An Assessment of Renewable Electric Generating Technologies for Florida

PREPARED BY THE

Florida Public Service Commission and the Department of Environmental Protection

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Executive Summary and Key Results

- The 2002 Florida Legislature directed the Florida Public Service Commission, in consultation with the Florida Department of Environmental Protection, to do an assessment of renewable energy in Florida and its potential for electric generation. The statutory language defined renewable energy as *electricity generated from any method or process that uses one or more of the following sources of energy, but not limited to: biomass; municipal solid waste; geothermal energy; solar energy; wind energy; wood waste; ocean thermal gradient power; hydroelectric power; landfill gas; and agricultural products and by-products.* Using only the specific enumerated categories of renewables, Florida has approximately 680 megawatts of renewable capacity.[1] However, under the "not limited to" rubric, Florida has an additional 340 megawatts of generation capacity from phosphate manufacturers who use waste heat to produce electricity. This results in a total net summer generating capacity of 1028 MWs. Discussions with the phosphate industry indicate an additional 90 MWs of capacity are off-line or being redeveloped. The vast majority of this waste heat is used to serve internal electric loads for this industry. The combined capacity of these resources (exclusive of capacity used to serve internal loads) provides about 2.4 percent of the 2002 summer generating capacity of the State.

- There is no nationally accepted definition of renewable resources. While almost all states treat solar and wind as renewables, some states exclude municipal solid waste facilities and some types of hydroelectric. It is the purview of each state legislature to determine what resources constitute "renewables" within that state.

- For the year 2000, the renewable resources as defined in the statute provided approximately 3 percent of Florida's net electric generation, with a minimal contribution from hydro-electric sources. By comparison, on a national level, the vast majority of renewable energy is provided by hydro-electric sources. Excluding hydro-electric energy, approximately 2 percent of national energy production is attributed to the remaining types of renewable generation resources.[2] Florida's renewable electric production is largely derived from municipal solid waste (MSW), biomass materials such as agricultural waste products and wood residues which are used as fuel in boilers, and waste heat recovered from industrial manufacturing processes. Florida has some 50 MWs of hydro-electric generation in the Panhandle of the state. There are a number of photovoltaic installations but their total generating capacity is insignificant since most of these are only a few kilowatts in size.

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[1] A megawatt (MW = 1000 kilowatts) is a measure of real power at any instant in time or, in other words, a measure of demand on the grid at any moment in time. Megawatt hours (MWhs) are a measure of the MWs demanded aggregated over some time interval and thus represents the amount of electric energy consumed. A typical Florida house will consume about one MWh per month, but the house demand for electricity at any given moment would average about .0014 MW (1.4 kW).

[2] US DOE/EIA *Renewable Energy Annual 2001*. Table C13, p.58. By 2001, Florida's renewable contribution had declined to approximately 2% of net generation.

- Renewables vary in cost and technical readiness. Florida has a number of feasible renewable resources where feasible is defined as technologies that are deployable in the near future (through 2008) and commercially mature technologies. These include, in no particular order, biomass derived fuels, MSW, landfill and digester gas, hydro-electric, solar photovoltaic, and certain industrial plants that involve the use of waste heat to cogenerate electricity. Phosphate production is the notable example of the latter.

- The following table provides a summary of some of the estimates of potential and commercially feasible, near term, and new renewable capacity that could be developed in Florida. These estimates were derived from information provided by stakeholders and industry representatives, preliminary discussions by developers with permitting agencies, and some technical assessments. With respect to wood/bark fuel, it is assumed that up to 4 percent co-firing of biomass with traditional fossil fuels is possible. In total, these resources amount to an additional 651 MW of generating capacity, bringing Florida's renewable total to approximately 1679 MWs.

TABLE 1

Feasibility of Renewable Technologies

Type of Renewable Energy	Potential Incremental Capacity (MW)
Municipal Solid Waste/Refuse Derived Fuel	60*
Wood/Bark	225**
Landfill Gas	32
Bagasse	150
Hydro-electric	43
Solar Photovoltaic	1 (assumed)
Waste Heat	140 to 440***

* Information provided by the Integrated Waste Services Association indicates that within a ten year period some 250-300 MWs of new capacity is potentially available from expanded facilities.

** Information provided by Gus Cepero of Florida Crystals suggested that an additional 75 MWs of urban wood waste facilities are possible and a 15,000 acre dedicated eucalyptus crop could support a 50 MW facility.

*** This estimate was provided by the Florida Industrial Cogeneration Association. The 140 MW potential exists from retrofitting existing plants with the latest heat recovery technology. An additional 300 MWs of potential exists from replacement plants as the industry migrates from current locations to other areas of phosphate rock deposits.

- Table 1 indicates that municipal solid waste and biomass derived fuels offer the most feasible near term options for expanding the deployment of renewables in Florida.

- With respect to future technologies, in the long term opportunities may exist for ocean conversion systems using current flows and tidal flow, gasification of certain hydrogen rich feedstocks, and perhaps some meteorologically unique off-shore wind locations. Estimates of potential capacity and costs are not available for these less developed technologies. Florida does not have geothermal resources or identified wind resources.

- Electricity produced from renewable technologies is usually more expensive than traditional technologies on a production cost basis. The following table portrays a relative ranking of the levelized production cost for various technologies using the costs per kilowatt hour as the benchmark metric. Except for the traditional generating technologies, these numbers largely reflect national averages and do not account for individual siting and construction parameters that may be unique to Florida. Detailed engineering analyses, siting issues, transmission impact analyses, interconnection costs, and a host of other variables would ultimately be needed to accurately assess the site specific cost of any given technology.

TABLE 2

Plant Type	Levelized Costs (cents/kilowatt hour)
Municipal Solid Waste	3.5 -15.3¢*
Biomass (direct combustion)	6.3 - 11.0¢
Landfill Gas	2.4 - 6.3¢
Hydro-electric	No Data
Solar Photovoltaic	19.4 - 47¢
Waste heat facilities using exothermic processes	Zero fuel cost**
Natural Gas Combined Cycle	3.9 - 4.4¢
500 Megawatt Pulverized Coal	5.2 - 5.5¢

* This assumes a $25 per ton tipping fee. Information presented by Integrated Waste Services Association indicates that for Florida plants, a $50 per ton fee is more typical and thus production costs could be closer to 2¢.

** Zero fuel costs when part of a manufacturing process. Capital cost for retrofit of existing plants (up to 140 MW) estimated at $2,300 per kW. Capital cost for replacement plant incremental generating capacity not available but substantially less than above.

- Almost all of the existing fleet of renewable based generators were constructed during the 1980's and early 1990's as a result of the 1978 Public Utilities Regulatory Policy Act which required utilities to purchase energy from certain qualified facilities at a price equivalent to a utility's cost of building and operating its own generation (i.e. the avoided cost standard). Current utility construction and operating costs for new combined cycle technologies are declining due to improved operational efficiencies. Therefore, it is unlikely that very many new renewable facilities will be constructed based on the current avoided cost payment levels.

- All energy production systems have environmental impacts. It is extremely difficult to quantitatively rank order the magnitude of such impacts since there is no single metric which can be agreed upon. A qualitative assessment is also difficult to perform since different stakeholders will assign different weights to the impacts. For example, renewable materials used as fuel inputs into combustion processes may have similar air emission profiles as traditional generation, but such facilities may have offsetting positive impacts such as reduction in waste volumes to be landfilled. In addition, if electric generating equipment is added at existing manufacturing facilities, waste heat cogeneration has minimal incremental impacts beyond the primary industry process itself.

- Many states in the U.S. have adopted strategies to encourage greater deployment of renewable resources. Generally, three broad strategies have been employed. States have employed what this report characterizes as market driven programs. These include utility-sponsored green pricing which allows customers to voluntarily purchase certain defined renewable resources. Other market driven state initiatives include establishing licensing and contractor standards, incorporating certain renewable technologies into building codes, and establishing trading and labeling procedures to allow purchasers and sellers to have renewables certified to enhance commercial transactions. Other strategies that have been adopted include non-by-passable surcharges imposed on utility bills or the allocation of specific tax revenue. These assignable charges are generally referred to as system benefit charges (SBC) and have been used to fund activities such as energy efficiency, low income assistance, research and development, in addition to the funding of renewable activities. Finally, some states have mandated programs like renewable portfolio standards (RPS), which dictate that a percentage of a state's electric production must be derived from defined renewable resources.

- Generally, market driven programs have the least impact on utility rates and have the least adverse income distribution consequences between classes of utility customers. System benefit charges or other fee systems ensure a more reliable funding source, but have the undesirable effect of increasing electric rates, even minimally. They also cause some inter-class equity issues between different utility customer classes. Finally, mandated renewable goals potentially have the most powerful impact on deploying renewables. However, RPS standards also can have the most dramatic economic impacts with respect to electric costs. Such strategies must carefully weigh the cost of renewables and their commercial and technical feasibility against the cost of traditional utility generation and find the appropriate balance that achieves the policy goals that a state wants to achieve. For example, if the state policy goal was to increase jobs in Florida, a RPS standard that directed certain levels of biomass energy be obtained would tend to increase employment within the state since collecting, preparing and delivering biomass fuels is a labor intensive process.

- Thirteen states have some type of RPS standards. The recent development of RPS standards seems to be a result of the movement toward deregulating electric markets by allowing retail choice for end use electric customers. Some 41 percent of states with active retail choice restructuring have implemented RPS programs, while only eleven percent of states without retail choice restructuring have found these initiatives necessary. Likewise, sixty-four percent of the states with active retail choice restructuring have implemented SBC programs, while only fifteen percent of the states with no retail choice restructuring have found these initiatives necessary to maintain public benefit programs.

CHAPTER I

INTRODUCTION and BACKGROUND

The 2002 Florida legislature passed HB 1601 (SB 1142) which was signed by the Governor on May 23, 2002. This Act modified 366.8255, F.S., to allow certain costs resulting from agreements entered into between regulated electric utilities and the Florida Department of Environmental Protection (FDEP) or the U.S. Environmental Protection Agency to be subject to recovery under the Environmental Cost Recovery Clause. As part of this revision to Chapter 366, F.S., the legislature added the following language:

> *Section 2. (1) The Florida Public Service Commission in consultation with the Florida Department of Environmental Protection is directed to perform a study for the purpose of defining public policy with respect to the use of renewable resources in Florida. At a minimum, the study shall assess cost, feasibility, deployment schedules, and impacts on the environment of increased use of renewables. In addition, the study shall describe options and mechanisms to encourage the increased deployment of renewables within our state. The results of this study shall be submitted to the President of the Senate and the Speaker of the House by February 1, 2003.*
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> *(2) As used in this section, the term: (a) "Biomass" means a power source that is comprised of, but not limited to, combustible residues or gasses from forest products manufacturing, agricultural and orchard crops, waste products from livestock and poultry operations and food processing, urban wood waste, municipal solid waste, municipal liquid waste treatment operations, and landfill gas. (b) "Green energy" means renewable energy. (c) "Renewable energy" means electricity generated from any method or process that uses one or more of the following sources of energy, but not limited to: biomass; municipal solid waste; geothermal energy; solar energy; wind energy; wood waste; ocean thermal gradient power; hydroelectric power; landfill gas; and agricultural products and by-products.*

Thus, the Florida Public Service Commission (FPSC) in consultation with the FDEP was charged to perform a study for the purpose of defining public policy with respect to the use of renewable resources to generate electricity. This report is the work product of that charge. The report discusses current policies and the limitations of such policies to the development of new renewable resources, contains descriptions of specific renewable technologies, provides estimated costs, describes likely environmental attributes of these technologies, and offers summaries of various options and mechanisms that other states have adopted to encourage renewables.

Having said what the report does, it is also important to identify what this report does not do. There are no specific recommendations for what policy options, if any, should be adopted in Florida. The report provides technical descriptions of the types of initiatives that Florida could adopt. Such initiatives are largely taken from the experiences of other states. At this time however, renewables are typically more costly than traditional fossil and nuclear based technologies and therefore any public policy initiatives will likely impose additional costs on some or all of Florida's citizens, or electric ratepayers. This report is meant to provide information to assist the Florida legislature's deliberations in case the legislature is interested in exploring possible new initiatives to promote renewable technologies.

The report does not attempt to forecast technological changes that could affect the ultimate timing and commercial status of various technologies. Research and development, both private sector and publicly funded, continues to be devoted to renewable energy. The United States Department of Energy (DOE) has for decades funded high end R&D for a variety of technologies but with special interest in solar applications. More recently, substantial private sector funding has been devoted to the development of fuel cells for both stationary and mobile applications. While fuel cells in themselves are not renewable, some efforts are being made to fuel them with hydrogen fuel derived from potential renewable resources. Most of the large automakers now have active fuel cell development teams in hopes of developing cleaner burning engines. In addition, there are exciting new concepts being investigated with respect to utilizing ocean currents to produce electricity. At this time, it is nearly impossible to predict the ultimate installed cost and widely accepted commercialization dates for these kinds of cutting edge technologies.

Finally, the report recognizes that no single point cost estimate is possible for many renewable technologies. For the most part, the cost estimates will always be embedded in a range of estimates. This is necessary due to the lack of standardization of technologies, limited experience siting and constructing certain technologies within Florida, and the difficulty of estimating future, in-service costs for less mature technologies.

