November 2004 • NREL/CP-200-37116

Conference Paper

The Integration of Renewables

Preprint

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To be presented at the 1st International Conference on the Integration of Renewable Energy Sources and Distributed Energy Resources
Brussels, Belgium
December 1–3, 2004

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Contract No. DE-AC36-99-GO10337

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THE INTEGRATION OF RENEWABLES

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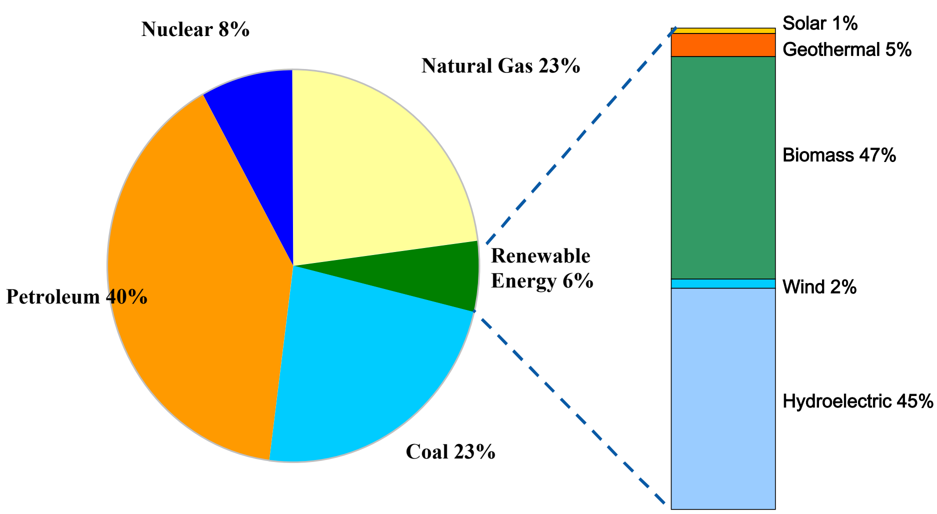
Progress in Renewable Energy Technologies

"Renewable energy" is energy derived from a broad spectrum of resources, all of which are based on self-renewing energy sources such as sunlight, wind, flowing water, the earth's internal heat, energy derived from the ocean, and biomass such as energy crops, agricultural and industrial waste, and municipal waste. These resources can be used to produce electricity for all economic sectors, fuels for transportation, and heat for buildings and industrial processes.

Renewable energy contributes 6% today to U.S. energy consumption of fuels.[1] Each renewable energy technology is in a different stage of development and commercialization. Some technologies are already commercial, at least for some situations and applications. Of the renewable energy consumed in the United States in 2003, hydropower comprised 45%; biomass, including municipal solid waste, 47%; geothermal, 5%; solar, 1%; and wind, 2%.[1]

Figure 1. U.S. Energy Consumption by Fuel — 2003



Source: EIA Renewable Energy Trends with Preliminary Data, Figure 1. The Role of Renewable Energy Consumption in the Nation's Energy Supply, 2003

Renewable energy technologies offer important benefits compared to those of conventional energy sources. Renewable energy resources are abundant; worldwide, one thousand times more energy reaches the surface of the earth from the sun than is released today by all fossil fuels consumed. Similar to fossil fuels, renewable energy resources are not uniformly distributed throughout the world. However, every region has some renewable energy resource. And, because different renewable energy resources complement each other, taken together they can contribute appreciably to energy security and regional development in every nation of the world, without dependence on foreign energy sources that are subject to political instability or manipulation.

Most renewable energy systems are modular, allowing flexibility in matching load growth. Today's markets for renewable energy technologies range from specialized niche markets to centralized energy production. For centralized energy production, renewable energy systems are relatively capital intensive compared to competing conventional technologies such as natural-gas combined-cycle power plants. However, after the initial investments have been made, the economics of renewable energy technologies improve in comparison with conventional technologies because operating and maintenance costs are low compared with those incurred using conventional fuels. This is especially true in the regions of the world where world fuel prices are relatively high, and will be especially true in the future as fuel prices increase. For both solar and wind systems, the fuel cost is not only constant, it is zero, for the life of the system.

