Recycling energy: How Illinois industry can lead a clean-technology revolution

Facing rising energy costs, Illinois manufacturers increasingly realize the value in the enormous amounts of wasted energy available within their own factories. Ironically, it is manufacturers, long criticized for their pollution, who are leading the charge for clean energy. Their key motivation may be saving money, but the results are making a difference in our environment.

The growing drive for efficient technologies results largely from rising electricity prices, which are likely to double in the next five to ten years. Recent double-digit increases have shocked Illinois, Maryland, and other states that had postponed imposing higher natural gas costs. Fuel prices, in fact, are three to five times their 1999 levels, and further electric price escalations are likely since long-term utility fuel contracts are below spot-market prices.

More ominous are the costs of building new power plants which are needed to replace many of today's units that are well over 50 years old. The expense of constructing a centralized coal-fired power plant has soared from $800 per kilowatt in the late 1990s to as much as $2,500 per kilowatt, largely because of new pollution control requirements, and additional mandates are in the wings. The Environmental Protection Agency's Clean Air Interstate Regulations (CAIR), for instance, are forcing coal plants to significantly reduce their sulfur and nitrogen-oxide emissions by 2009, and the Clean Air Mercury Regulations require substantial emissions reductions from both existing and new coal-fired power plants. Electricity company filings indicate these added pollution controls will cost $550 to $850 per kilowatt of capacity, which often exceeds the plant's original cost.

Not included in this calculus are the costs associated with reducing greenhouse gases to mitigate global climate change. Carbon-restricting legislation is likely, and a moderate $20/ton charge would add two cents/kilowatt-hour to delivered power costs. No doubt the United States and other countries, largely because they adopted scrubbers and other pollution-control technologies, have achieved significant reductions in sulfur dioxide and nitrogen oxides from power plants. Carbon dioxide, however, is different. It simply cannot be scrubbed or cleaned. This greenhouse gas, in fact, is a fundamental result of burning carbon-containing fossil fuels, including coal, natural gas, oil, and propane. Some 40 percent of U.S. CO2 emis-

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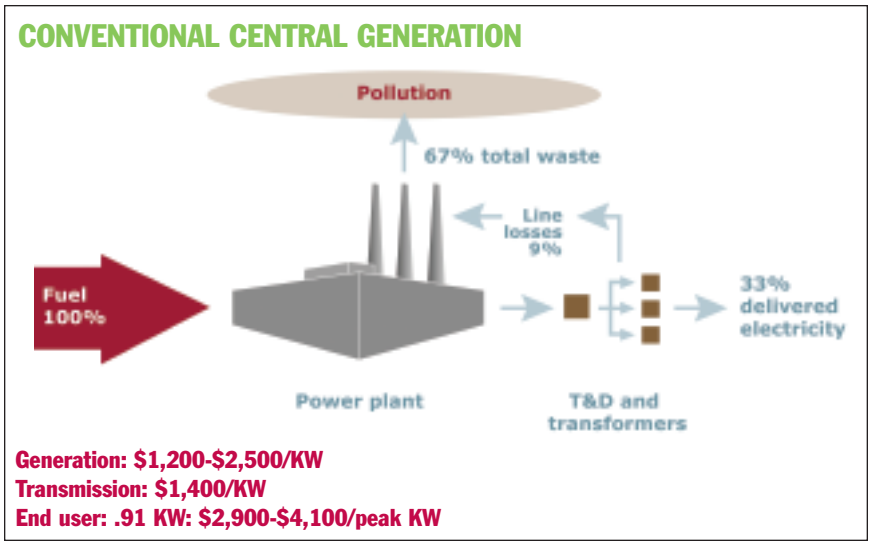