Process

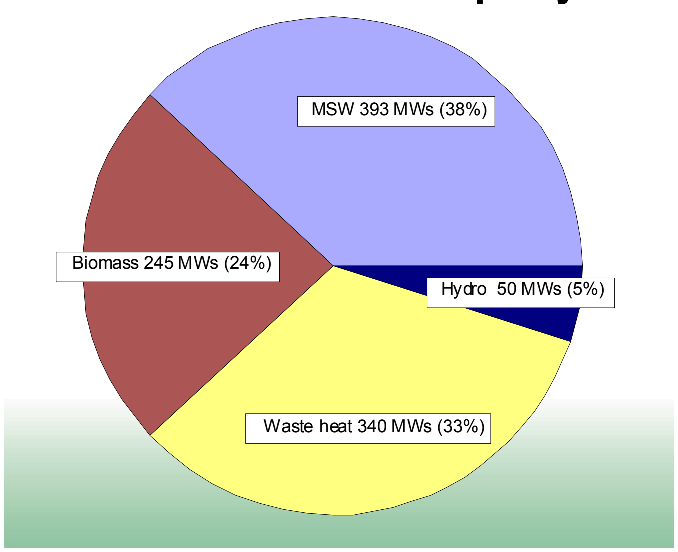
The FPSC and FDEP conducted three public workshops to solicit input from various stakeholders, utilities, and citizens on the content of this report. Prior to the first workshop, a questionnaire was sent to all known stakeholders who operate or have information about potential renewable facilities in Florida. The questionnaire mined for information about specific performance characteristics of renewable facilities, operating ranges, size ranges, and non-proprietary operating cost information. Much of this data was used to develop the cost estimates presented in Chapter III. Staff of the FPSC/FDEP conducted the first workshop in Tallahassee on July 2, 2002; over 70 people attended the July 2 workshop. Some 27 people made presentations to the staff. A second workshop was held in Jacksonville on August 28 which was attended by all five FPSC Commissioners. Here again, about 50 people attended and some 25 speakers offered information and technical data on the characteristics of various technologies and various policy options to encourage additional deployment. Finally, after making a draft of this report available on November 1, 2002, staff conducted a third and final workshop on November 14, 2002, in Tallahassee, and received direct input and written comments on this draft from interested parties.

Background Information

Using the enumerated list of renewables in the statute, Florida has approximately 1028 MWs of net summer generating capacity. For the purposes of this report, included in this number are 340 MWs of waste heat cogeneration which was considered a renewable resource since these facilities are listed as operating plants in the current *2002 Regional Load and Resource Plan* prepared by the Florida Reliability Coordinating Council. Discussions with the phosphate industry indicate an additional 90 MWs of waste heat is currently off-line or being redeveloped. The vast majority of the waste heat generation is used within the industry to serve internal process loads which results in a reduced demand on the utilities. This 1028 MWs represents about 2.4 percent of the 2002 summer installed capability. Of this 1028 MWs of capacity, some 512 MWs are either owned or delivered to utilities under firm contracts for distribution to end use customers. The other 516 MWs have the capability to generate energy to the grid based on individual operational constraints at the facilities and the hourly, spot market cost of energy. (See Appendix A for a listing of larger, interconnected, renewable generators).

FIGURE 1

Florida's Renewable Capacity



Fuel inputs to these generators largely come from MSW, including refuse derived fuel (RDF), biomass materials, waste heat from manufacturing, and a very small amount of hydroelectric capacity. Figure 1 shows the relative contribution of each of these renewable capacity resources.

As might be imagined, these numbers pale in comparison to the capacity of fossil and nuclear fueled electric generators. Florida currently has some 43,000 megawatts of installed summer capacity and some 45,500 megawatts of winter capacity. During the last 10 years, Florida has added an average of approximately 900 megawatts of new generating capacity per year. Based on the latest planning documents, Florida is expected to add some 1,500 megawatts per year for the next ten years. This capacity is meant to replace long term purchase contracts and to serve new load growth.[3]

Figure 2 shows the relative contribution of renewables in the overall generation output produced by Florida's electric generators. As evidenced by this pie chart, Florida has a diversified mix of fuel inputs. Some 53 percent of the year 2000 net generation was derived from coal and nuclear.[4]

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[3] Florida Reliability Coordinating Council, *2002 Regional Load & Resource Plan*, July 2002, p. S-10.

[4] Data for Figure 2 and 3 was taken from the Energy Information Administration's *Electric Power Annual 2000*. EIA reports that this data is based upon all reported kilowatt-hours generated by utility and non-utility generators.

Natural gas provided 23 percent, but that figure is expected to increase to almost 50 percent by 2011. It is worthwhile to note that some 19 percent of the electric industry's fuel input in Florida was petroleum, or approximately 56 million barrels of oil in 1999. By 2011, total electric industry oil use is projected to decline to about 25 million barrels of oil. However, the use of natural gas is projected to triple during that period.

FIGURE 2

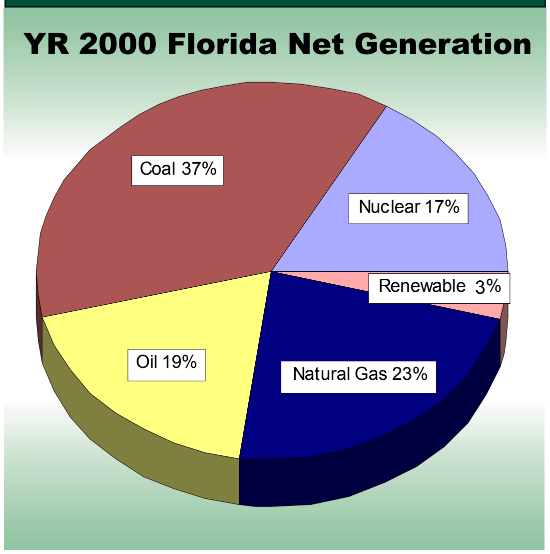

FIGURE 3

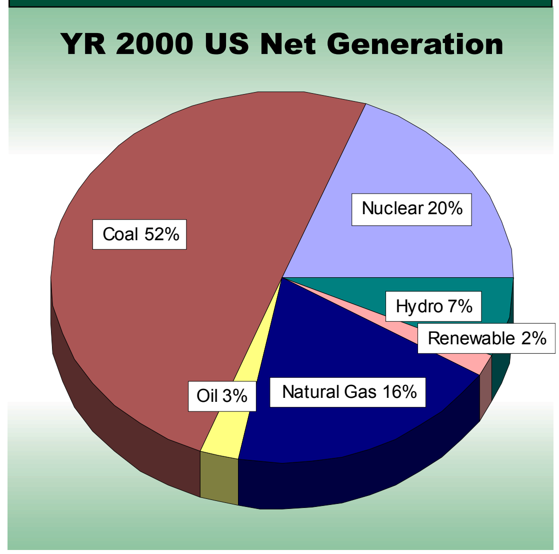

Figure 3 shows similar data for the United States. Notice that while Florida gets an insignificant amount of its electric energy from hydroelectric, for the United States in year 2000 approximately 7 percent of net generation is hydro production. Notice also that Florida uses significantly more petroleum than the national average.

Focusing specifically on reported renewable generation, and excluding hydro, the various types of renewables that comprise these percentages are of interest. At the national level some 2 percent of electric production is derived from renewables. Of this amount, biomass accounts for 77 percent, geothermal some 15 percent, wind about 6 percent, and solar is less than 1 percent. Florida, on the other hand, gets about 3 percent of its net generation from renewables. While it is difficult to get exact data on production on some in-state renewable generators since much of the output is used to serve internal loads at the plant site, the most recent DOE report indicates that some 53 percent comes from MSW plants and some 46 percent comes from biomass fueled facilities.[5]

Finally, mention must be given to the transmission system in Florida. Florida has limited interties with the southeastern states. Currently, the bulk transmission system will allow, under normal operating conditions, some 3600 MWs of import into the state, or about 8 percent of our installed generating capacity. Of this amount, some 2600 MWs are committed purchases from facilities in Georgia or under firm contract. Thus, opportunities to import substantial amounts of renewables – if they existed – from other southeastern states is somewhat limited.

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[5] DOE/EIA *Renewable Energy Annual 2001 with Preliminary Data for 2001*, November, 2002. Table C.6

Catalysts for Renewables

Almost the entire fleet of renewable generators were developed as a result of the federally mandated Public Utility Regulatory Policy Act of 1978 (PURPA). The PURPA was one of the most significant actions in fostering the development of facilities to generate electricity from renewable energy sources. This Act required utilities to buy electricity from qualifying facilities (QF's). Under PURPA, QF's are defined as non-utility facilities that produce electric power using cogeneration technology, or power plants with no greater than 80 megawatts of capacity that use renewable energy sources. PURPA empowered the Federal Energy Regulatory Commission (FERC) to establish rules requiring that electric utilities purchase power from QF's at an "avoided cost" price based on energy and capacity costs that the utility would otherwise incur by generating the power itself or purchasing it elsewhere.

Generators that avail themselves of PURPA can sell their electric output to the utility under a variety of options. If the generator can meet certain deliverability or capacity factor requirements, then they can be paid both a capacity and energy component for the output of their facilities under firm contract. The majority of these contracts in Florida were entered into over ten years ago.

Many facilities have seasonal or operational constraints such that they cannot commit to meeting certain deliverability requirements. In this situation, generators can sell the energy they produce on an "as-available" basis to the utility. The as-available energy price is defined as the next increment of power cost that the utility would have incurred if it either produced or purchased the power. In most cases, the price paid for as-available energy is less than the payment under a full avoided cost contract.

At this time, Florida has a number of generators that produce waste heat through exothermic reactions in the production of phosphate fertilizers. The net capability of these facilities is over 430 MWs. Much of the power produced is used to self-serve the electrical needs at the phosphate plant site, thereby significantly reducing demand on the electric utility system. In addition, some 29 MWs are committed under PURPA contracts with Florida utilities as firm capacity. See Chapter II for a further discussion of the specific exothermic production technologies.

Another catalyst for renewables is the public interest in investing in solar energy. As one scales down from megawatt sized mechanical generators, there are about 300,000 installations of solar thermal devices in Florida. Solar thermal is a well-established technology that can provide both hot and ultra-high heated water for residential and commercial applications. Most of the applications in Florida are for domestic hot water and pool heating. While solar thermal technology does not directly produce electricity, its use allows customers to avoid the direct purchase of electricity, natural gas, or other fossil fuel that would have been used to heat water. On average, there are about 18,000 new solar pool heating systems, 5,000 solar water heating systems and 30 new grid-connected solar photovoltaic (PV) systems installed each year. The grid-connected PV market is, however, highly dependent on subsidy programs, and may result in just a handful of systems without rebates or other incentives.[6]

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[6] Information provided by the Florida Solar Energy Center. November 15, 2002.

Cost Considerations of Renewable Resources

Renewable fueled generating technologies ultimately must compete with traditional generating technologies to sustain themselves as a viable alternative resource. Presently, renewable technologies are, for the most part, more expensive than the incremental generating unit that would be built to serve electric customers. Due to advances in jet engine technologies, the electric industry's preferred generating technology to serve peak load is a natural gas fired combustion turbine generator operating in a simple cycle mode. When a more base loaded type generator is needed the simple cycle can be connected to a heat recovery unit to capture the high temperature exhaust gases from the turbine, which in turn produces steam that is also used to produce electricity. While natural gas is the preferred fuel for these kinds of machines, oil and coal that have been converted into a gas can also be used as fuels.

Proponents of renewable technologies point out that renewables have certain desirable characteristics which may not always be appropriately captured by bottom line production costs. They cite the modular nature of many technologies, the fact that renewables do not use coal, oil, natural gas, or nuclear fuels, and that fuel input costs are either negligible or have less volatility than fossil based fuels. On the other hand, some renewables have characteristics which may diminish their economic value. Intermittent resources like solar and wind are sometimes harder to incorporate into reserve requirements. Some renewables that are remote from load centers may require transmission upgrades to get the energy to customers and there may be line losses associated with moving the power. Finally, while distributed resources can be helpful for certain aspects of distribution stability, power quality must be maintained.

Chapter III provides a discussion of the various life cycle cost estimates for renewable resources.

Environmental Considerations of Renewable Resources

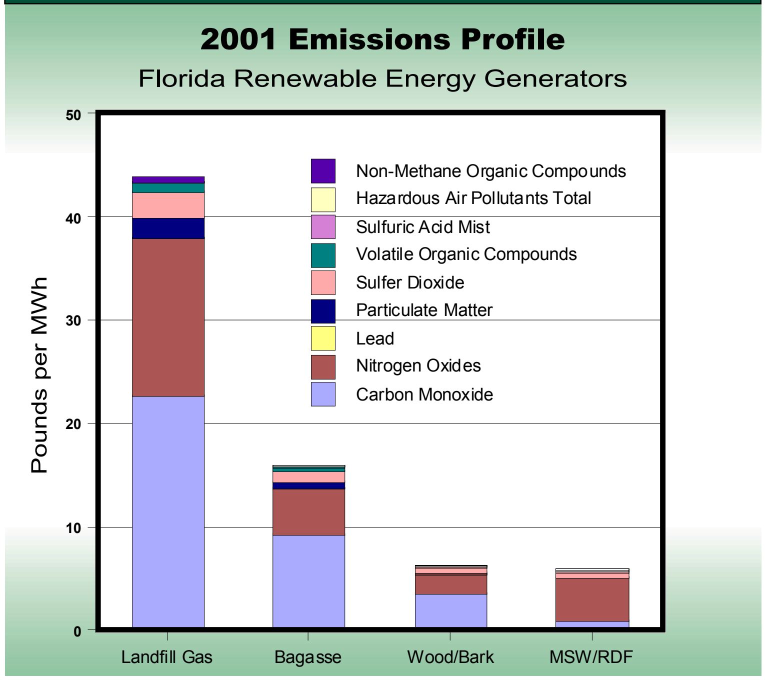
Many people assume that by definition renewable resources are "cleaner" or have less environmental impacts than non-renewable resources. Such assertions should be carefully examined. All energy infrastructure has some kind of impacts. The challenge is to evaluate the relative seriousness of various impacts and how to best mitigate them. For example, windmills have no air emissions associated with combustion processes, but where they are sited has generated controversy on the aesthetic issues associated with their construction.[7] Likewise, MSW facilities, while deemed renewable by definition in this statute, often are opposed because of the combustion process involved in producing electricity. The air emission profile for a MSW facility would look more similar to a conventional fossil fueled unit depending on the vintage of the unit. Here again, this report discusses the environmental characteristics of various renewable technologies, but does not attempt to assign a single, unidimensional ranking in terms of their qualitative impacts on the environment.

