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Project Summary

Cogeneration: Status and Environmental Issues

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The purpose of this project was to determine the planned cogeneration development by the utility and industrial sectors; to assess the environmental impacts and energy savings from cogeneration; and, to identify potential environmental issues associated with cogeneration development. Major emphasis was placed on environmental impacts. The study investigated the energy savings and environmental impacts of five industrial facilities which are considering a switch to in-plant cogeneration. Potential regional environmental impacts of cogeneration development in New England, the Tennessee Valley Authority service area and northern New Jersey were investigated. Finally, the environmental impacts of a cogeneration-based district heating system were considered. It was found that there are a number of factors which determine the relative magnitude of environmental impacts of a cogeneration system compared to a conventional energy supply system. These include fuel type, control technology efficiency and the type of power source used. As a result, each cogeneration system must be considered separately. Generally, it was found that the most significant environmental impacts were changes in air emissions; these increased on-site, but usually were reduced on a region-wide basis.

This Project Summary was developed by EPA's Industrial Environmental Research Laboratory, Cincinnati, OH, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Introduction

This study examines the potential environmental impacts of cogeneration during the next two decades. Cogeneration, the simultaneous production of thermal energy and electrical power, has been the subject of extensive studies since the mid-1970's. It has the potential for significant energy savings for in-plant power production, industrial energy parks, and district heating systems.

The objectives of the current study were to:

- Determine the status of planned cogeneration development by the utility and industrial sectors.
- Assess the energy savings and environmental impacts from cogeneration
- Identify potential environmental issues which may impact cogeneration development.

From this investigation, several areas warranting further study were identified.

The major emphasis of this study is on environmental issues. A considerable amount of information is available on the technical, economic, and institutional issues associated with this technology, and those areas are briefly discussed.

The final report upon which this summary is based, describes the research and development contributions of utility, industrial, and government agencies and personnel to cogeneration; previous studies dealing with cogeneration and a thorough review of literature on the subject are also detailed in the final report.

Because industry has the best near-term potential for utilizing cogeneration, a review was made of five major studies which project cogeneration development in the industrial section over the next 15 to 20 years. The review included combustion technologies currently available or planned for cogeneration, along with a survey of non-environmental constraints which might impede cogeneration systems development.

The environmental impacts of proposed cogeneration facilities and of conventional power generating facilities were analyzed. The environmental impact analysis estimated waste residuals emitted by cogeneration facilities and compared them to residuals from conventional power generation systems. In this part of the study emphasis was on air emissions; water effluents and solid waste residuals were also estimated.

The environmental impact analysis covered five proposed site-specific facilities, and industrial park, and three studies of regional cogeneration development. The results of a case study on district heating development are also reported. The site-specific analyses were made in five energy-intensive industries: chemicals, textiles, food and kindred products, petroleum refining, and pulp and paper production. In the industrial park study thermal energy was received from a nearby utility power plant. Two of the three regional studies examined industrial cogeneration in utility service areas: the Tennessee Valley Authority and the Public Service Electric and Gas Company in northern New Jersey. The third regional study investigated the potential for the use of cogeneration in commercial establishments in New England, with emphasis on development in Massachusetts. The district heating case study considered the development of such a system in Minneapolis-St. Paul.

The project developed a simple model for estimating the national energy savings that could result from expanded cogeneration. Recommendations were also made for future research on the environmental impacts of cogeneration development.

Status of Cogeneration

Cogeneration systems are identified under three general categories: in-plant systems, industrial complexes, and district heating systems. In-plant cogeneration systems produce process steam and electricity which are used on-site; any excess electricity generated may be sold to a utility. Industrial complexes consist of a large, central power plant (often utility-owned) which supplies electricity to a grid and process steam to nearby industries. Industrial cogeneration systems must be within 2 or 3 kilometers of the power plant to keep piping costs low. District heating systems typically utilize a large electric generating power plant which simultaneously provides hot water for space heating and cooling to residential, commercial, and industrial buildings that are usually within 10 or 20 km of the generating plant.