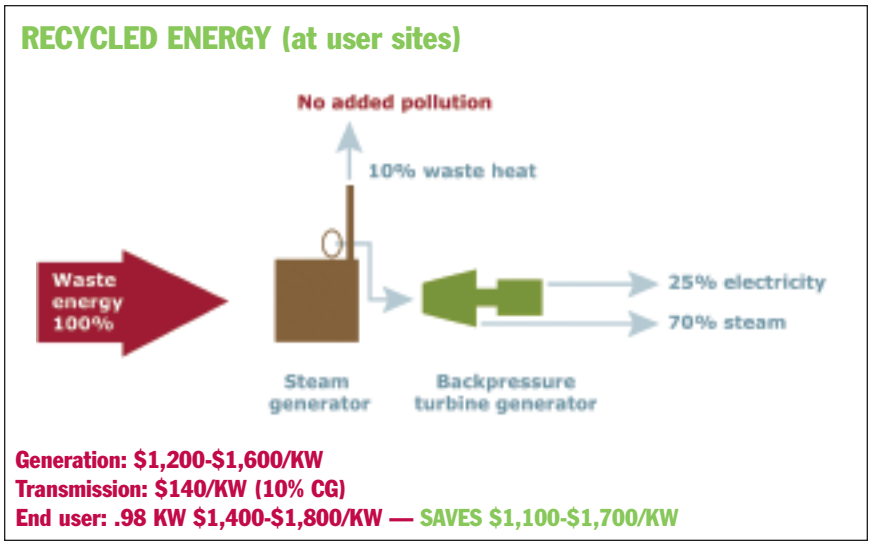

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sions come from electricity generation. Reducing electric use by using more efficient lights and appliances will reduce CO_2 emissions, but the only way power plants can reduce carbon-dioxide emissions is to burn less fossil fuel per kilowatt hour.

Also on the horizon are additional costs for new transmission wires and transformers since today's systems are strained. New power lines, even if they can overcome public opposition, will cost far more than the wires strung only a decade ago.

Higher electricity costs, of course, present both challenges and opportunities. Within the price-conscious industrial sector, fuel and power price increases have accelerated a drive toward energy alternatives, particularly those that manufacturers can control. Industrialists increasingly realize that their manufacturing processes emit substantial quantities of energy that they can be profitably recycled.

Some manufacturers long have obtained both electricity and heat from their processes. The pulp and paper industry, for instance, burns its wood wastes to produce both electricity and useful steam. Dow Chemical has upgraded its combined heat and power (CHP) systems to save, compared to a 1994 baseline, 250 trillion BTUs of energy, equal to the annual household energy consumption of New York City or Tokyo. As part of its effort to cut fuel usage and carbon-dioxide emissions, Dow declares that cogeneration is "significantly more efficient than purchasing power from an outside utility power plant and then separately generating steam." Smart industries use one fire to do two jobs. But what of industrial waste energy?

The Lawrence Berkeley National Laboratory, in a report for the U.S. Environmental Protection Agency, examined 19 clean-energy technologies, ranging from small distributed power systems on farms to large integrated gasifiers at petroleum refineries. The researchers found that recycled energy already provides almost 10,000 megawatts of power, equal to the output of ten large nuclear reactors, and they identified sufficient waste energy for another 96,000 megawatts, enough to provide almost 20 percent of U.S. electricity. This recycling of industrial waste energy would cut carbon dioxide emissions by nearly 400 million metric tons, more than 17 percent of the nation's current output.

Recycled energy projects can be big (several hundred megawatts, with a single megawatt supplying about 500 homes) or small (40 kilowatts). Capital costs also vary, ranging from $300 per kilowatt for back-pressure steam turbines to more than $1,800 for certain steam-turbine plants. Even the highest construction costs are still below the costs per kilowatt of capacity from a new coal-fired unit, and the distributed generator requires no transmission wires, and, if utilizing free waste energy, no additional fuel.

In addition to recycling industrial waste heat, more clean-energy opportunities exist to capture the vented heat from most electricity generators. This thermal energy can displace the fuel burned in separate boilers and supply water heating, space heating, and absorption cooling. These cogeneration, or combined-heat-and-power, units also can provide the steam needed for several industrial processes.

Capturing such heat from electricity generation requires a shift away from centralization. Since low-temperature heat cannot be transported economically over long distances, heat recycling requires smaller, on-site electric generation plants. These local units may be smaller than central plants, but are not toys. They use the same technologies, only smaller steam boilers, steam turbines, gas turbines. The shift to local generation, however, offers enormous fuel savings. Recycling half of the heat currently thrown away by fossil-fueled central generators would save more than 15 percent of the nation's fossil-fuel consumption and greenhouse-gas emissions substantially.

Other benefits abound. By providing electricity close to the users, recycled energy plants reduce transmission-line losses as well as the need for additional wires. These facilities improve industrial competitiveness by reducing industrial energy costs and creating the potential to sell excess power and obtain new revenue streams. By reducing pollution, recycled energy saves public-sector costs associated with health care and environmental protection. Such dispersed generation, moreover, increases power reliability and helps to stabilize the grid.

