corp.	Panama City, FL	247	\$100
	California Steel Industries Inc. - Tubular Products	Fontana, CA	933	\$1,283
	Chanute Manufacturing Company (Optimus)	Tulsa, OK	N/A	N/A
	Independence Tube Corporation	Chicago, IL	241	\$25
	JSW Steel (USA) Inc.	Bayton, TX	7,060	\$3,157.4
	Lakeside Steel Corporation	Ontario, Canada	500	\$142.2
	Lincoln Manufacturing	Magnolia, TX	260	\$52
	Paragon Industries, Inc.	Sapulpa, OK	300	\$82.8
	Roscoe Moss, Co.	Los Angeles, CA	100	\$37.8
	Stupp Corporation	Baton Rouge, LA	265	\$117.7
	Tex-Tube Company	Houston, TX	170	\$75
	U.S. Steel Tubular Products	Dallas, TX	49,000	\$15,873
Wheatland Tube Company	Sharon, PA	500	\$22	
Electrical Component Manufacturers	Mitsubishi Electric America	Cypress, CA	3,700	\$2,300
	Siemens Boiler Technology Services	Orlando, FL	83,500	\$28,872

Fired Prime Movers (Engines & Gas Turbines used in CHP)	Alstom Power	France	76,000	\$21,689.8
	Caterpillar, Inc.	Peoria, IL	101,333	\$44,958
	Cummins Northeast Energy Systems	Dedham, MA	38,000	\$14,340
	General Electric	Fairfield, CT	327,000	\$172,738
	Hitachi Power Systems America Ltd.	Basking Ridge, NJ	106,994	\$35,682
	Kawasaki Gas Turbines- Americas	Houston, TX	2,000	\$1,500
	Solar Turbines (a Caterpillar co.)	San Diego, CA	2,500	\$1,750
	Siemens Boiler Technology Services	Orlando, FL	83,500	\$28,872
	Wartsila North America Inc.	Houston, TX	18,812 U.S.: 400	\$5,852

Source: CGGC, based on company annual reports, company websites, personal communications, and OneSource.

Case Study: Recycled Energy Development (RED)

Westmont, Illinois-based Recycled Energy Development (RED) is a new enterprise whose predecessor companies, including its subsidiary Turbosteam, have developed 250 CHP projects over the past 30 years. These projects involve nearly every thermal-intensive industry, including steel, cement, glass, silicon and petrochemicals, and represent about \$2 billion of capital investment (Recycled Energy Development (RED), 2008). Each of these decentralized power plants is 2-3 times as efficient as the U.S. electric grid. According to company estimates, on an annual basis the projects reduce greenhouse gas emissions by 50 million tons and save the host facilities nearly \$400 million (T. Casten, 2008).

The company's Chairman, Tom Casten, and its President and CEO, Sean Casten, are recognized as leaders in the field of energy recycling. Each has played a significant role in advocating for reforming the nation's energy sector, including by removing the associated regulatory barriers (Bronson, 2009).