An emission profile of regulated air emissions was established for Florida's current "fleet" of renewable resource electrical generators, and is presented in Figure 4. It should be noted that this chart reflects actual data reported during the year 2001, for existing Florida generating units

[7] "Cape Cod: Twisting in the Wind," *Public Utilities Fortnightly*, May 15, 2002, Vol. 140, No. 10.

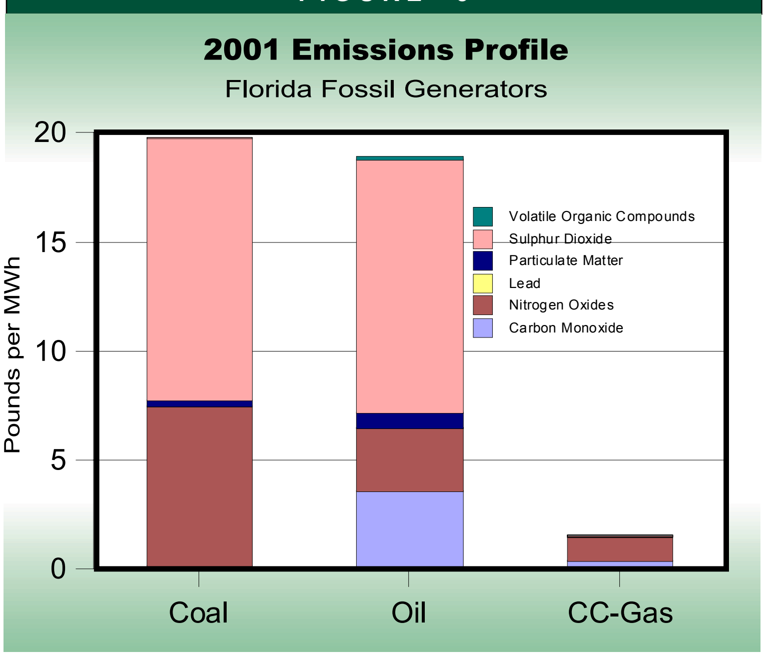
which were designed to provide electricity to the grid. It is also noteworthy that only three units are included within the profile fueled with bagasse and landfill gas, versus five units fueled with wood, and over 30 MSW/RDF fueled units (based upon actual 2001 fuel combustion). More landfill gas units exist within Florida, yet those units were excluded due to minimal landfill gas consumption during 2001. Digester gas combustion was reported in such low quantities that an emissions profile could not be developed. The 2001 actual heat inputs were utilized as a surrogate for capacity factor in estimating MWh production.

FIGURE 4



It should be noted that Figure 4 does not appropriately capture the emission profiles for facilities that use waste heat cogeneration. Since a substantial portion of the input fuel stock is used for production output and not dedicated to electric output, this table overstates the emission profile associated with such facilities.

FIGURE 5



For comparison purposes, an emissions profile for coal, oil and natural gas units is provided in Figure 5. This profile was provided by the FDEP and based upon a sample of approximately 3000 MW of operating capacity from each type of commercial generating unit. The basic unit profiles within Florida's fossil fleet are conventional coal, conventional oil, and natural gas combined cycle. Three unique facilities were included for the development of each of the profiles below, so as to ensure that the profile included a sample of the differing unit vintages comprising the existing units in Florida. Some pollutants were emitted in such small quantities that they were excluded from this chart.

One conclusion which can be reached, is that most of Florida's current fleet of electrical generating units constructed primarily for the purpose of combusting renewable fuels are at least as clean, with respect to regulated emissions, as Florida's existing coal- and oil-fired units (which includes grandfathered units). However, combined cycle natural gas-fired units clearly emit the lowest amount of air pollutants per MWh generated of all existing carbon-based fuels. Modern natural gas-fired combined cycle power plants emit nearly no sulfur dioxide and about 3 parts per million of nitrogen oxides.

Concerning thermal emissions, each of the above types of generating units (whether fossil or renewable fuel-fired) is responsible for heat being emitted to the air and, in some cases, water bodies. Additionally, modern units of each type are typically designed as zero discharge facilities, implying that no wastewater streams exist. Older units, however, represent a source of wastewater discharges.

The waste streams to land associated with each technology can also vary. As a general rule, waste streams are higher for solid fuels than liquid fuels, with gaseous fuels having nearly no ash. For example, the quantities of ash generated from the combustion of MSW and RDF are typically double that of coal combustion. Ash generated from the combustion of coal is roughly equivalent to that of bagasse, wood or bark, per MWh of electricity produced. Comparably speaking, fuels such as petcoke and oil generate very low quantities of ash (perhaps five percent that of coal), while the generation of ash from the combustion of natural gas and landfill gas is essentially zero.[8]

Figures 4 and 5 do not include carbon dioxide emissions because carbon dioxide is currently not a regulated pollutant in the U.S. Nevertheless, many scientists, and perhaps a majority of scientists, believe that carbon dioxide emissions are the principal anthropogenic contributor to global warming. There are active discussions nationally and internationally regarding whether or not carbon dioxide emissions should be regulated. Indeed, the U.S. has agreed to voluntarily monitor and report the annual inventory of carbon dioxide emissions. To this end, the U.S. Environmental Protection Agency publishes an annual report entitled *Inventory of U.S. Greenhouse Gas Emissions and Sinks*.

[8] For additional information regarding waste streams see the U.S. Environmental Protection Agency's Report to Congress dated March, 1999 entitled *Wastes from the Combustion of Fossil Fuels Volume 2 – Methods, Findings, and Recommendations.*

CHAPTER II

TECHNOLOGY DESCRIPTIONS

This chapter provides a description of each of the major renewable technologies and assesses its potential deployability and environmental impacts. Where possible Florida specific data is provided and supplemented with national data. A number of technologies such as geothermal and wind are not applicable to Florida, but for completeness these technologies are included in the inventory.

Biomass Fuels

According to information from the National Renewable Energy Lab (NREL) and the U.S. Department of Energy (DOE), biomass represents the largest opportunity for renewable energy production in the U.S. in the short-term (five-year horizon). Biomass derived fuel has two major applications. It can be used as a direct fuel stock into power plants either through direct combustion or by conversion into a gas or liquid that can then be combusted. In addition, unlike other renewable energy sources, biomass can be converted directly into liquid fuels for transportation needs. The two most common types of biofuels are *ethanol* and *biodiesel*. The following descriptions of sources of biomass fuels will focus on their availability and suitability as input fuels to power generation.

Wood Product Residues

Wood processing residues constitute the most important biomass fuel source used in the United States, consistently accounting for more than 50 percent of the country's total biomass fuel supply.[9] Wood processing residues come in a variety of forms. Almost half the biomass content of a typical saw log becomes residue at a primary sawmill. A variety of secondary forest product applications have been developed to use a portion of this material. Active markets for wood processing residues in many regions include pulp chips, wood fiber for fiberboard and composites, animal bedding, and garden products such as decorative bark. Sawmills segregate residues for sale in the highest-value markets available. However, a substantial amount of the residues, typically 15 to 20 percent of the biomass content of the saw logs brought to a sawmill, have no useful application and must somehow be disposed. Biomass power plants have become the disposal option of choice for much of this material.

The traditional method used to dispose of wood processing residues at sawmills was historically incineration in "teepee burners," a technology that produces copious amounts of smoke and other air pollutants. Beginning in the early 1970s, air pollution control efforts applied increasing pressure on sawmills to close down their teepee burners, leading them to search for new disposal alternatives. This was an important factor that led to the development of the biomass power industry in the United States during the 1980s. In states as diverse as California, Maine, and North Carolina, virtually all the readily available wood processing residues that have no higher-valued applications are used as power-plant fuel. Wood processing residues are one of the cheapest forms of biomass fuel to produce and deliver. The only readily available option for disposing of these materials, if fuel use were not a possibility, is landfilling. However, landfilling of waste wood is an undesirable

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[9] Much of the material for this chapter was provided by the National Renewable Energy Laboratory, Golden, Colorado.

option for a variety of reasons. Waste wood has a slower decay rate than other biomass forms, and is thus slow to stabilize in the landfill environment. Waste wood can take up 15 to 20 percent of the available space in a typical county landfill, and its decay leads to emissions of methane, a more potent greenhouse gas than carbon dioxide.

In-Forest Residues

In-forest residues constitute a major source of biomass fuels in the United States. Timber harvesting operations produce forest residues in the forms of slash (tops, limbs, bark, broken pieces) and cull trees. If left in place these residues can impede forest regeneration, and increase the risk of forest fire. Increasingly, harvesting plans on public and private lands require some form of residue management, which usually means either piling and burning on-site, or removal and use as fuel. Logging slash is an important source of biomass fuel in several regions. In addition to logging residues, forest treatment residues, or thins, comprise an important source of fuel for the biomass energy industry. Because of past forestry practices and aggressive fire-fighting efforts during the past 80 to 100 years, vast areas of U.S. forests are likely overstocked with biomass material, representing an increased risk of destructive wildfires and a general degradation of the forest ecosystems. These forests can benefit from mechanical thinning operations. The amount of in-forest biomass residues that could be converted to energy is reportedly far greater than the total amount of biomass fuel demand in most regions of the country. However, this fuel source is generally more expensive to produce than other biomass fuels, so the quantity used is less.

As the market for biomass fuels has retracted in the United States, the amount of logging residues converted to fuel use has remained relatively constant, because of its link to the lumber market. The major adjustment has been in the quantities of thins being collected and converted to fuel. Most logging residues used for energy production would be pile burned if energy applications were not available. On the other hand, forests would simply not be thinned, so material of this origin would accumulate as excess biomass.

Urban Wood Residues

As much as 15 to 20 percent of the solid waste traditionally disposed of in U.S. landfills is clean wood waste that can be segregated and converted into power plant fuel. This material comes from a variety of sources, including: 1) construction and demolition wood waste; 2) wood and brush from land clearing; 3) wood and brush from public and private tree trimmers and landscapers; 4) wood waste from the manufacturing of cabinets, furniture, and other wood products; and, 5) discarded pallets.

Agricultural Residues

Agricultural operations produce large quantities of residues, which come in a wide variety of forms and consistencies. Agricultural residues suitable for use as power plant fuels include: 1) food processing residues such as pits, shells, and hulls; 2) orchard and vineyard removals and prunings; and, 3) field straws and stalks. Most of these residues require some form of treatment as a part of normal agricultural practice. In most cases the lowest-cost treatment option is open burning, a major source of smoke and air pollution. Avoiding agricultural burning is a principal reason biomass energy facilities have been developed.

Bagasse is an important agricultural residue used in power generation and is of particular significance for Florida. Bagasse is the matted cellulose fiber residue from sugar cane that has been processed in a sugar mill. Bagasse is a fuel of varying composition, consistency, and heating value. These characteristics depend on the climate, type of soil upon which the cane is grown, variety of cane, harvesting method, amount of cane washing, and the efficiency of the milling plant. In general, bagasse has a heating value between 3,000 and 4,000 British thermal units per pound (Btu/lb) on a wet, as-fired basis. Most bagasse has moisture content between 45 and 55 percent by weight. The U.S. sugar cane industry is located in the tropical and subtropical regions of Florida, Texas, Louisiana, Hawaii, and Puerto Rico. Except for Hawaii, where sugar cane production takes place year round, sugar mills, including those in Florida, operate seasonally from 2 to 6 months per year.

Currently, Okeelanta is the only operating electrical generating facility in Florida for input to the grid, which combusts bagasse. Cogeneration facilities such as Okeelanta take sugar cane bagasse, or clean wood waste, convert it into process fuel, and then use the fuel to operate the sugar processing facility on-site as well as generate electricity. During 2001, Okeelanta reported combusting over 700,000 tons of bagasse. The control and reduction of carbon monoxide emissions remains one of the largest challenges for new units.

Dedicated Biomass Crops

Energy crops are plantings developed and grown specifically for fuel. These crops are carefully selected to be fast growing, drought and pest resistant, and readily harvested to minimize costs. Energy crops include fast-growing trees, shrubs, and grasses. Examples under development in the U.S. include hybrid poplar, willow, switchgrass, and eucalyptus.

Energy crops can be grown on agricultural lands not needed for food, feed, or fiber. In the U.S., it is estimated that about 77 million hectares (190 million acres) of land could be used to produce energy crops. This includes lands taken out of service for price control reasons and other agricultural lands that are considered marginal for food production. Compared to traditional agricultural crops, energy crops are lower maintenance and require less fertilizer and pesticide treatment. The period between harvests for woody energy crops varies from 3 to 10 years, depending on the tree species, and the period between plantings can be longer than 20 years. In addition to their fuel value, energy crops can also be planted for erosion control, soil remediation, and as filters that prevent nutrient run-off from land into waterways. As is the case with other biomass fuels, energy crops are classified as a carbon dioxide neutral resource, because the carbon dioxide consumed during plant growth is believed to offset the carbon dioxide produced during burning. However, care must be taken to use such crops in an environmentally responsible way. One way is through closed-loop technology in which the carbon dioxide released during burning is equal to, or less, than carbon dioxide consumed during growing. The goal is no net increase in carbon dioxide emissions.

