



Risk in Perspective

Reducing Risk By Conserving Fuel and Recovering Wasted Heat



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When policy makers make decisions that alter the selection and amount of fuels used by industry to produce goods, they also alter risks to public health, safety, and the environment. This phenomenon, which often goes unexamined in regulatory decisions, reflects the fact that the use of fossil fuels, America's major source of energy, is an important source of risk to people and ecosystems. Although these energy-related risks are sometimes regulated, they are often not fully reflected in the prices of fuels and electricity faced by consumers in the marketplace. Therefore, policy makers need to make special efforts to ensure that energy-related risks are considered in decision making.

In this issue of **RISK IN PERSPECTIVE**, we describe the roles that heat integration and fuel recovery from waste play in reducing consumption of fossil fuels thereby reducing energy-related risks. By examining the risk tradeoffs associated with burning hazardous waste as a source of fuel, we discuss how well-intentioned regulatory proposals aimed at reducing risk may inadvertently increase risk by failing to account for energy implications. We argue that policies that penalize heat integration and fuel recovery from wastes should be questioned unless the magnitude of changes in energy-related risks are considered. Although imperfect, this kind of risk-tradeoff analysis is feasible given currently available data and methods.

Heat Integration and Fuel Recovery as National Objectives

Almost 25 years ago, the quadrupling of oil prices by the Organization of Petroleum Exporting Countries (OPEC) sent shock waves through the U.S. economy as our nation's dependence on foreign oil collided with our increasing demand for fuel. This caused an immediate recognition of the importance of heat integration in industrial processes. Chemical engineers took advantage of opportunities to bring hot substances that needed cooling into indirect contact with cooler substances that needed heating so that the heat exchanged between the two substances decreased the net fuel requirements for production processes. Although investments in heat integration typically are made on economic grounds, they may coincidentally offer risk-reduction benefits because they offset additional fossil fuel consumption.

This type of integration may also be possible at a community level as has been demonstrated by the integration of four process industries in the Danish town of Kalundborg. In this town the "waste" steam, which remains after coal is burned to produce electricity, is piped to homes and industries in the town and used for heating. This heat use offsets the consumption of thousands of tons of oil and reduces the thermal load to the water supply. This type of integration occurs to some degree between U.S. industries (where industries now use or

sell for fuel the "waste" natural gas they previously burned as flares), but its full potential is probably unrecognized and will remain so until the resource value of waste is recognized.

In the United States, approximately 280 million tons of hazardous waste were generated in 1995. Most of it was in the form of wastewater that had to be treated. However, some organic wastes that have high fuel values are considered hazardous, in part because they are combustible. Currently, less than 3% of the hazardous waste generated each year is burned, and most of this occurs in industrial incinerators and boilers. These wastes vary in composition with respect to their carbon, hydrogen, water, metal, and halogen contents; and some of them are better sources of fuel than others. If these wastes are going to be burned, it makes sense to look for ways to recover the fuel values stored in them and to use this energy to reduce the risks associated with using other energy sources.

Although this type of recovery is already occurring at some kilns that make cement and lightweight aggregate, opportunities may exist to recover even more.

Why Bother Recovering Fuel Values from Waste?

Since the 1970s, the U.S. has increasingly recognized the adverse human and ecological consequences of fuel production and use, and has appreciated that energy-related risks can be changed in character but cannot be avoided by simply shifting from one energy source to another. Extracting nonrenewable fuels from the earth (e.g., mining coal or uranium and drilling for oil) and harnessing renewable sources (e.g., building dams and making photovoltaic cells) lead to significant occupational hazards and diseases. Interestingly, comparative risk analyses have relatively similar numbers of deaths and workdays lost to nonfatal injuries for different energy industries. These analyses normalize overall risk by units of energy and account for hazards associated with facility construction, operation and maintenance, and fuel

acquisition and transport. Considering current fuel consumption, these studies suggest that there are on the order of 1,000 deaths and 1 million workdays lost per year in the U.S. associated with occupational risks in energy industries.

Non-occupational risks and ecosystem damages can also result from transporting fuels and electricity to end users, using the fuels and electricity, and handling the wastes. Accidents associated with transporting coal or oil contribute to the total number of vehicle-related injuries and fatalities, and can lead to ecosystem damages in the case of spills. Burning fossil fuels in automobiles, factories, and power plants leads to emissions of gases and particles into the air that contribute directly to human health risks and local environmental effects, while also contributing to regional environmental concerns and the possibility of global climate change.

Although scientific uncertainties impede our ability to measure many of these energy-related risks with precision, it seems clear that increases in fuel and electricity consumption lead to increases in the risks to public health, safety and the environment. Ideally, an economist would like to see these energy-related risks "internalized" into the prices of fuel and electricity observed in the market place. In reality, however, energy-related risks are "internalized" only imperfectly through the multitude of environmental and safety regulations implemented by different agencies. Some of the most powerful rules aimed at reducing health and environmental risks govern what facilities may emit into air or water and what they may do with their material and fuel wastes. Unfortunately, these rules are fragmentary and are subject to uneven degrees of enforcement over time and around the country. In general, energy-related risks are typically overlooked, even though explicit consideration of them might change decisions about what regulatory strategy actually produces the largest health, safety, and ecological benefits.