Renewed interest in cogeneration technology over the last several years is a result of known benefits of this technology. For example, overall energy-use efficiencies as high as 85% have been obtained with cogeneration systems, compared with 30-35% for conventional systems which provide only electricity. Cogeneration systems can reduce fuel consumption, often with reduced pollution emissions. Economic benefits arise from reduced capital and operating costs.

Some disadvantages have also been identified: increased local pollution around the cogeneration plant site, and the need for scarce fuels such as oil for small cogeneration systems which utilize diesels.

Steam turbines, gas turbines, and diesel engines are the most common combustion devices currently used in cogeneration systems; and probably will remain so in the near term (mid-1980's). Probably, by the end of this decade fluidized bed combustion will be available. In the 1990's, fuel cells and Stirling engines may be commercially feasible.

Energy Savings

Estimated energy savings from cogeneration have ranged from between 0.60 to 1.83 quads for 1985, depending upon which industries have been included in the estimates, to between 1.33 and 3.65 quads by 1990. Much of the energy savings will be in the form of residual oil, distillate oil, and natural gas replaced by coal and process residuals. The industries in which the major energy savings are expected to occur are petroleum refining, chemicals, pulp and paper, food, and textiles.

Although a few utility companies in the U.S, (e.g., Gulf States Utilities Co., Texas; Public Service Electric and Gas Co., of New Jersey) have been cogenerating for decades, cogeneration accounts for only a small portion of electricity production nationally. Several studies have assessed the potential for cogeneration in selected regions of the United States. In the Tennessee Valley Authority service area, an estimated annual savings equivalent to 1.8 to 6.2 million barrels of oil could be achieved in the 1989-1998 time period with an aggressive program to increase cogeneration operations. Likewise, in the New England area, savings estimated at 3.85 million barrels of oil per year in Massachusetts or 10.1 million barrels per year throughout the region, could be realized by the mid-1980's.

Environmental Impacts

A number of factors determine how the environmental impacts of a particular cogeneration system differ from those of a conventional energy supply system. The influence of some of these factors will vary depending upon which of the three types of generic cogeneration systems is under consideration; other factors will have similar effects on all three systems. It is important to note, however, that the *magnitude* of environmental impacts is very site-specific for cogeneration and therefore each proposed facility should be considered on a case-by-case basis.

When cogeneration is being considered as an energy-conserving replacement, the fuels to be used in the cogeneration system must be compared with those used in an existing, conventional energy system. Many future cogeneration systems will employ coal in a new fossil-fueled boiler. Unless highly efficient pollution control equipment is employed in such cases, on-site emission rates will be higher. The same is true when wood or municipal wastes are used in the cogeneration system. Since all three of these "dirtier" fuels require more efficient pollution controls and generally have a higher ash content than oil or gas, their use usually results in a higher production of solid waste and wastewater

Even if there is no fuel change or no boiler modification, a net increase in emissions at the site of the cogeneration system combustion unit will result because the boiler firing rate will have to be increased to accommodate the additional load from either steam withdrawal or electricity production.

The relative efficiency of pollution control devices used on system combustion technologies also will affect the *net* change in emissions. However, conversion to cogeneration is often not covered by existing environmental regulations. Most in-plant cogeneration units are so small that they are not covered by current New Source Performance Standards (NSPS). Also, changes in the load factor of an existing boiler are exempt from Federal Prevention of Significant Deterioration (PSD) or nonattainment regulations, although they may be covered by state permits.

The analyses of five proposed in-plant cogeneration systems indicated that onsite air pollution emissions would increase for each plant. In two cases, associated reductions in utility emissions due to reduced fuel use are projected to offset the increases in cogeneration plant emissions. Whether solid waste and wastewater effluents will increase or decrease with cogeneration depended upon the degree of pollution controls on either plant, as well as the type of fuel switch. Thermal water pollution is expected to decrease in all cases because of reduced load on utility plants.