In addition to environmental benefits, energy crops can provide income benefits for farmers. The typical modern farm produces one or two major commercial products such as corn, soybeans, milk or beef. The net income of the entire operation is often vulnerable to fluctuations in market demand, unexpected production costs, and the weather, among other factors. Since biomass fueled power plants require a fairly steady supply of fuel throughout the year, raising energy crops can provide income stabilization for farmers who choose to diversify their production.

Information provided to the FPSC suggested that given a production level of 20 dry tons per year per acre, a 15,000 acre dedicated crop area could reasonably support 50 MW of generation, resulting in 350,000 MWh per year of electric energy.[10]

Environmental Impacts of Biomass Disposal

All alternatives for the disposal of biomass wastes and residues, including leaving forest residues in place, entail environmental impacts. Energy production from biomass residues produces air pollutants and solid waste (ash), and consumes water resources. These impacts must be balanced against those impacts that would occur if the energy alternative were not employed, including the impacts of alternate disposal of the material used as fuel, the impacts on industries that want to use that material for alternative non-electric products, and the impacts of alternative production of the electricity that must be supplied to the market.

Environmental Impacts of Open Burning

Setting aside the recognized benefits of prescribed burning, open burning of forestry and agricultural biomass residues is a source of air pollution. Open burning can produce massive amounts of visible smoke and particulates, and significant quantities of emissions of nitrogen oxides, carbon monoxide, and hydrocarbons that contribute to the formation of atmospheric ozone. Quantifying the emissions resulting from open burning is difficult because residues, burning practices, and environmental conditions are extremely variable. Nevertheless, use of these residues as power plant fuel vastly reduces the smoke and particulate emissions associated with their disposal, and significantly reduces the amounts of carbon monoxide, nitrogen oxide, and hydrocarbons released to the atmosphere. California's air quality regulatory agencies recognized that the biomass power industry could help eliminate open burning of agricultural residues. To give the biomass power producers credit for the air quality benefits they provide, regulators in California developed a set of agricultural offset protocols, through which facilities that burn agricultural residues that would otherwise be open burned earn an offset for their emissions of pollutants at the power plant. Because emission offsets are required only for pollutants for which the receiving basin is non-attainment, most agricultural offsets have been for emissions of nitrogen oxide and particulates. For most facilities that were permitted on the basis of the agricultural offset protocols, the permits require that one-half to two-thirds of their fuel be obtained from agricultural residue sources.

Environmental Impacts of Burial

Recoverable wood waste represents approximately 15 percent by weight, and as much as 20 percent by volume, of the material that typically enters sanitary landfills. One study by the University of Florida concluded that 23 percent of the waste stream headed to landfills could be attributed to demolition/renovation waste from the construction industry in Florida. Typically, these materials enter the landfill gate separate from mixed household garbage. In the absence of a fuel-use option, they may be buried along with other wastes entering the landfill. It is noteworthy that the combustion of pressure-treated lumber causes unique emission problems and, at this time, this material is best placed in a lined landfill.

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[10] Post workshop comments provided to the FPSC by Gus Cepero dated November 22, 2002.

Landfill burial of the wood residues that can be recovered and converted into power plant fuel entails the same kinds of environmental impacts associated with the disposal of all kinds of organic wastes in landfills. Compared to other types of organic wastes, woody materials are slow to degrade, which means that landfill stabilization is delayed. Like all organic material in the landfill, waste wood can be a source of water-polluting leachates, and as the material degrades, it produces emissions of methane and carbon dioxide in roughly equal quantities. Methane and carbon dioxide are both greenhouse gases, but methane is much more reactive, by a factor of some 25 times per unit of carbon. Large landfills are now required by EPA regulations to control their fugitive emissions by collecting a portion of the landfill gas and flaring it. In general, gas collection systems capture about 80 percent of the methane released by the landfill, which means that final emissions of the waste carbon to the atmosphere are approximately 90 percent carbon dioxide and ten percent methane (compared with approximately 50/50 for an uncontrolled landfill). The only effective means of eliminating methane emissions from the disposal of wood residues that would otherwise be buried in a landfill is to use the material as fuel. Table 3 shows emissions factors for burial of waste wood in landfills, emissions estimates for open burning of biomass residues under various conditions, as well as emissions factors for other activities described in the following sections. Table 3 also shows emissions factors for fossil fuel-fired electricity production, based on and other sources. These data include only the emissions at the power plant, not those associated with producing and processing the fuels.

TABLE 3

Emissions Factors for Biomass Disposal Activities and Energy Production Activities

	sulfur dioxides (lb/th.bdt)	nitrogen oxides (lb/th.bdt)	particulate (lb/th.bdt)	carbon monoxide (lb/th.bdt)	methane (lb/th.bdt)	non-methane hydro carbons (lb/th.bdt)	carbon dioxide (ton/th.bdt)	landfill (m^3/th.bdt)	thinned (acres/th.bdt)
DISPOSAL ACTIVITY									
open burning	150	7,000	15,000	150,000	8,000	24,000	1,690		
landfill					430,000		1,200	2,400	
composting - immediate					33,000		850		
composting - delayed					65,000		800		
spreading					130,000		1,600		
forest accumulation	150	7,000	21,000	280,000	7,000	23,000	1,690		40
ENERGY PRODUCTION ACTIVITY									
biomass energy*	150	2,500	450	7,500	250	25	1,780	24.2	
coal (unit/mmkWh)	3,500	3,100	140	960	15	290	1,100	43.9	
gas/st (unit/mmkWh)	6	270	80	910	25	60	600		
gas/cc (unit/mmkWh)	5	85	330	860	130	60	450		

** Note that for biomass energy production, unit/th.bdt is approximately the same as unit/mmkWh.*

lb/th.bdt = pounds per thousand bone dry tons
mmkWh = 1,000 MWhs

gas/st = natural gas steam unit
cc = natural gas combined cycle unit

The immediate result of diverting landfill-bound waste wood to a power plant is that virtually all the carbon content is added to the atmospheric stock of carbon dioxide, rather than being stored underground as buried waste. This means that the atmospheric greenhouse gas burden associated with the biomass residue used as fuel is greater in the immediate aftermath of its combustion than if the material were landfilled. Over time, however, the landfill out-gases a mixture of methane and carbon dioxide, and the much greater radiative effectiveness of methane rapidly leads to a greater greenhouse gas burden, which eventually becomes a major liability for the landfill option, even with the use of gas control systems on landfills.

Environmental Impacts of Energy Generation from Biomass

Combustion of biomass fuels in modern power plants leads to many of the same kinds of emissions as the combustion of fossil fuels, including criteria air pollutants and solid wastes (ash). Fuel processing, which in most cases involves some type of grinding operation, produces emissions of dust and particulates. Air emissions and water consumption are usually the principal sources of environmental concern related to biomass combustion facilities. Biomass power plants are required to achieve stringent emissions control levels for the criteria, or regulated, pollutants. These include particulates, nitrogen oxides, oxides of sulfur, hydrocarbons, and carbon monoxide. Nitrogen oxides, hydrocarbons, and carbon monoxide are usually controlled by using advanced combustion technologies, often including fluidized-bed combustors, staged-combustion, and flue-gas recirculation. Newer biomass power facilities are required to use ammonia injection to further control nitrogen oxide emissions. Sulfur oxide emissions generally are not a concern with biomass combustion because biomass, especially woody forms of biomass, has a very low sulfur content. Some facilities that have fluidized-bed combustors inject limestone to capture sulfur, but biomass facilities are generally not required to have flue-gas scrubbers to control sulfur oxide emissions. Particulates are controlled using a variety of technologies. Virtually all biomass power plants use cyclones to remove most large particulates from the flue gas. Most biomass combustion facilities are equipped with electrostatic precipitators for final particulate removal; some facilities use baghouses. Most modern biomass power plants are required to achieve near zero visible emissions to meet environmental permit conditions. Emissions of particulates are also regulated and controlled to stringent levels, usually comparable to the emissions levels achieved by the large fossil fuel electric generators.

Table 4 shows average emissions levels of the criteria pollutants for biomass power generation. The data is useful for differentiating biomass emissions by combustor type. The fluidized-bed combustors achieve lower emissions levels of all criteria pollutants of concern for biomass power plants, compared to the grate-burners. The most dramatic difference is in carbon monoxide emissions, for which the fluidized-bed combustors are more than an order of magnitude better than the

TABLE 4

Emissions from Biomass Power Plants (lb.bdt)

	PERMIT LEVELS			MEASURED EMISSIONS		
	All	Grates	FBs	All	Grates	FBs
nitrogen oxides	2.6	3.1	1.5	2.0	2.5	1.0
sulfur oxides	1.2	0.9	1.7	0.1	NA	0.1
carbon monoxide	11.5	16.3	2.0	10.3	14.7	0.2
hydrocarbons	1.7	1.8	1.6	0.5	0.7	0.1
particulates	0.8	1.0	0.6	0.5	0.6	0.3

Data averaged for 34 California biomass facilities, 23 grates, 11 fluidized-bed burners.

grate-burners. The fluidized-bed combustors achieve emissions factors of half or less than the grate-burners for all pollutants for which data are available.

The production of electricity in biomass power plants can help reduce air pollution by displacing the production of power using older, more conventional sources. The full net emissions reductions can be calculated as the difference between the net emissions associated with the biomass power cycle alone, and those that would have been produced by the displaced fossil fuel-based generation.

Finally, mention must be made of the concerns of exotic plants being dedicated to biomass production. While certain non-indigenous plants have very rapid growth rates and thus make superior candidates for dedicated biomass crops, the impact of the introduction of such plants into Florida must be carefully evaluated. Due to our climate conditions, a number of invasive plants have created problems and without proper evaluation, dedicated biomass plants could have similar consequences. In fact, plants considered invasive by one state or section of the country may be deemed beneficial by other regions. The recent interest of the JEA in purchasing Arundo donax is one such example.[11]

Co-Firing Biomass as an Alternative

During 2001, three Florida facilities reported combusting over 700,000 tons of bark/wood as a primary fuel (Okeelanta, Ridge and Jefferson Power) for the generation of electricity to the grid. Additionally, some facilities have been permitted to combust agricultural fuels by co-firing with coal. Co-firing refers to the use of biomass derived fuels blended with non-biomass fuels where both are simultaneously fed into combustion boilers. Such firing can be accomplished with solid biomass fuels or biomass that has been gasified. The City of Lakeland and Tampa Electric Company (TECO) have received permits for co-firing at specific generating units. Dr. Alex Green from the University of Florida stated at the July 2, 2002 FPSC workshop that co-firing was a feasible, near term option to increase the use of renewable energy in Florida.[12]

Generally speaking, emissions of air-borne pollutants of high concern (such as sulfur dioxide and nitrogen oxide) are reduced when agricultural products are co-fired with coal, even though some pollutants (such as carbon monoxide) may actually increase. Technical problems can exist with the direct application of specific coal-fired clean-up and handling equipment due to differences in the physical properties of coal and biomass, but these can be mitigated by appropriately limiting the biomass fuel percentage used for co-firing. During 2001, one coal-fired unit (at TECO's Gannon station) reported combusting over 500 tons of wood via co-firing, although this facility is currently being repowered as a natural gas combined cycle facility. However, Florida has ten other coal-burning facilities which are possible candidates for such an operation.

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[11] "Arunda Has 2 Lives: A Pest in California But to Florida a Boon." *Wall Street Journal*, October 16, 2002, p. A1.

[12] Presentation by Dr. Alex Green of the Interdisciplinary Center for Aeronomy and Atmospheric Sciences (ICAAS). FPSC Workshop, July 2, 2002, Tallahassee, Florida.

Municipal Solid Waste

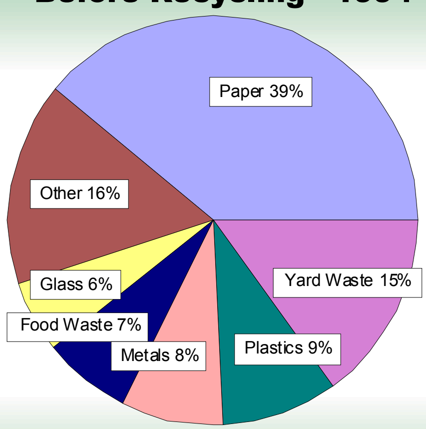
As defined by the Florida legislation for purposes of this study, biomass means a power source that is comprised of, but not limited to, combustible residues or gasses from forest products manufacturing, agricultural and orchard crops, waste products from livestock and poultry operations and food processing, urban wood waste, municipal solid waste, municipal liquid waste treatment operations, and landfill gas. Within this group of defined biomass, municipal solid waste represents the largest existing source of renewable energy in Florida. Waste-to-Energy (WTE) facilities play an important role in Florida's use of biomass. Based upon a presentation by the Integrated Waste Services Association, WTE is an essential component of Florida's municipal solid waste management strategy. Over 50 percent of Florida's population is served by solid waste management systems that include WTE and over one-third of Florida's waste is disposed of through WTE facilities.