An Example: Burning Hazardous Wastes as Fuels in Cement Kilns

The production of cement and light-weight aggregate requires consumption of large amounts of fuel to heat the raw materials required to convert them into cement. Due to the nature of the production process, kilns can burn some hazardous wastes as fuels (those with high fuel values, low water content, and low concentrations of halogenated substances and metals). Burning these wastes provides a way to simultaneously destroy the waste and reduce the kiln's consumption of other types of fuels. Some kilns currently do this as a commercial venture, and it reduces the cement industry's annual fossil fuel consumption by the equivalent of approximately 1 million tons of coal or 170 million gallons of oil.

Producing cement also results in the emission of gases and particles into the air and in the generation of wastes from the kiln, so-called cement kiln dust, that may pose risks to human health and the environment. As with other industries, there is pressure to eliminate or reduce the emissions and wastes from kilns.

Regulatory Options for Reducing Risk from Cement Kilns

Consider the general question of how a regulatory agency should limit the amount of air pollution from a cement kiln that is burning a mix of coal and hazardous waste as fuel. Although emissions of sulfur oxides, nitrogen oxides, carbon monoxide, particulates, and some metals may be greater when coal is used, and emissions of halogenated compounds and other metals may be greater when hazardous wastes are used, we assume that the risks from air emissions are similar for both fuels. This assumption appears reasonably valid given the ranges of existing emissions data from the industry for sources burning hazardous waste and for those not burning hazardous waste.

A common regulatory approach is to examine the technological control strategies available to the cement kiln opera-

tor and compel adoption of those controls that are feasible and will achieve the maximum amount of emission reduction for some or all of the emissions. This type of approach typically assumes that the mix of fuels used by the kiln would not change, and it would require that all kilns use control technology such that they perform as well as the best-controlled kilns in the industry.

A different approach, which is strongly advocated by some groups, might be to establish health-based limits for each type of pollutant emitted by the kiln and force the kiln operator to meet each of these limits. This approach typically does not consider what is technologically achievable and affordable.

In either of these cases, the control requirements might change the relative costs of operating the kiln using coal alone compared to operating it with a mixture of fossil fuels and hazardous waste. If the kiln responds by reducing the ratio of hazardous waste to coal in the fuel mix, the risk reduction benefits of the kiln's lower fossil fuel consumption will be lost. Under these circumstances, the reduction in risks from reduced air emissions at the kiln (if there are any under this circumstance) will be partially offset or even overwhelmed by the increased risks from additional mining and transportation of coal. In addition, one must also be concerned about the alternate disposal of the hazardous waste. If it is burned in an incinerator, then additional risks may be associated with building the incinerator (if insufficient capacity were to exist), fueling the incinerator (since it may also require the use of some fossil fuels), and with the emissions resulting from the combustion of the waste.

A very different approach would be applied by a regulator who strives to minimize *net risks* as an objective and who understands the importance of energy-related risks. This regulator might create a form of regulatory incentives for firms that reduce risks by burning wastes instead of fossil fuels, or might apply air emission rules differently

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FURTHER READING

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for kilns to encourage the use of hazardous waste as a fuel source.

If the risks associated with mining and transporting coal are already captured in the price of coal, there is no theoretical case or need for such regulatory incentives. Although such risks are regulated to some extent under existing federal and state laws, it is doubtful that such regulations cause complete "internalization" of risk into the market price of coal.

In this example, it is certainly true that the people and ecosystems affected by the kiln's air emissions will generally be different than the people and ecosystems impacted by the mining and transport of coal. However, it is not necessarily appropriate to make this comparison since the hazardous wastes will be disposed of or destroyed as described above. Any risk transfer that occurs regarding handling of the wastes would be from the community near the incinerator to the community near the kiln, a transfer that has no obvious injustice associated with it.

A potentially valid objection to creating regulatory incentives for the kilns would be that a waste-management competitor to the kilns might offer cleaner processes for handling the hazardous wastes, thereby creating a risk preference for diverting the wastes away from the kilns. If such a cleaner alternative were available, the regulator would need to weigh the superior waste management against the risk-prevention benefits associated with reduced consumption of fossil fuels by the kiln.

A general policy interest in minimizing the generation of hazardous wastes at the source is not at odds with the case for the regulatory credit. Lowering the disposal costs for generators whose wastes can be used for fuel can be

expected to undercut incentives for waste minimization, but also to increase compliance and the likelihood that the waste will be properly managed. Even under the best of circumstances for waste-minimization advocates, there will be some amounts of hazardous waste produced in a modern industrial economy for the foreseeable future. Whatever the optimal amount of hazardous waste generation may be, it is important that the wastes that are generated be handled and regulated with energy-related risks in mind; and opportunities to divert even more waste to kilns or other large fuel-consuming sources should be considered.

Conclusion

There is a compelling case in risk-prevention for policies that promote heat integration and fuel recovery from wastes. This policy argument should not be used as a trump card to defeat all other policy considerations, but it is important enough to consider seriously in a wide range of regulatory decisions. The cement kiln example illustrates that the energy implications of alternative policy choices need to be carefully considered. Regulators should strive to provide cement kiln operators with incentives to reduce the net risks associated with meeting national demands for cement.

It may be decades in the future before the adverse health and environmental effects of energy production and use are fully reflected in the observed market prices of fuels and electricity. We are certainly not in a position today to know exactly how to optimally regulate each source of energy. We can, however, take incremental steps that promote the risk-prevention benefits associated with diminished needs for fossil fuels.