Renewable energy systems generate little if any waste or pollutants that contribute to acid rain, urban smog, and health problems, and do not require environmental cleanup costs or waste disposal fees. Potential global climate change, caused by anthropogenic carbon dioxide and other gases in the atmosphere, is an environmental concern; systems using solar, wind, and geothermal sources do not contribute carbon dioxide to the atmosphere.[2] Biomass does release carbon dioxide when it is converted to energy, but because biomass absorbs carbon dioxide as it grows, the entire process of growing, using, and re-growing biomass results in very low to zero carbon dioxide emissions.

Although the energy of the sun and wind has been used by mankind for millennia, modern applications of renewable energy technologies have been under serious development for only about 20 years. In that period of research and development investment by industry and government (primarily the U.S. Department of Energy [DOE]), dramatic improvements have occurred in the cost, performance, and reliability of renewable energy systems.

Today's Trends and Issues Affecting Renewables

As is evident from the preceding discussion, scientific and engineering advances continue to strongly influence the progress of renewable energy technology development, as do advances in information technology. Easily accessed World Wide Web sites relating to renewable energy technologies provide valuable and accurate information that is easily accessible by everyone. Real-time metering is opening up innovative electricity pricing; sophisticated equipment and controls are improving the use of energy in buildings; and complex systems are being modeled in the laboratory, accelerating technology development.

But despite the excellent technical progress of the last 20 years, electricity and fuels from renewable energy are still generally more expensive than electricity and fuels from conventional fossil-fuel sources, with some exceptions. Table 1 summarizes the projected costs of major renewable energy electric systems. Although it is difficult to compare costs of electricity from renewable technologies to those of conventional grid electricity, it should be noted that the average retail price of electricity in the United States is approximately 7¢/kWh, which is less than most renewables. The cost of electricity and fuels from renewable energy would easily be less expensive than fossil fuels if the true, hidden costs of fossil fuels—environmental costs, health costs, and energy security costs—were considered. But our society has not yet found acceptable ways to incorporate these costs into the cost of energy.

Table 1. Renewable Energy Costs

	Costs (¢/kWh)		
Electricity Technology	**Today**	**2010**	**2020**
Wind	3–5¢ @ 15 mph	3¢ (2012) @ 13 mph	5¢ (> 2012) offshore
Solar			
PV	24–30¢	12–14¢	6–8¢
CSP	10¢	6¢	4–5¢
Geothermal	5–8¢	3–5¢ (2007)	–

To encourage the use of renewable energy electricity in the United States, policy measures will be needed. The most prominent measure under consideration is the renewables portfolio standard that has been adopted by 16 states in the U.S., a market-based mechanism for ensuring a minimum level of renewable energy development in the electricity portfolios of power suppliers as determined by a state or other implementing entity. Electricity sellers could meet their obligation through direct ownership of renewable generation, contracts for power from renewable generating facilities, or purchase of credits for sufficient renewable electricity from another power supplier.

Integration with Distributed Generation

Distributed power is modular electric generation from relatively small generating systems ranging from less than a kilowatt to tens of megawatts and located at or near consumer sites. Distributed systems can either be grid connected or operate independent of the grid. The goal of proponents of distributed power is to reinvent the power grid so that instead of producing electricity only at large, central plants and transmitting it in one direction, consumers would have some degree of energy independence and open the system to millions of small suppliers.

With distributed power, homes and businesses could produce power using technologies such as fuel cells, photovoltaic systems, wind turbines, biomass-based generators, microturbines, engine/generator sets, and electric storage systems. Excess power could be sold to the grid adding to grid capacity and consumers could obtain power from the grid when needed or desired.