Municipal Solid Waste Industry Profile

The municipal solid waste (MSW) industry has four components: recycling, composting, landfilling, and combustion. The U.S. Environmental Protection Agency defines MSW to include durable goods, containers and packaging, food wastes, yard wastes, and miscellaneous inorganic wastes from residential, commercial, institutional, and industrial sources. It excludes industrial waste, agricultural waste, sewage sludge, and all categories of hazardous wastes, including batteries and medical wastes.

FIGURE 6

Total U.S. Waste Generation Before Recycling - 1994



Source: U.S. Environmental Protection Agency, *Municipal Solid Waste Factbook*, database version 3.0 (Washington, D.C., March 1996).

More than 209 million tons of MSW was generated in the U.S. in 1994. Paper and paperboard accounted for 81.3 million tons (38.9 percent) of the total waste stream, yard wastes 30.6 million tons (14.6 percent), plastics 19.8 million tons (9.5 percent), metals 15.8 million tons (7.6 percent), food 14.1 million tons (6.7 percent), glass 13.3 million tons (6.3 percent), and "other" 34.2 million tons (16.4 percent).

Trends in Municipal Solid Waste Generation

Nationally, the production of MSW has increased from 88 million tons in 1960 to 209 million tons in 1994. During that time, per capita production of MSW increased from 2.7 pounds per person per day to 4.4 pounds per person per day. Per capita MSW production was expected to remain constant through 2000, when total MSW generation was expected to reach 223 million tons. Florida is expected to produce over 38 million tons of MSW by year 2018, as compared to 15 million tons in 1998.

As illustrated in Table 5, in 1960, approximately 30 percent, or 27 million tons, of MSW produced in the U.S. was incinerated, most without energy recovery or air pollution controls. During the next two decades, combustion declined steadily to 13.7 millions tons by 1980, as old incinerators were closed. Less than 10 percent of the total MSW generated in 1980 was combusted. With the enactment of the Public Utility Regulatory Policies Act of 1978 (PURPA) which created a guaranteed energy market, combustion of MSW increased to 31.9 million tons or 16 percent by 1990. At present, all of the major new WTE facilities are designed with air pollution controls and have energy recovery capability. During the 1990s, the absolute amount of MSW combusted and converted into energy remained fairly constant, although the share declined slightly. By the year 2000, the entire amount of MSW combusted in the country was expected to reach 34 million tons. During 2001, Florida combusted over 4 million tons of MSW as well as over 1 million tons of refuse derived fuel.

TABLE 5

Historical and Estimated U.S. Production of Municipal Solid Waste (MSW) Years 1960-2000 (Million Tons)

DISPOSITION	1960	1970	1980	1990	1991	1992	1993	1994	2000
Combustion*	27.0	25.1	13.7	31.9	33.3	32.7	32.9	32.5	34.0
Recovery for Recycling and Composting	5.6	8.6	14.4	32.9	37.3	41.5	45.0	49.3	66.9
Discards to Landfill	55.3	89.5	124.3	132.3	126.2	128.8	129.0	127.3	122.0
Total Production	**87.8**	**121.6**	**152.4**	**197.1**	**196.8**	**206.9**	**203.9**	**209.1**	**222.9**

* Includes combustion of MSW in mass burn or refuse-derived form, incineration without energy recovery, and combustion with energy recovery of source-separated materials in MSW.

Note: Totals may not equal sum of components due to independent rounding.

Sources: 1960, 1970, 1980, 1990, 1994, and 2000: U.S. Environmental Protection Agency, *Municipal Solid Waste Factbook*, database version 3.0 (Washington, DC, March 1996). This source has revised some of the historical data. 1991, 1992, and 1993: U.S. Environmental Protection Agency, *Characterization of Municipal Solid Waste in the United States: 1995 Update*, EPA/530-S-96-001 (Washington, DC, March 1996).

FDEP records indicate that as of 1998, 57 percent of the waste stream in Florida was landfilled, 13 percent combusted, and the remainder recovered.

Waste-to-Energy (WTE) Facilities

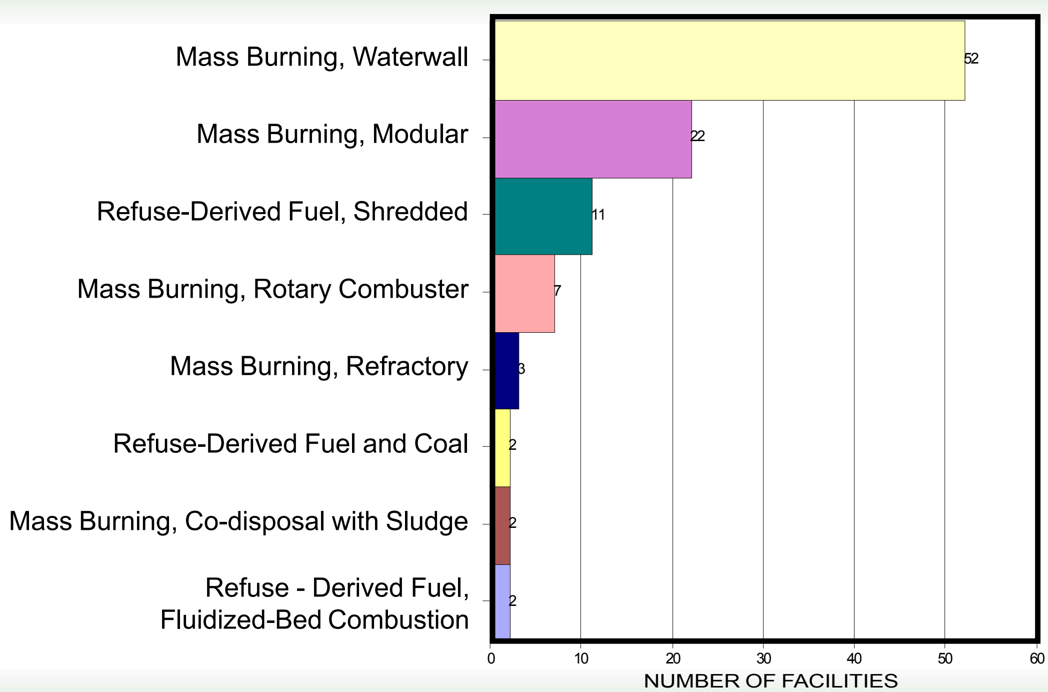
As of the fall of 1996, there were 102 WTE facilities marketing energy in the United States. The number of facilities had declined by more than 10 percent during the years prior to 1996. Most of the WTE facilities in the United States are located in the East, where landfill space is the scarcest. WTE capacity had declined by approximately 2 percent during the prior year or so, from almost 101,000 tons per day to approximately 99,000 tons per day.

Generally, WTE facilities can be divided into two process types: mass burn and refuse-derived fuel (RDF). Mass burn facilities process raw waste; it is not shredded, sized, or separated before combustion. Very large items such as refrigerators or stoves and hazardous waste materials such as batteries are removed before combustion. Non-combustible materials such as metals can be removed before or after combustion, but they are usually separated from the ash with magnetic separators. The waste is usually deposited in a large pit and moved to furnaces with overhead cranes. Combusting waste usually reduces its volume by approximately 90 percent. The remaining ash is buried in landfills. The ash is divided into two categories: bottom ash and fly ash. Bottom ash is deposited at the bottom of the grate or furnace. Fly ash is composed of small particles that rise during combustion and are removed from the flue gases with fabric filters and scrubbers.

Waste is preprocessed prior to combustion at RDF facilities. Non-combustible materials are removed, increasing the energy value of the fuel. The extent to which non-combustible materials are removed varies. Most systems remove metals with magnetic separators; glass, grit, and sand may be removed through screening. Some systems utilize air classifiers, trammel screens, or rotary drums to further refine the waste. Mass burn waterwall facilities are usually custom-designed and constructed at the site. Waterwall furnaces contain closely spaced steel tubes that circulate water through the sides of the combustion chamber. The energy from the burning waste heats the water and produces steam. Some waterwall facilities also use rotary combustors to rotate the waste, resulting in more complete combustion.

FIGURE 7

Number of Facilities Performing Waste-to-Energy Operations by Process Type - 1996 (United States)



Note: One reporting facility did not list type of process.
Source: Derived from Governmental Advisory Associates, Inc., *Municipal Waste Combustion in the United States: 1996-97 Yearbook, Directory, and Guide* (Westport, CT, 1997).

The overall majority of WTE facilities in the United States employ mass burn processes. Of the 101 facilities reporting the type of process employed in 1996, 86 were mass burn facilities and 15 were RDF facilities. Two of the mass burn facilities co-disposed their waste with sludge. Within Florida, 11 of the 13 facilities are of the mass burn, waterwall type. Only 3 of Florida's electrical generating facilities reported combusting RDF during the year 2001, one of which was a coal-facility that had co-fired the fuel. Two Florida facilities are designed to fire primarily RDF.

The average capacity to burn waste at U.S. WTE facilities was reported as almost 1,000 tons per day in 1996. RDF facilities, on average, have more than twice the capacity to burn waste as mass burn facilities (almost 1,900 tons per day versus 850 tons per day). For reference, the two RDF facilities in Florida are capable of handling over 1,800 and 2,600 tons per day, respectively.

Solid Waste Management in the State of Florida

As of 1998, Florida had established the largest capacity to burn MSW/RDF of any state in the U.S., with actual combustion in calendar year 2001 at nearly 5.5 million tons, or approximately 15,000 tons per day and with a capacity of 19,000 tons per day. As noted, the operating WTEs in Florida have the capacity to generate nearly 600 MWs of electricity (at a heat rate of about 16,000 btu/kWh) and have become an essential component of Florida's MSW management strategy.

The FDEP, in the annual report entitled *Solid Waste Management in Florida*, estimates that yard trash represents about 14 percent and construction and demolition (C&D) debris represents another 23 percent of the total waste generated in Florida. A significant component of the C&D debris is clean wood material which is suitable boiler fuel. In summary, it is reasonable to assume that well over 20 percent of the total waste generated in Florida is clean biomass material which could be used as fuel in biomass power plants.

Florida currently collects about 28 million tons of solid waste per year. By 2018, FDEP projects that solid waste collection will increase to 38 million tons per year. It should be noted that there is additional solid waste material which is generated but disposed of outside the solid waste management system. For example, land clearing debris is often open burned on-site rather than transported to a landfill. Based on the above figures, it can be inferred that there are as much as 5.6 million tons per year of available biomass material in Florida which could be used as fuel. By 2018, the figure could increase to 7.6 million tons per year. If it is conservatively assumed that only 50 percent of this material can be practically recovered and processed into fuel, this volume of biomass could supply over 300 MW of new renewable generating capacity per year at an 80 percent capacity factor.

A primary factor favoring the development of WTE in Florida is the adverse environmental and land use consequences of landfilling and the failure of competing disposal technologies other than landfilling. By the early 1980s, increasing ground water contamination from unlined landfills began to become apparent, and many landfills ended up on the National Priority List as Superfund sites. Even when lined, because of Florida's generally high ground water conditions, landfills begin at ground level and go up, in a "high rise" configuration. While protective of ground water, these landfills can rise to as high as two hundred feet above ground level and are prominent features of the landscape in many Florida counties. In fact, the landfill is commonly the highest elevation in Florida coastal counties. In addition, as population density increases, particularly in the coastal counties, finding a suitable site for a landfill, where typically 1,000 to 4,000 acres of land are needed, at a reasonable cost is becoming nearly impossible. A related issue is the lack of success of competing technologies for disposal other than landfilling. Mixed waste composting was touted in the early 1980s as a cost-effective rival of WTE, but several mixed waste composting projects have failed in Florida. At this time, only one small mixed waste facility is in operation in Central Florida.

A second factor spurring WTE development was the energy crisis of the mid-1970s, which led to increased interest in alternative energy technologies. Indeed, alternative energy resource development planning of that era included WTE as a central element, although in retrospect it appears that the amount of energy available from this source may have been overestimated.

Thirdly, WTE was given a major boost in Florida in the late 1970s with the passage of several key pieces of State Legislation that created favorable legal and tax conditions for the construction of WTE facilities. The Florida Resource Recovery Act created the Resource Recovery Council to evaluate and promote resource recovery, which includes WTE. The Act further directed the 19 most populous Florida counties to draft resource recovery and management plans to determine if WTE was a feasible option. As a consequence, through the remainder of the 1970s, comprehensive evaluations of WTE were conducted in all of Florida's most populous areas.

Moreover, in response to concerns from the financial community about the fiscal viability of resource recovery facilities without a guaranteed waste stream, the State Legislature enacted a flow control statute. This provision authorized counties which were undertaking resource recovery, to direct the flow of MSW generated in the county to a designated solid waste disposal facility. WTE and other resource recovery facilities were given a further advantage when the legislature exempted resource recovery equipment owned by, or operated on behalf of, local governments from the state sales tax.

In the comprehensive Solid Waste Management Act of 1988, WTE received an additional financial incentive. The Act directed that, when the utility industry purchased electricity from WTE facilities, the WTE facilities were to be assumed to have a 100 percent capacity factor. Other cogeneration facilities selling to utilities have a lower capacity factor, for example, 80 percent. This increased the revenues to the MSW plants from energy production. However, at the time of the 1993 revisions to the Solid Waste Management Act, much of the early enthusiasm for WTE had cooled because of perceived conflicts with recycling and concerns about emissions.

Regarding recycling, concerns began to be raised that WTE was in conflict with the State's recycling program. It was feared that if there were excess WTE capacity, materials that would have otherwise been recycled would be burned. To ensure that no excess WTE capacity developed, the 1993 Amendments subjected WTE facilities to a series of new siting and need criteria considered during the siting of new facilities and expansion of existing facilities. Key among these criteria are the requirements that WTE facilities cannot be built unless the county in which the facility was to be located had met the State's required 30 percent waste reduction goal, and the county can show that the facility is an integral component of the county's solid waste management program.

