

ATTACHMENT A5
TENNESSEE VALLEY AUTHORITY
“THE ROLE OF RENEWABLE ENERGY IN REDUCING GREENHOUSE GAS BUILDUP”
SEPTEMBER 2003

Tennessee Valley Authority

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Greenhouse Gas Buildup”**

September 2003



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The Role of Renewable Energy in Reducing Greenhouse Gas Buildup

As a result of human activities, greenhouse gases (GHG) are increasing in the earth's atmosphere. Many in the scientific community now believe that this increase of carbon dioxide (CO₂), methane (CH₄), and other GHG is causing the earth's temperature to rise, and that this increase in GHG will lead to even greater global warming during this century. However, significant scientific disagreement still exists regarding the relative importance of anthropogenic GHG emissions versus natural variability in climate as the cause of these temperature changes.

To address this uncertainty, the Bush Administration, in 2002, proposed increased funding for scientific research on the impact of anthropogenic GHG emissions on climate change and on GHG reduction and sequestration technologies. Also, the Administration announced the Global Climate Change Initiative, with the goal of reducing the U.S. GHG intensity by 18 percent over the next 10 years. To minimize the potential impact on TVA, various types of GHG mitigation technologies are being evaluated to determine costs, impacts on the system, timing of implementation, and any additional environmental benefits. One strong option is to increase the use of renewable energy in electric power generation.



Figure 1. TVA wind turbines on Buffalo Mountain near Oak Ridge, Tennessee.

What is Renewable Energy?

Electricity produced from wind (Figure 1), solar, or geothermal sources, biomass energy conversion systems, and increases resulting from modernization of hydroelectric systems (HMOD) generally are considered renewable energy. Biomass energy systems encompass a wide range of sources, including dedicated energy crops, wood waste, landfill gas, digester gas, animal waste, and municipal solid waste. However, what qualifies as a renewable energy source varies among private and governmental organizations.

How Does Renewable Energy Reduce GHG Emissions?

Unlike the combustion of coal, natural gas, and distillate fuel—which produces carbon dioxide—wind, solar, and hydroelectric energy

systems emit no GHG because their fuel or energy source is carbon-free. Thus, the amount of GHG emitted into the atmosphere can be reduced only when fossil-fuel generation is avoided or replaced by renewable systems or other non-GHG-emitting electric generation systems.

Although biomass energy systems utilize combustion and do produce carbon dioxide emissions in producing electricity, these emissions are considered “carbon dioxide neutral.” The carbon dioxide in these emissions is not considered to increase the amount of GHG in the atmosphere because the carbon dioxide was removed from the atmosphere by plants within the very recent past as part of the natural global carbon cycle. Also, if not used for electricity generation, the biomass would have decayed, thus emitting an equivalent amount of carbon dioxide to the atmosphere. In contrast, coal and other fossil fuels contain carbon that has been “locked-up” for millions of years. Therefore, when fossil fuels are used to generate electric power, carbon dioxide that has been locked away and otherwise would not have been emitted is added to the atmosphere. Thus the use of biomass as an energy source reduces the amount of “fossil” carbon dioxide that is emitted to the atmosphere by displacing fossil fuels.

Co-firing wood waste with coal reduces the amount of methane that is emitted into the atmosphere. Wood waste, if disposed in a landfill, would decay and emit methane from the decomposition of the organic matter. Methane is a potent GHG that, pound-for-pound, has 21 times the impact of carbon dioxide on global warming. Therefore, significant GHG reductions can be achieved from co-firing wood waste with coal.

Landfill gas energy systems also reduce GHG emissions by combusting the methane that is generated within the landfill. Carbon dioxide is emitted from the combustion of the methane, but, as discussed above, this carbon dioxide comes from biomass sources that are considered carbon dioxide neutral. Therefore, using landfill gas to produce electricity reduces GHG emissions in two ways: (1) by destroying methane, and (2) by using it as a fuel to displace carbon dioxide emissions from fossil fuel combustion.

Renewable Energy Resources in the Valley

A preliminary study by TVA’s Renewable Energy Team concluded that approximately 3,000 MW-equivalent of energy—from wind, HMOD, bioenergy (wood waste, energy crops, and landfill gas), and solar energy—exist within and directly adjacent to the TVA service territory. However, at present, less than 30 percent of this is cost-competitive with TVA’s generation mix. But technology improvements over the next 15 years are expected to lower the cost of electricity produced by renewable energy systems.

Biomass. Biomass is the largest renewable energy resource in the Tennessee Valley. Approximately 11 million tons of wood waste (mill residue, forest residue, and urban wood waste) is generated each year. Also, studies project that approximately 10 million tons of

switchgrass, a native, high-yielding grass, could be grown annually as an energy crop in the TVA service area. Combined, these could produce an energy equivalent of approximately 900 MW in the TVA service territory. However, the cost of switchgrass and other energy crops currently is almost twice the cost of coal on a Btu basis. Furthermore, the lack of adequate infrastructure, along with transportation and handling costs, are primary obstacles when considering the economic and technical feasibility of this renewable energy source.