The benefits of distributed power systems are seen to be reliability of service and power quality. In addition, greater efficiency of energy use is realized by using the heat loss from the power generation system. With blackouts in parts of the country, one of the biggest drivers today for distributed power is that it can serve as a standby generator or as an uninterruptible power supply. More and more consumers are in need of electric service 24 hours a day, 7 days a week without interruption. Distributed power offers an approach to this need.

There are barriers to robust implementation of distributed power. The key barrier today is interconnection with the grid. The Institute of Electrical and Electronics Engineers led the development of a consensus standard for interconnection. This standard, IEEE 1547 Standard for Interconnecting Distributed Resources with Electric Power Systems adopted in June 2003, is intended to ensure that distributed systems operate safely and reliably and are applied in a uniform way across the U.S. power system. With this standard and associated testing in place, the installation and operation of distributed systems will be streamlined.

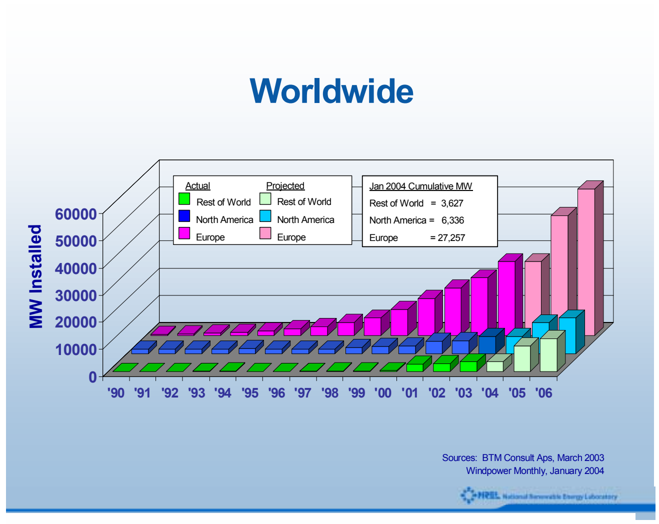
Integration with Hydrogen and Fuel Cells

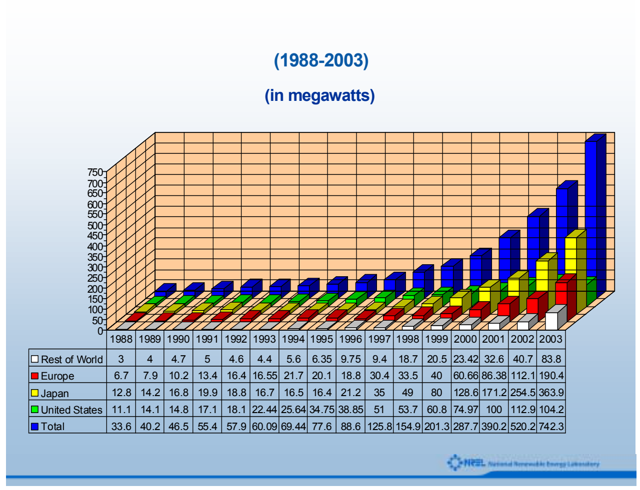
Hydrogen today is produced from natural gas for limited markets but it can be produced from renewable sources and promises substantial contributions to global energy supplies in the long term. Hydrogen is the most abundant element in the universe, the simplest chemical fuel (essentially a hydrocarbon without the carbon) that makes a highly efficient, clean-burning energy carrier. It has the potential to fuel transportation vehicles with zero emissions, provide process heat for industrial processes, supply domestic heat through cogeneration, help produce electricity for centralized or distributed power systems, and provide a storage medium for electricity from renewable energy sources. The U.S. government has launched a national initiative to develop the hydrogen economy.