Another issue affecting development of mass burn WTE facilities is the fact that such facilities were identified as significant sources of mercury. The primary sources of mercury in MSW include: batteries, mercury containing devices such as thermostats, thermometers and switches, and lighting. In a study conducted for the then Florida Department of Environmental Regulation (now the FDEP) in 1992, WTE plants were determined to be one of the major sources of anthropogenic mercury emissions. Other major sources include biomedical waste incinerators and fossil fuel power plants. In the 1993 Amendments, measures were enacted to reduce mercury in the waste stream. These included provisions to control the amounts of mercury in packaging and batteries, and the required recycling of mercury containing batteries, devices and bulbs. The 1993 legislation further called for a demonstration project to collect and recycle fluorescent tubes. In October 1993, Florida's Environmental Regulation Commission (ERC) adopted the strictest mercury emission limit in the nation for WTE facilities. Additionally, all new and existing WTE units with capacity to incinerate 250 tons per day or more are required to meet the EPA's Maximum Achievable Control Technology (MACT) standards.

Finally, Chapter 403.706(4)(a) Florida Statutes, outlines Florida's recycling requirements with respect to municipal waste. A county's solid waste management and recycling programs shall be designed to reduce total waste volume by 30 percent prior to final landfilling or incineration. Biomass yard trash is only allowed a certain percentage toward this goal if a composting or mulching program is in place. Thus, fuel that could be directed into renewable generators is incented to be mulched. If the legislature decides to promote additional renewable fuel generation, it may wish to consider revising this statute to ensure that the policy objectives and incentives are aligned.

Typical Air Pollution Control Equipment

Table 6 illustrates the various types and designs of air pollution control equipment which are used by most WTE facilities. Dry scrubbers and baghouse filters used in combination are more efficient than most electrostatic precipitators in removing acid gases and particulates from stack gases. Nitrogen oxide and mercury emissions must also be controlled. Modular facilities that have exclusively used afterburn or two-chamber combustion systems can no longer rely on those systems for adequate pollution prevention in many parts of the United States. As a result, some have been retrofitted, whereas others have permanently closed down.

TABLE 6

Air Pollution Control Equipment at Waste-to Energy Facilities by Type of Process, 1996 (%)

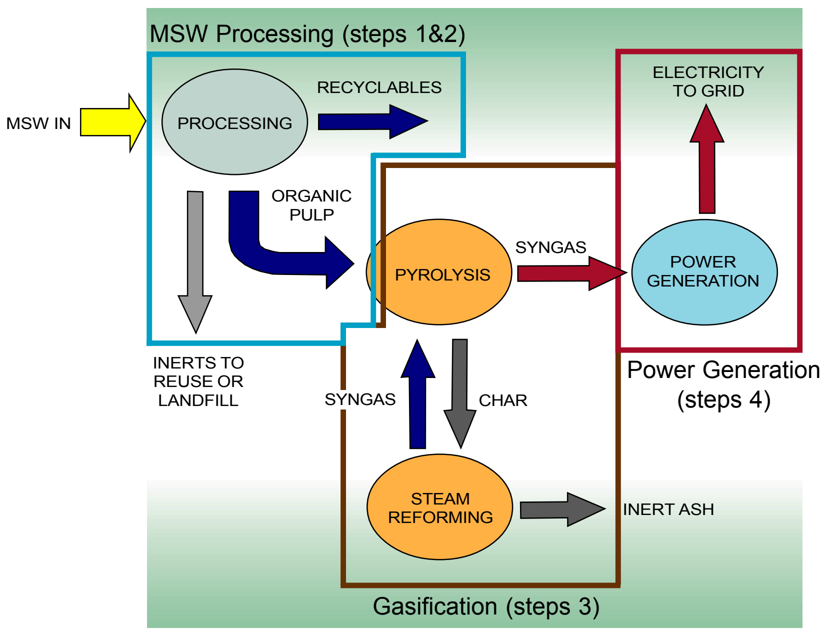
TYPE OF EQUIPMENT	MASS BURNING	MODULAR UNITS	ALL RDF PROCESSES
Dry Scrubbers	68.7	22.7	80.0
Baghouse/Fabric Filters	53.1	22.7	60.0
Electrostatic Precipitators	39.1	63.6	46.7
Wet Scrubbers	1.6	13.6	6.7
Ammonia De NO_x System	21.9	4.5	20.0
Dry Sorbent Injection	25.0	0.0	6.7
After-Burn System	0.0	22.7	0.0
Other Technologies	3.1	13.6	20.0

RDF = refuse-derived fuel.

Note: One facility did not list process type.

Source: Derived from Governmental Advisory Associated, Inc., *Municipal Waste Combustion in the United States: 1996-97 Yearbook, Directory, and Guide* (Westport, CT, 1997).

A major element in both the size and cost of WTE technology has been the steadily increasing requirements for air pollution control equipment. The earliest plants built were required to have electrostatic precipitators (ESP) for particulate control. By the late 1980s, dry scrubbers for acid gas controls were required as well as filter fabric baghouses (FF) for particulates. The latest plant built, in 1994, was required to have dry scrubbers and FF, as well as nitrogen oxide controls and continuous emission monitors (CEM). Now, the Lee, Lake and Pasco plants have also installed an activated carbon injection system (CI) for mercury and dioxin control. Recent technological advances and reduced costs have allowed nitrogen oxide control technologies such as Selective Catalytic Reduction (SCR) to become a viable add-on control for newer units. As a result of the Clean Air Act Amendments of 1990, all WTE facilities in Florida without dry scrubbers or FF have since been retrofitted.



An alternative means of converting waste to energy was developed by Brightstar Environmental, an Australian company. Brightstar utilizes a process which is unlike the typical mass burn combustion predominant in Florida. Their stated goal is "100% utilization of MSW through recycling, conversion to energy and utilization of residuals in useful products." The key steps of this process are: 1) the waste is autoclaved; 2) recyclable materials are recovered; 3) organics are pyrolytically converted to syngas; and, 4) syngas is used as fuel to produce power.

Brightstar currently employs this process at a facility (the SWERF plant) in Wollongong, NSW, Australia. Based upon FDEP reviews of gasification projects, the reliability of gasification equipment will continue to be a challenge for the foreseeable future. However, given that SWERF is capable of diverting up to 90 percent of waste from a landfill, while generating electricity with emissions touted as being comparable to natural gas fired generators, the process appears promising. The FDEP understands that at least two entities are considering its application within Florida.

Landfill Methane Gas

Landfills across the United States represent a source of potential energy. For every 1 million tons of MSW placed in a landfill, sufficient landfill gas (LFG) is produced to generate approximately 8500 MWhs of electricity. Landfill gas is created when waste in a landfill decomposes. This gas is about 50 percent methane, commonly referred to as natural gas, and 45 percent carbon dioxide. Instead of allowing landfill gas to escape into the air or flaring it, the gas can be captured, converted, and used as an energy source. Using the gas helps to reduce odors and other hazards associated with landfill gas emissions, and helps prevent methane from migrating into the atmosphere.

Landfill methane projects can involve a variety of power generation technologies in a wide range of sizes. The size and type of generation technology depends upon the amount of methane captured. Landfills with low capture rates use internal combustion engines with a capacity of 250 kW and above, while those with medium capture rates can use gas turbines with a capacity of 3 MW and above. Landfills with high capture rates can use Rankine Cycle steam turbines with a capacity of 8 MW and above, or combined cycle engines with capacity of 20 MW or greater.

Landfill methane generation has attracted considerable attention due to its relative ease of installation and its clear environmental benefits. On an electricity production basis, when burning methane that would otherwise be released from a landfill into the atmosphere, a landfill gas fueled electric generator typically avoids the equivalent of 10,000 to 15,000 pounds of carbon dioxide per MWh. In effect, such a landfill gas fueled electric generator may be offsetting more carbon dioxide emissions per MWh of electric generation than is emitted from coal plants or other common forms of electric generation.

Landfill methane project economics are promising, with electricity costs from different landfill methane options falling within the general range of costs for new combined cycle natural gas plants. In addition to the 200 landfill methane recovery projects in the United States, the EPA estimates that up to 500 landfills in the United States could install economically viable landfill energy projects.

Extraction of Landfill Gas

The technology for converting landfill gas to a useful source of energy has been improving continuously. With careful maintenance programs in place, a landfill gas collection system can be optimized, transforming a potential liability into an asset. What follows is a brief description of the general process for extracting landfill gas.

1. An active landfill. Organic (biodegradable) waste is placed in an engineered repository and compacted to a specified density. The layers generally become stratified and, once microbial activity takes over, gas production begins.

2. The site is at the beginning of the methane-producing phase. To ensure a successful power generation scheme, it is essential to prove the gas resource before construction of the power station starts. This is a two-staged process; the first is a theoretical study, whereby a series of gas production curves are generated. This is then backed up with an on-site pumping trial.

3. Installation of a full gas extraction system. This involves drilling into the landfill, installing a series of gas extraction wells and connecting pipe. It is essential at this stage to ensure that all pipework is laid properly, as the process of methane production within a landfill produces saturated landfill gas.

4. The extraction wells are joined together via a series of pipelines. In some landfill sites these are buried to return the site to its pre-installation standard of restoration. As noted, it is essential to ensure that the pipelines are of the correct size and are laid to adequate falls to shed the condensate.

5. Power generation can begin once the pipeline is connected to the engines. These must be selected so as to be adequate for use with a poor quality gas. With careful handling, it is possible for the engines to produce electricity at up to 95 percent availability. A detailed program of maintenance on the engines, together with a comprehensive gas extraction system maintenance plan, will ensure that electricity production is optimized.

Electricity Production from Landfill Gas in Florida

According to FDEP records, landfill gas was utilized for the production of electricity at four facilities in 2001: JEA Northside (which is being repowered as a CFB coal facility), East Duval Sanitary Landfill, Volusia Solid Waste Management and Ridge Generating station. These facilities reported 2333 thousand cubic feet of consumption, yielding an equivalent 1.5 MW of continuous electricity production to the grid.

Based upon analyses prepared by Energy Developments, Ltd., Florida has the potential for 143 MW of landfill gas generating capacity.[13] Since most Florida landfills which are large enough to support power generation projects already have LFG collection systems and flares in place or planned, conversions are readily accommodated. Additionally, environmental permitting should be straightforward via the modification of existing permits as well as obtaining building and zoning approvals. Energy Developments indicates that facilities such as this require no additional water and support zero water discharges to the environment.

At the national level, the U.S. Department of Energy has attempted to estimate the potential for landfill methane production and the associated megawatts that it could support for each of the electric reliability regions in the country. Using various assumptions about the methane yield potential, the study indicated that Florida's landfills could support approximately 199 MWs of capacity. The vast majority of these landfills are low yield methane and thus the associated costs would be higher.[14] Therefore, each landfill type has associated differences in terms of generator size, number of wells, and cost of gas cleanup, piping, and other gas collection and generating requirements. These variations lead to different production costs of electricity due to increases in material cost as well as economies of scale. In general, high methane yield sites produce electricity at a lower cost per kilowatt-hour than lower yielding sites.

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[13] David R. Wentworth, Energy Developments, *Landfill Gas to Electricity Development in the State of Florida.* Presentation at the FPSC Staff Workshop on Renewables, July 2, 2002, Tallahassee, FL.

[14] *Model Documentation - Renewable Fuels Module of the National Energy Modeling System.* United States Department of Energy, Energy Information Administration, February, 2002.

The U.S. Environmental Protection Agency has a "Landfill Methane Outreach" program to encourage the use of landfill gas as an energy resource.

Digester Gas

In recent years increasing awareness that anaerobic digesters can help control waste odor and disposal has stimulated renewed interest in the technology. The application of anaerobic digesters in the treatment of human wastes at modern wastewater treatment plants has become commonplace. Dairy farmers faced with increasing federal and state regulation of the waste their animals produce are looking for ways to comply. New digesters are currently being built because they effectively eliminate the environmental hazards of dairy farms and other animal feedlots.

Anaerobic digester systems can reduce fecal coliform bacteria by more than 99 percent, virtually eliminating a major source of water pollution. Separation of the solids during the digester process removes about 25 percent of the nutrients, and the solids can be culled out of the drainage basin where nutrient loading may be a problem. In addition, the digester's ability to produce and capture methane reduces the amount of methane that otherwise would enter the atmosphere and provides an opportunity for power generation.

Types of Anaerobic Digesters

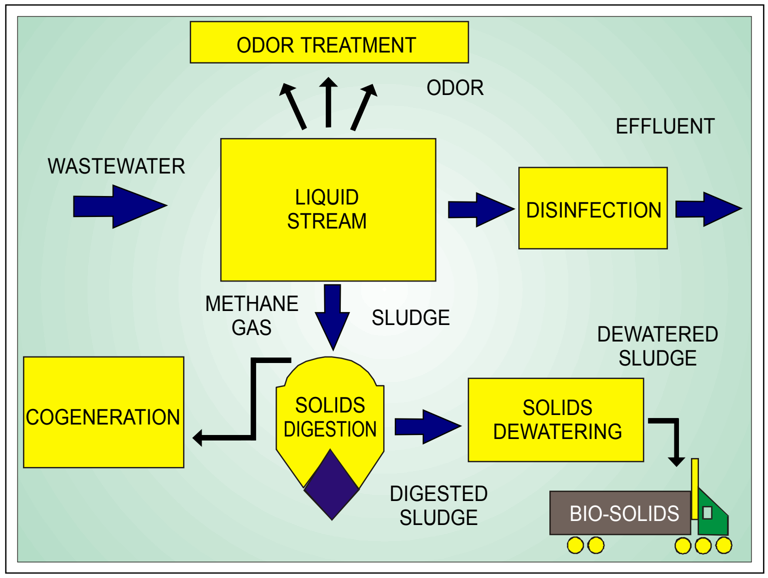
There are three basic digester designs. Each can trap methane and reduce fecal coliform bacteria, but they differ in cost, climate suitability, and the concentration of solids they can digest.