Such a shift to decentralization is possible, as demonstrated by Denmark, which over the past two decades raised cogeneration's share of total electricity production to more than 50 percent. Netherlands, Finland, and Russia also have substantial cogeneration, while several other developed countries – including Germany, Poland, Japan, and China – have CHP rates more than twice those in the United States. Denmark's transition required no new technologies, but simply used smaller applications of the technologies used in central generation, and then capture and utilize the wasted energy. Even nuclear reactors can recycle their waste heat, as evidenced by the fact that all nuclear-power submarines and aircraft carriers use wasted reactor heat to warm and cool the ships.

The concentration of cogeneration has much more to do with policy than any mix of energy resources and users. Regulators in California and Hawaii, for example, have worked to open the market to entrepreneurs, and each produce more than 20 percent of their power from cogeneration plants. South Carolina, in contrast, has no CHP units because it maintains many old laws, including one that makes it illegal for an entrepreneur to sell power, even to a manufacturer on whose property the generator sits.

The limits of power-plant centralization

The U.S. power system is less than optimal. The status quo, in fact, is not sufficient for the 21st century digitalized economy that demands efficiency and reliability. The average generating plant – built in 1964, using technology from the 1950s – suffers an efficiency rate of only 33 percent, meaning that for every three "lumps" of fuel, it provides only one "lump" of electricity. This inefficiency largely results from

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power plants being centralized, located far from consumers, and unable to utilize wasted heat.

No doubt it remains cheaper on a per-kilowatt basis to build one large centralized plant rather than many smaller dispersed power plants. Yet initial capital costs of generation are only part of the equation. Since transmission lines are in short supply, new centralized power will require new high-voltage wires, which cost some $1,380 per kilowatt of capacity (ironically, more than power generator itself). New on-site generation, in contrast, avoids most transmission and distribution costs by delivering power directly to local customers. Dispersed projects also avoid most of the line losses – which average 9 percent but can reach 20 percent during peak periods when lines are loaded – associated with high-voltage lines.

Today's transmission and distribution system, in fact, loses substantial electricity, averaging 9 percent but reaching 20 percent during peak periods when wires are loaded. Most of the problem results from remote generation having to transform its electricity to high voltages (requiring capital and losses) in order to allow the use of smaller copper wires for the tall transmission lines that cross the landscape. When the high voltage reaches a city or other large load center, it is transformed back down to medium voltages (requiring more capital and losses). Then distribution wires carry the power up every street and feed smaller transformers, often mounted on the electricity line poles, which transform the power to user voltages to power hair dryers and other appliances.

By contrast, local generation can feed power directly to the industrial user, freeing the system described above, and it can feed excess power into the distribution system, avoiding several transformer steps, as well as avoiding capital and losses. Excess locally-generated power, in fact, can be transformed backwards in existing transformers and fed into the larger grid. Since all power flows to the nearest user, regardless of contract, local power generation cuts losses.

Policy lags technology

Policymakers long have ignored industrial waste as an energy source. It's been a bipartisan habit. Republicans tend to assume the premise that free markets fix all inefficiencies, while Democrats get distracted by the shining promises of wind turbines or solar cells. Even when rival politicians agree about the need to clean up coal-fired power plants, both camps express almost a blind faith in new and unproven technologies – such as sequestering carbon deep within the earth. Few confront the basic issues of how flawed policies create technical and financial inefficiency.

Even most environmentalists ignore industrial efficiency, preferring instead to focus on solar and wind technologies. No doubt these and other renewable energy sources are carbon neutral and reduce dependence on fossil fuels. Yet since it's obviously bad for the environment to waste two-thirds of every coal mine, the terms of the policy debate need to broaden.

Faced with rising electricity costs, manufacturers increasingly see their wasted energy as a revenue stream, and they have moved to the forefront of clean-power development. Global warming, as Al Gore notes, is a reality we would rather not face, yet the convenient truth we need to recognize is this: Energy recycling profitably mitigates climate change. Recycling already provides substantial power and can generate 20 percent of U.S. electricity without burning any additional fuel or emitting any additional pollutants or greenhouse gases. Cogenerating heat and power also produces electricity with half the fossil fuel of conventional electricity generation.

Policy needs to catch up with technology. Lawmakers and regulators must recognize that today's energy system is not optimal, and that enormous opportunities exist for efficiency gains. They must encourage manufacturers and entrepreneurs to "mine" industrial waste energy. ■