Analysis of an industrial park configuration showed net decreases in particulate, SO_2, and NO_x emissions of 34%, 11%, and 27%, respectively. Reductions in waste heat releases also occurred. However, there were increases in suspended solid effluents and in the amounts of solid waste generated. The environmental effects of an industrial park are highly site-specific and depend upon the number and types of plants within the park, steam/heat demands, and the types of fuel used by each of the industrial plants.

The district heating case study examined in this project indicated that environmental benefits result in the form of reductions in sulfur dioxide concentrations and thermal effluents. Ambient SO_2 concentrations decreased despite the fact that there was a net increase in source SO_2 emissions due to oil and gas being replaced by coal. Thermal effluents decreased because waste heat was being used for space heating, instead of being ejected to the environment. However, water pollution and solid wastes increased with addition of the pollution control system and process requirements in the heating plants. From residential units there are virtually no releases of these pollutants.

Analysis of the cumulative impacts of developing utility and industrial cogeneration throughout a region showed important environmental benefits. Table 1 indicates the annual emission reductions attainable from utility and industrial cogeneration of varying amounts of electrical power in the Tennessee Valley Authority (TVA) service area. Coal characteristics for the Widows Creek Station were chosen to determine emissions changes. Cogeneration of 1865 MW of electricity represents approximately 16 percent of the theoretical cogeneration potential in the TVA region.

The near-term (mid-1980's) potential for cogeneration has been predicted to be 644 MW in Massachusetts and 1683 MW in New England. Utility residual fuel oil is displaced by distillate oil used for cogeneration at commercial sites. Emissions from cogeneration systems may cause localized sulfur oxide and nitrogen oxide problems, but substantial net reductions in regional emissions would occur. These net reductions in emissions would be on the order of 10,000 tonnes per year. Changes in carbon monoxide, hydrocarbon, and total suspended particulate emissions would typically be one to two orders of magnitude smaller.

Environmental Issues

The final report identifies two environmental issues raised by cogeneration use. System developers believe that the costs of meeting stringent air pollution control regulations, particularly in nonattainment areas, will significantly reduce the economic benefits of cogeneration. Local air quality control agencies believe that the use of diesel engines and gas turbines in urban areas may result in significant increases in nitrogen oxide and particulate emissions because these sources may not be adequately covered by current emission regulations.

Recommendations

The study recommends the following research should cogeneration, as expected, have significant market penetration in the coming decade.

Develop an Environmental Data Base Specific for Cogeneration Systems

The development of an environmental data base would facilitate the ability of the Agency to communicate regulatory policies to cogeneration developers and would provide an up-to-date assessment of this expanding energy supply technique. Potential users of cogeneration systems could employ this information to assess potential impacts and regulatory policies that have to be considered when such systems are installed. Emerging energy technologies, as well as conventional power sources, should be included in this data base.

Increase Effort in Pollution Reduction Techniques for Small Combustion Devices

As a result of uncertainties associated with future supplies of oil and gas, many industrial firms have increased the use of coal and other fuels, such as wood and municipal wastes. The use of these fuels in small combustion devices is often impractical because of the expense of currently available pollution control equipment. The development of suitable control technologies/methods for small combustion devices will allow the utilization of these fuels with minimal environmental impact.

*Table 1. Emission Reductions from Cogeneration in the TVA Region**

Cogenerated Electricity, MW(e)	Emission Reduction, Megagrams/Year (Tons/Year)		
	TSP	SO_x	NO_x
530	486 (536)	7,015 (7,737)	3,820 (4,213)
1080	970 (1,070)	14,025 (15,468)	7,635 (8,421)
1865	1,675 (1,847)	23, 375 (25,670)	13,155 (14,508)

**Coal Characteristics: Sulfur: 3.7%*
Ash: 25%
Heat Content: 23.2 megajoules/kilogram (10,000 Btu/lb)
Control Efficiency: 80% for SO_2, 99.5% for TSP
(Note that since this study was completed, regulations have been revised to require 90% SO_2 removal.)

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The complete report, entitled "Cogeneration: Status and Environmental Issues," (Order No. PB 84-155 175; Cost: $11.50, subject to change) will be available only from:

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