A *covered lagoon digester*, as the name suggests, consists of a solids storage lagoon with an impermeable cover. The cover traps gas produced during decomposition of the solids. Covered lagoon digesters are used for liquid manure with less than 2 percent solids, and require large lagoon volumes and a warm climate. This type of digester is the least expensive of the three, but is typically used for small applications.

A *complete mix digester* is suitable for wastes that are 2 percent to 10 percent solids. Complete mix digesters process solids in a heated tank above or below ground. A mechanical or gas mixer keeps the solids in suspension. However, complete mix digesters are expensive to construct and cost more than a plug-flow digester to operate and maintain.

Plug-flow digesters are suitable for wastes having a solids concentration of 11 percent to 13 percent. In a plug-flow digester, raw sewage slurry enters one end of a rectangular tank and decomposes as it moves through the tank. New material added to the tank pushes older material to the opposite end. Coarse solids form a viscous material as they are digested, limiting solids separation in the digester tank. As a result, the material flows through the tank in a "plug." Anaerobic digestion of the slurry releases gas as the material flows through the digester. A flexible, impermeable cover on the digester traps the gas. The plug-flow digester design offers a high-temperature variation. High temperature speeds the digestion process and reduces the required volume of the tank by 25 percent to 40 percent. High-temperature digesters also are more prone to imbalance because of temperature fluctuations, and their successful operation requires close monitoring and diligent maintenance.

Waste-Water Treatment Facilities (WWTF) also incorporate anaerobic digesters. The process uses bacteria, which do not need atmospheric oxygen to survive, so therefore, no air is bubbled into the tanks. In fact, air mixed with the gasses may be explosive. The anaerobic digesters produce a stable sludge, which is readily dewatered. The process is also a source of methane gas, which fuels the engine generators to produce electricity. The engines can usually run on digester or natural gas and supply electrical power to essential pieces of treatment plant equipment as well as the potential to feed the grid.



Florida's existing generating capacity from digesters is just under 8 MW and made up of many small engines. JEA is adding an additional 800 kW, which should be operational during 2002.

Example of Anaerobic Digester

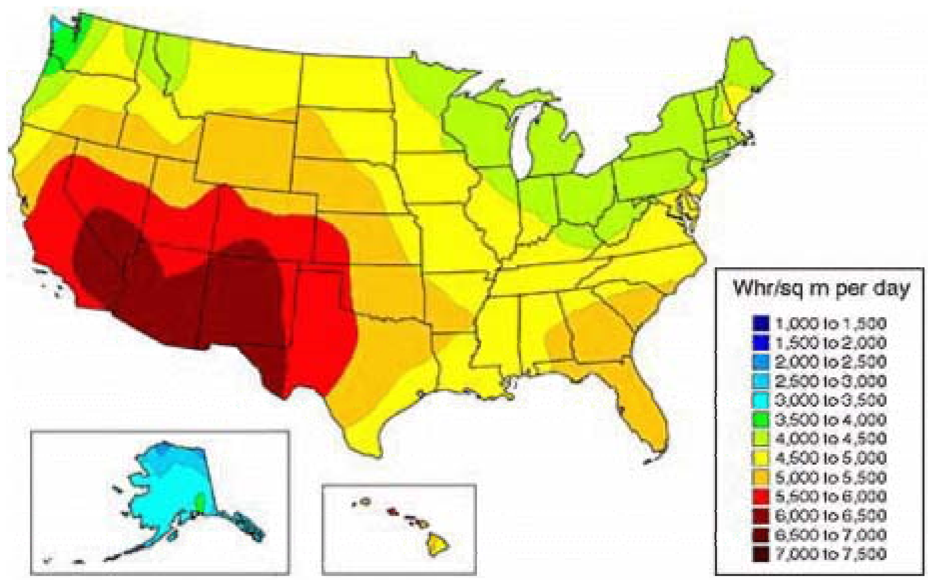
Solids collected from the various clarifier tanks are ultimately pumped to the anaerobic digesters.

In the anaerobic (absence of oxygen) digesters, different groups of bacteria further decompose the organic solids. A major by-product of this process is methane gas. The methane gas is used as a fuel for heating the digesters and several buildings and to fuel an electric generator. About 40,000 cubic feet of methane gas is produced per day. The lid of the anaerobic digester (shown in black) moves up and down and is supported by the pressure of the methane gas generated in the process.

Solar Technologies

The basic principles behind the development and practical use of solar energy are fairly simple. The sun's energy is radiated through space, filtered by our atmosphere and strikes the surface of the earth in a predictable and quantifiable manner. Thermal design applications are based upon the amount of heat energy or work to be done, and then engineered to arrive at the amount and type of collection equipment necessary. Direct thermal transfer such as solar pool or home water heating use the basic principles of radiation, conduction and convection to design a system that will provide the proper results. In the case of photovoltaics, electrons are activated using the sun's energy and the net result is a flow of electrical charge that can be used without conversion (direct current, or DC) or converted to alternating current (AC) for a broader range of uses. There are three basic applications for converting solar energy to useful energy in Florida: pool heating, water heating and photovoltaics (PV).

The efficiency of any solar technology is directly proportional to the availability of solar radiation. While solar radiation is universally available, its diffuse nature requires that it be collected and concentrated before it is available as an energy resource. This table shows the relative intensities of available solar radiation in the United States.



Solar resource for a flat-plate collector

Pool Heating

In these systems, pool water circulates through a large heat exchange surface, usually located on the roof, and absorbs the sun's energy. The principle is similar to the way a car radiator works; except these solar heat exchangers collect heat instead of radiating it. Most solar "collectors" are flat black panels manufactured from high technology plastics, which have been designed to resist weather and ultraviolet radiation.

The major advantage of these systems is that they have little or no operating cost (nor emissions). The major disadvantage is that solar does not provide heat on demand, and is dependent upon the amount of solar energy on any given day. Used in conjunction with a cover, solar can more than double the comfortable swimming season, up to nine or ten months per year.

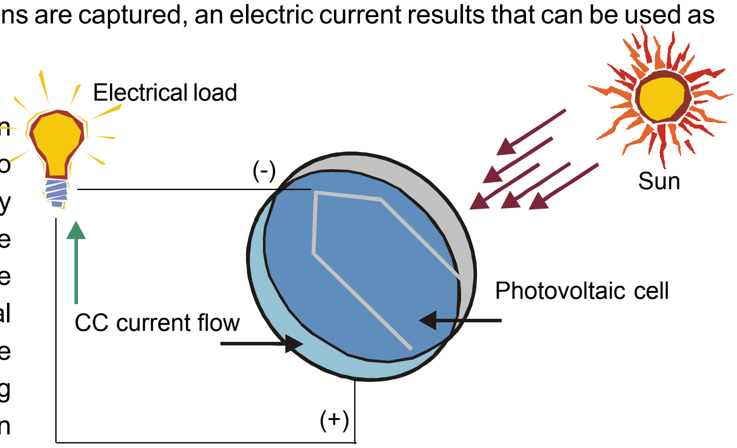
Water Heating

Although there are different types of systems (e.g. active versus passive), solar water heating systems consist of a single or multiple set of collectors on the roof, providing the heat energy that is stored in an insulated tank. In areas where freezing temperatures can occur with some regularity, such as North Florida, a heat exchange system using anti-freeze such as a non-toxic glycol solution may be used to prevent damage to the collection system on the roof. However, in most of Florida a direct exchange method using the water that actually comes out of the tap is used to carry the sun's energy from the roof into the storage tank. The tank then holds the heated water for when needed.

Photovoltaics

The ability to produce electricity directly from the sun's energy is a revolutionary development. The technology involved in the production of these silicon cells is complicated and the efficiencies are still not close to those of thermal solar applications, but these unique energy devices are now seen in places as common as landscapes (solar powered lights), highways (solar powered traffic lights and sign lights), and calculators.

Photovoltaics (PV) is the direct conversion of light into electricity. Some materials exhibit a property known as the photoelectric effect, which causes them to absorb photons of light and release electrons. When these free electrons are captured, an electric current results that can be used as electricity.



This diagram illustrates the operation of a basic photovoltaic cell, also called a solar cell. When light energy strikes the solar cell, electrons are knocked loose from the atoms in the semiconductor material. If electrical conductors are attached to the positive and negative sides, forming an electrical circuit, the electrons can be captured in the form of an electric current — that is, electricity. This electricity can then be used to power a load, such as a light bulb or a water pump. A typical four-inch silicon solar cell produces about 1.5 watts of electricity in bright noon sunshine. Remote locations such as billboards, road signs and other areas where it is cost-effective to install solar electric systems with battery backup are becoming more and more common.

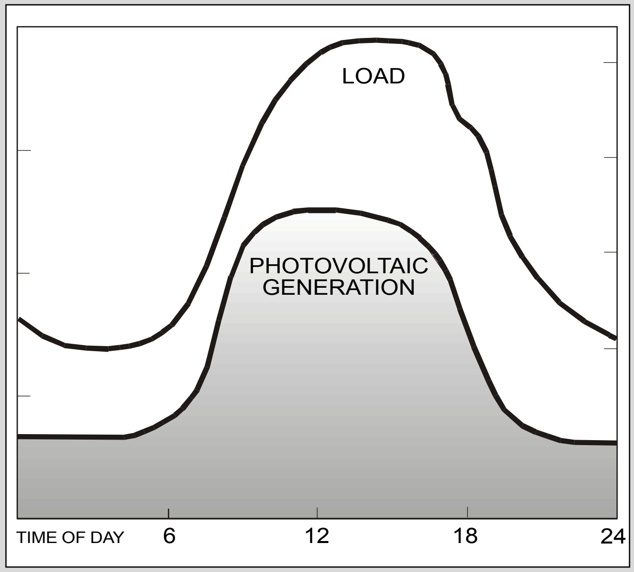
Solar Applications in Florida

The amount of solar power that is currently part of the electricity mix in the U.S. is quite small. According to the U.S. Department of Energy's *Annual Energy Review of 1999*, 0.076 quadrillion BTU's of energy were produced by solar power. This is about 0.1 percent of the overall 72.523 quadrillion BTU's produced in the U.S. This percentage is dwarfed by the 57.673 quadrillion BTU's, or 80 percent, of the total produced using fossil fuels. Coal alone fueled 52 percent of the electricity produced in the U.S. in 1999.

Since the application of solar energy in Florida has not caused air emissions to occur, FDEP's databases do not record information related to solar electrical generation. However, data obtained from the NREL indicates that approximately 70 installations of photovoltaics exist in Florida, comprising approximately 500 kilowatts (kW) of capacity as of 2001. These systems are typically sized at 4 kW or less, with the largest (EPCOT), listed as 73 kW of capacity. Though solar-powered water heaters and pool heaters are common, only about 100 homes in Florida have solar-energy systems producing electricity for the actual home, according to the Florida Solar Energy Center (FSEC). New Smyrna Beach has nine of them, with three more planned for Fall 2002.

Solar Potential

A recent study performed by the FSEC stated that if the potential market for solar water heaters in the U.S. were fully realized, 41 million kWh would be generated per year. However, more promising is the potential to utilize photovoltaics for peak shaving. In order to better understand this, some definitions are in order. Effective load-carrying capacity (ELCC) is the ability of a power generator — whether PV or conventional — to effectively contribute to a utility's capacity, or system output, to meet its load. Therefore, ELCC for a photovoltaic system represents PV's ability to provide power to the utility when it is needed. A typical example of high ELCC for PV occurs when the utility system load reflects commercial customers' demand for midday air-conditioning; this load is a good match to PV's power output. A graphic example of this is depicted in the chart above.



Utility load and PV output versus time of day.

Florida's summer loads are largely driven by air-conditioning demand. Of course, air-conditioning demand is highest on clear sunny summer days, correlating to the maximum periods of PV generation. Accordingly, the application of PV in Florida, for the specific application of reducing *summer peak loads* appears to be a reasonable fit. However, depending on the extent and duration of winter cold fronts, utilities in Florida can also experience a winter demand peak. In such cases, solar makes little if any contribution to avoidance of installed capacity to serve winter demand.

Hydroelectric Generation Technologies for Florida

There are three primary types of hydropower facilities. *Storage projects* impound water behind a dam, forming a reservoir. Water is then released through turbine-generators to produce electricity. The water storage and release cycles are variable. In contrast, *run of the river* projects typically use relatively low dams where the amount of water running through the turbines is determined by the water flowing in the river. Electricity generation from these plants will vary with changes in the amount of water flowing in the river. Finally, *pumped storage* projects use off-peak electricity to pump water from a lower reservoir to an upper reservoir. During periods of high electrical demand, the water is released back to the lower reservoir to generate electricity.

Negative environmental effects can occur for each type of facility. For example, with storage projects such as dams, the associated environmental impacts may include altered flow regimes, water quality degradation, and mortality of fish that pass through hydroelectric turbines. Generally, run of the river projects have the least environmental effects on aquatic life. Lastly, pumped storage projects may result in lower water levels, which can decrease fish habitat and possibly hurt spawning and nursery areas. Water quality may also be affected.