Wind. Approximately 800 MW of wind capacity energy is available within 5 miles of the TVA service area. Since the average capacity factor for wind energy systems in the Valley is about 25 percent, the 800 MW of wind capacity is equivalent to only 267 MW of fossil capacity.

HMOD. It is projected that modernization of TVA's hydroelectric generating facilities will increase the total hydro capacity by 750 MW.

Landfill Gas. The installation of waste-to-energy systems at municipal landfills can provide significant GHG reductions; however, the capacity of the system, existing electrical infrastructure, and the age and projected life of the landfill must be taken into account when considering such systems. Electricity also can be produced from methane generated at wastewater treatment and animal waste treatment facilities. In 1999, it was estimated that a total of 150 MW of landfill gas energy capacity exists in the TVA service territory. However, only about 70 MW of that was considered economically viable.

Solar. Although a considerable amount of solar photovoltaic (PV) capacity exists in the Valley—roughly 400 MW of capacity—the large land requirement and high capital cost of solar PV systems make them a non-viable renewable energy source at the present time.

GHG Reduction Costs

Although renewable energy systems produce little or no GHG emissions, the electricity produced by these systems typically costs more than electricity generated from fossil, hydroelectric, and/or nuclear power plants. The higher cost is the result of higher capital and fuel costs and the availability of the energy source.

Figure 2 reveals the range in generation costs (dollars per kilowatt hour) and GHG reduction costs (dollars per ton of carbon dioxide-equivalent) for HMOD, wood waste co-firing (with and without assuming methane reductions), landfill gas, and wind energy systems. As the graph indicates, HMOD has the lowest generation cost, and wood waste co-firing and landfill gas energy systems can generate electricity at a lower cost than wind. Solar PV is not shown because of the very high generation costs associated with this system—from 35 to 60 cents/kWh.

The cost per unit of GHG reduction from renewable energy sources is lowest with wood waste (with methane reduction) and landfill gas. The lines in the graph depicting these two energy systems exhibit different slopes than the other systems because their reduction in carbon-dioxide-equivalents per dollar is greater as a result of reductions in both carbon dioxide and methane emissions. Wind and solar energy systems avoid coal-based carbon dioxide emissions, but they have rather high capital costs and low capacity factors that make them less attractive for reducing GHG emissions at the present.

Potential Issues

Wind and solar energy systems depend on the availability of sufficient wind and sunlight to produce electricity. The lack of control over when and how much wind and solar energy will be available makes these renewable energy systems non-dispatchable, thus reducing their value to the system. TVA is investigating energy storage technologies that may help solve this problem.

Unlike sulfur dioxide and nitrogen oxide emissions, which can be readily measured and monitored by gas analyzers and flow rate meters, reductions in, or avoidance of, GHG emissions may require that an independent third-party be brought in to verify that the reduction has occurred. Depending on the size of the GHG reduction/avoidance project, third-party verification costs can be significant.

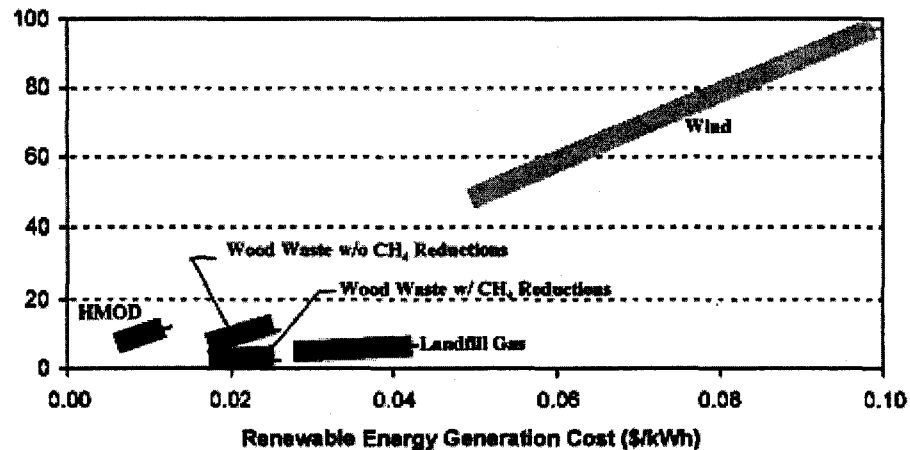


Figure 2. Current estimated ranges in costs per kWh and per ton of carbon-dioxide-equivalent (CO₂e) for five types of renewable energy systems. HMOD refers to modernization of hydroelectric facilities.

Conclusions

The use and incorporation of renewable energy systems into the electric power generation mix is one way that utilities could address the buildup of GHG in the atmosphere. The utilization of renewable energy depends upon resource availability, capital, and fuel cost. Reductions in generation cost, and possibly tax incentives, are needed if the utilization of renewable energy is to increase in the Tennessee Valley and the nation.

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Information Contacts:

[Edward A. Stephens, Jr.](#), (423) 751-7474,

[L. Daryl Williams](#), (256) 386-2973

If you would like additional information on important air quality topics, please contact Jeanie Ashe by telephone (256-386-2033), E-mail (jbashe@tva.gov), facsimile (256-386-2499), or mail at TVA, CEB 2A-M, Muscle Shoals, Alabama 35662.

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