Research challenges include cost-effective, energy-efficient production technologies and safe, economical storage and transportation technologies. Major advances have occurred recently in both production and storage technologies for hydrogen. Researchers have doubled the previous efficiency of producing hydrogen from water and have made major advances in carbon nanotube storage technology.[3,4]

Tomorrow's Impact of Renewable Energy on the World

From the dawn of human civilization to about 100 years ago, the sources of energy used by mankind were predominantly human and animal muscle and wood, with lesser amounts of solar, wind, hydro, and geothermal. With the discovery of oil, the development of natural gas fields, and the widespread distribution of electricity from coal-powered central power plants, fossil fuels became the predominant sources of energy in the United States and the world. Is there another major transition ahead for energy? Can the renewable resources that sustained early civilization be harnessed with enough efficiency and availability and at a cost to meet a significant portion of the much higher energy needs of today's society?





	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Rest of World	3	4	4.7	5	4.6	4.4	5.6	6.35	9.75	9.4	18.7	20.5	23.42	32.6	40.7	83.8
Europe	6.7	7.9	10.2	13.4	16.4	16.55	21.7	20.1	18.8	30.4	33.5	40	60.66	86.38	112.1	190.4
Japan	12.8	14.2	16.8	19.9	18.8	16.7	16.5	16.4	21.2	35	49	80	128.6	171.2	254.5	363.9
United States	11.1	14.1	14.8	17.1	18.1	22.44	25.64	34.75	38.85	51	53.7	60.8	74.97	100	112.9	104.2
Total	33.6	40.2	46.5	55.4	57.9	60.09	69.44	77.6	88.6	125.8	154.9	201.3	287.7	390.2	520.2	742.3

Figure 2. Historical and Projected Growth of Wind and Photovoltaic Energy Systems

Figure 2 illustrates the worldwide rapid growth of wind and photovoltaic energy systems. Over the past 5 years, these growth rates have exceeded 30%. If these growth rates are projected into the future, the contribution in the world's energy mix can indeed be substantial.

Summary

Within the broad variety of technologies that constitute renewable energy, some are already making large inroads in the marketplace. Other technologies, perhaps those most beneficial to a sustainable future, are further from commercialization. Most, however, are progressing more quickly than ever; there are no technical stumbling blocks for renewable energy. Renewable energy is a force today and *will* be a major force in the world's future—the only question is when. The answer will depend only on the will of the people for clean energy—or the next major energy supply disruption.

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REPORT DOCUMENTATION PAGE	*Form Approved* *OMB No. 0704-0188*

1. **REPORT DATE** *(DD-MM-YYYY)*	2. **REPORT TYPE**	3. **DATES COVERED** *(From - To)*
November 2004	Conference Paper	December 1-3, 2004

4. TITLE AND SUBTITLE
The Integration of Renewables: Preprint

5a. CONTRACT NUMBER
DE-AC36-99-GO10337

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)
Stanley R. Bull

5d. PROJECT NUMBER
NREL/CP-200-37116

5e. TASK NUMBER
2000.1000

5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
National Renewable Energy Laboratory
1617 Cole Blvd.
Golden, CO 80401-3393

8. PERFORMING ORGANIZATION REPORT NUMBER
NREL/CP-200-37116

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)

10. SPONSOR/MONITOR'S ACRONYM(S)
NREL

11. SPONSORING/MONITORING AGENCY REPORT NUMBER

12. DISTRIBUTION AVAILABILITY STATEMENT
National Technical Information Service
U.S. Department of Commerce
5285 Port Royal Road
Springfield, VA 22161

13. SUPPLEMENTARY NOTES

14. ABSTRACT *(Maximum 200 Words)*
This is an overview of renewable energy technologies, especially those that can be used for distributed generation of electricity or heat. It This paper reviews the types of technologies, their present usage in the United States, their advantages in terms of resources, availability, modularity, emissions, and integration in distributed energy systems. It reviews some of the history of their use and projects their growth and cost.

15. SUBJECT TERMS
Renewable energy; distributed energy systems; wind energy; photovoltaics; growth history and projections; geothermal energy; biomass energy; integration with distributed generation; hydrogen; fuel cells. "

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			19b. TELEPONE NUMBER (*Include area code*)
Unclassified	Unclassified	Unclassified	UL		

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Prescribed by ANSI Std. Z39.18