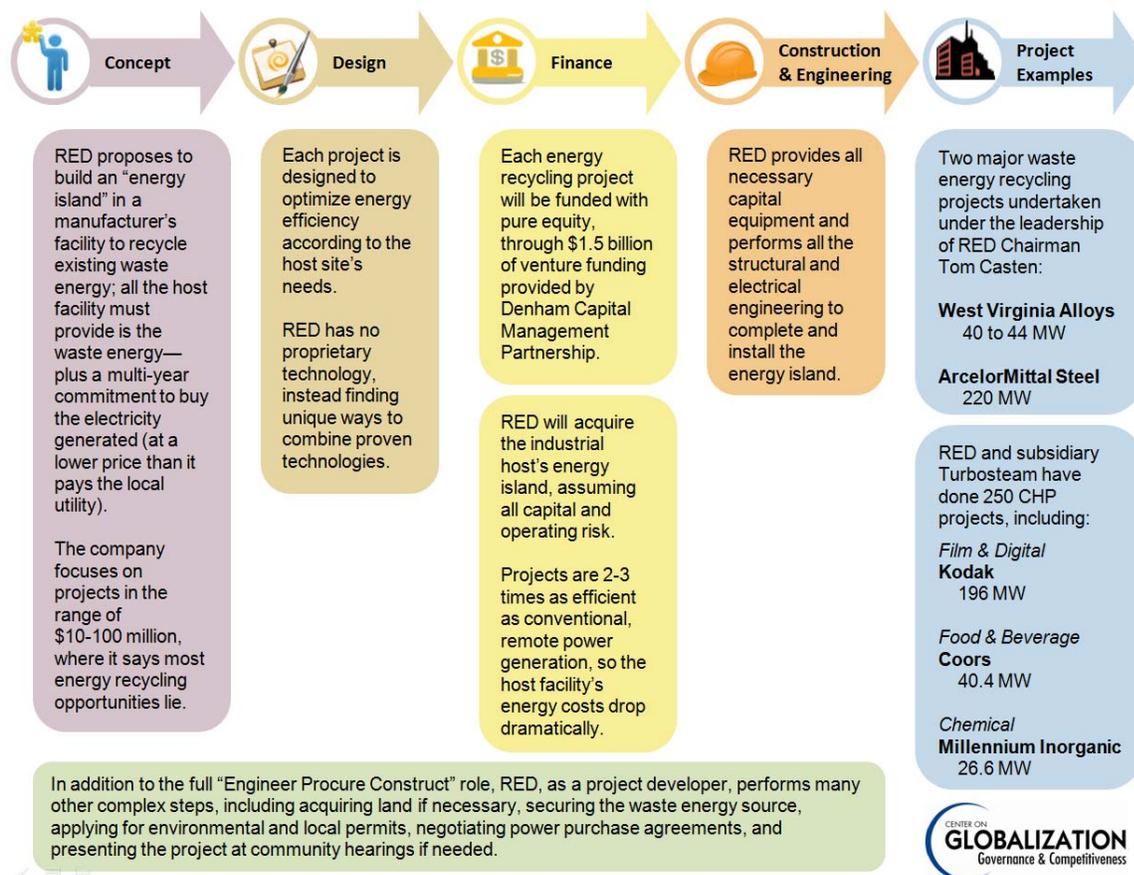
RED seeks to focus its future efforts on developing the potential of recycling industrial waste energy. The company's business model is summarized in Figure 5. The company will approach a large, heat-intensive manufacturing plant and propose to build an "energy island" to recycle the facility's waste energy into electricity. All the host plant must provide is the waste energy. RED will analyze the manufacturing process and devise the concept, then provide the design, engineering, construction, and installation—even funding the project with venture capital from a \$1.5 billion portfolio provided by Denham Capital Management Partnership. The host site commits to buying back electricity from RED for a 20-year period, at a lower rate than the local utility charges. The host site's energy costs thus drop dramatically, and RED and the host split these savings equally, selling any excess to the grid (Recycled Energy Development (RED), 2008).

RED's first energy recycling project developed under its current business structure will be at West Virginia Alloys, a subsidiary of Globe Metallurgical Inc., the largest U.S. independent producer of silicon. The plant uses electric arc furnaces operating at 7,000° Fahrenheit. RED will recycle the plant's exhaust heat into clean energy, providing the following benefits:

- 40-44 MW of clean energy, equal to powering 20,000 homes
- 290,000 metric tons of avoided CO₂, equal to taking nearly 60,000 cars off the road
- Creating 20 jobs in the energy island
- Increasing productivity and stabilizing power costs, thus increasing competitiveness

RED has identified \$100 billion worth of potential energy recycling projects, along with an additional \$250 billion in related CHP. The company estimates that if realized, these efforts could save the U.S. economy \$70 billion per year in avoided energy costs (T. Casten, 2008).

Figure 5. Recycled Energy Development (RED) Value Chain



Source: CGGC, based on RED interviews and RED company website.

Conclusion

Recycling industrial waste energy into electricity offers vast potential for saving energy. It is feasible in any existing thermal intensive industry, using common, traditional technologies. While these projects require considerable upfront capital, they constitute a solid investment by ensuring a steady return thereafter.

Several regulatory barriers stand in the way of wider adoption of waste energy recycling and other forms of CHP. Fully embracing these opportunities will require removing federal and state restrictions on decentralized power production, as well as re-designing government incentives for renewable energy so that important energy efficiency improvements can also qualify.

A scale-up of industrial waste energy recycling would have many U.S. job implications, including jobs manufacturing the needed equipment; jobs building the on-site power plants, including welders, pipefitters, design engineers and construction workers; and jobs operating the power plants. Additional job opportunities can be expected to result from increased international competitiveness, as the industrial host facilities improve their margins through lower energy costs and higher productivity.

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