Changing operations can significantly reduce many impacts. For example, installing fish passage systems can reduce impacts on migratory fish. Converting a dam from peaking to run of the river operation can ensure that the natural flow of the river remains undisturbed and can adapt the hydropower facility to the unique conditions of each river system. Because every river and dam are different, the type and severity of impacts caused by each dam varies.

With respect to future development opportunities, a total of 13 sites in Florida were identified and assessed for their undeveloped hydropower potential.[15] The analysis results for individual site capacities range from 200 kW to 18 MW. The majority of the hydropower sites reviewed for Florida are greater than 1 MW, and less than 10 MW. The undeveloped hydropower potential total for Florida was identified as 61 MW. The 13 identified sites were located within one major river basin and several minor river basins. Most of the hydropower sites (11 sites) were located within the many minor river basins in Florida. Only two sites were located within the major river basin, Apalachicola River basin. It should be noted that about 41 percent of the undeveloped hydropower potential in Florida was contained in two sites located within the Florida Apalachicola River basin.

An analysis using Hydropower Evaluation Software (HES) was then run on the 61 MW of undeveloped power to more precisely evaluate the expected output of these specific locations. The results of the analysis concluded that 43 MW was a more realistic representation of the potentially undeveloped hydropower for Florida.

FIGURE 8

Florida's Existing Hydroelectric Capacity

OWNER/OPERATOR	LOCATION	MW CAPACITY
City of Tallahassee Electric	Lake Talquin, FL	11.0
Southeastern Power Admin.	Gadsden County, FL	39.0

Phosphate Plants and Exothermic Reactions

Although not considered a traditional renewable resource, the phosphate fertilizer industry takes advantage of waste heat to provide electrical power via cogeneration. According to the Florida Industrial Cogeneration Association, over 400 MW of generating capacity is installed in Florida's phosphate fertilizer plants. Large amounts of heat are produced in the manufacturing of phosphate from the input stocks of sulfuric acid. These exothermic processes release excess heat which can be captured and used to produce electricity. Although similar examples exist with other industries, given the large amount of generating capacity represented by this industry, a general description follows.

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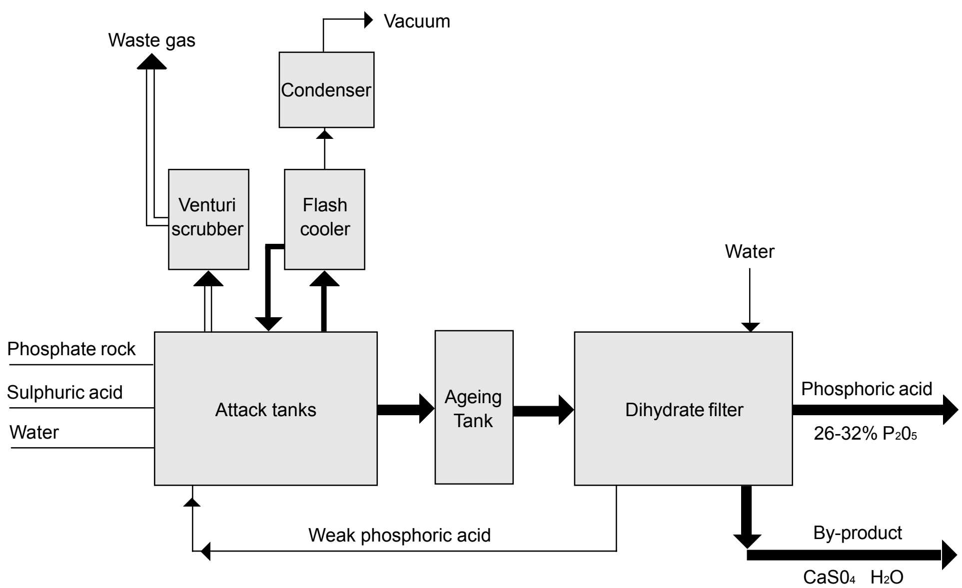
[15] *U.S. Hydropower Assessment for Florida.* United States Department of Energy, February 1998.

There are several methods for the production of phosphate fertilizer. What is shown below is referred to as the Dihydrate Process, which is common in Florida. As indicated in the schematic, the key inputs to the process are phosphate rock, sulfuric acid and water. Downstream of this process, the phosphogypsum generation process takes place. There, the phosphoric acid is concentrated and initially, kept in contact with the phosphate rock. This is done to convert the phosphate rock as far as possible to soluble monocalcium phosphate. The second stage is to take this soluble monocalcium phosphate and to precipitate calcium sulphate. This precipitate exists in a number of different crystal forms and appears as a slurry. The slurry is then filtered to create the final product.

Typically, the ratio of waste gypsum to product is 5 to 1. In Florida, this phosphogypsum is typically stacked on the ground, and can be as high as 200 feet, covering 400 or more acres. The Florida Institute of Phosphate Research estimates that over 70 million tons of this waste exists in Florida alone, with an additional 30 million tons generated annually.

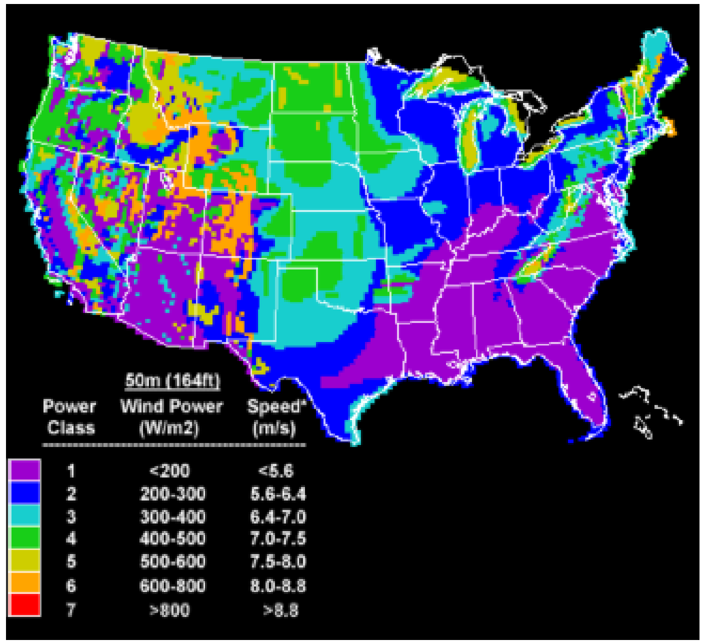


Within the attack tanks, an exothermic reaction occurs, meaning that heat is produced from the chemical reaction. The heat is removed via the flash evaporation of water in the flash cooler. This provides an opportunity within a phosphate fertilizer plant for cogeneration, since steam is created which is otherwise wasted to the atmosphere via a condenser.

Phosphate fertilizer plants represent a potential source of pollutants to the air, water and land. However, once permitted for operation, such facilities are able to provide a source of electrical generation with few additional environmental impacts.

Wind Generation

Wind turbines, like windmills, are mounted on a tower to capture the most energy. At 100 feet or more above ground, they can take advantage of the faster and less turbulent wind. Turbines catch the wind's energy with their propeller-like blades. Usually, two or three blades are mounted on a shaft to form a rotor. A blade acts much like an airplane wing. When the wind blows, a pocket of low-pressure air forms on the downwind side of the blade. The low-pressure air pocket then pulls the blade toward it, causing the rotor to turn. This is called *lift.* The force of the lift is actually much stronger than the wind's force against the front side of the blade, which is called *drag.* The combination of lift and drag causes the rotor to spin like a propeller, and the turning shaft spins a generator to make electricity.



Wind turbines can be used as stand-alone applications, or they can be connected to a utility power grid or even combined with a photovoltaic (solar cell) system. For utility-scale sources of wind energy, a large number of wind turbines are usually built close together to form a wind plant.

Wind turbines require certain minimum wind speeds to be viable. While Florida has notable diurnal coastal breezes, there are no known locations in Florida that can support commercial wind generators. Information presented by the JEA indicates they are investigating some potential offshore sites, but site feasibility studies have not been completed. The attached map shows the key wind producing areas in the continental United States. Areas designated class 3 or greater are suitable for most wind turbine applications, whereas class 2 areas are marginal. Class 1 areas are generally not suitable, although a few locations (e.g., exposed hilltops not shown on the maps) with adequate wind resource for wind turbine applications may exist in some class 1 areas.

Geothermal[16]

Most power plants need steam to generate electricity. The steam rotates a turbine that activates a generator, which produces electricity. Many power plants still use fossil fuels to boil water for steam. Geothermal power plants, however, use steam produced from reservoirs of hot water found a couple of miles or more below the Earth's surface. There are three types of geothermal power plants: *dry steam, flash steam,* and *binary cycle*.

Dry steam power plants draw from underground resources of steam. The steam is piped directly from underground wells to the power plant, where it is directed into a turbine/generator unit. There are only two known underground resources of steam in the United States: The Geysers in northern California and Yellowstone National Park in Wyoming, where there's a well-known geyser called Old Faithful. Since Yellowstone is protected from development, the only dry steam plants in the country are at The Geysers.

[16] NREL Webpage at: http://www.nrel.gov/clean_energy/geoelectricity.html

Flash steam power plants are the most common. These plants use geothermal reservoirs of water with temperatures greater than 360°F (182°C). This very hot water flows up through wells in the ground under its own pressure. As it flows upward, the pressure decreases and some of the hot water boils into steam. The steam is then separated from the water and used to power a turbine/generator. Any leftover water and condensed steam are injected back into the reservoir, making this a sustainable resource.

Binary cycle power plants operate on water at lower temperatures of about 225° to 360°F (107°to 182°C). These plants use the heat from the hot water to boil a *working fluid,* usually an organic compound with a low boiling point. The working fluid is vaporized in a *heat exchanger* and used to turn a turbine. The water is then injected back into the ground to be reheated. The water and the working fluid are kept separated during the process, so there are little or no air emissions.

Small-scale geothermal power plants (under 5 megawatts) have the potential for widespread application in rural areas, possibly even as distributed energy resources. Distributed energy resources refer to a variety of small, modular power-generating technologies that can be combined to improve the operation of the electricity delivery system. In the United States, most geothermal reservoirs are located in the western states, Alaska, and Hawaii.

Ocean Thermal Generation[17]

Ocean thermal energy conversion (OTEC) is used for many applications, including electricity generation. There are three types of electricity conversion systems: *closed-cycle, open-cycle,* and *hybrid*. Closed-cycle systems use the ocean's warm surface water to vaporize a *working fluid*, which has a low-boiling point, such as ammonia. The vapor expands and turns a turbine. The turbine then activates a generator to produce electricity. Open-cycle systems actually boil the seawater by operating at low pressures. This produces steam that passes through a turbine/ generator. Hybrid systems combine both closed-cycle and open-cycle systems.

Ocean mechanical energy is quite different from ocean thermal energy. Even though the sun affects all ocean activity, tides are driven primarily by the gravitational pull of the moon, and waves are driven primarily by the winds. As a result, tides and waves are intermittent sources of energy, while ocean thermal energy is fairly constant. Also, unlike thermal energy, the electricity conversion of both tidal and wave energy usually involves mechanical devices.

A *barrage* (dam) is typically used to convert tidal energy into electricity by forcing the water through turbines, activating a generator. For wave energy conversion, there are three basic systems: *channel systems* that funnel the waves into reservoirs; *float systems* that drive hydraulic pumps; and *oscillating water column systems* that use the waves to compress air within a container. The mechanical power created from these systems either directly activates a generator or transfers to a working fluid, water, or air, which then drives a turbine/generator.

Although ocean energy is renewable and clean, it is not without environmental challenges. For instance, tidal power plants that dam estuaries can impede sea life migration, and silt build-ups

[17] NREL Webpage at: http://www.nrel.gov/clean_energy/ocean.html

behind such facilities can impact local ecosystems. Tidal fences may also disturb sea life migration. Newly developed tidal turbines may prove ultimately to be the least environmentally damaging of the tidal power technologies because they do not block migratory paths.

An artist's rendition of ocean driven mechanical turbines.

In general, careful site selection is the key to keeping the environmental impacts of OTEC and wave energy systems to a minimum. OTEC experts believe that appropriate spacing of plants throughout the tropical oceans can nearly eliminate any potential negative impacts of OTEC processes on ocean temperatures and on marine life. Similarly, wave energy system planners can choose sites that preserve scenic shorefronts and avoid areas where wave energy systems are likely to significantly alter flow patterns of sediment on the ocean floor.

Another challenge with ocean energy systems is economics. While it may cost little to operate ocean energy facilities, they are currently quite expensive to build. For example, construction costs for tidal power plants are high, and payback periods are long. The cost of a proposed tidal power plant across the Severn River in the United Kingdom is estimated at about $12 billion, far more expensive than even the largest fossil fuel power plants. As a result, at present the cost per kWh of tidal power is not competitive with conventional fossil fuel power.

Wave energy systems also cannot compete economically with traditional power sources. However, the costs to produce wave energy are decreasing, and some European experts predict that wave power devices will find lucrative niche markets soon. Once built, however, wave energy systems and other ocean energy plants should have low marginal energy production costs, because the fuel they use — seawater — is free.

Electricity from Hydrogen

Although not an individual technology, hydrogen itself is a potential fuel stock into generating equipment and fuel cells. Hydrogen is not a naturally occurring molecule found in a free or gaseous state but is nearly always bound with other elements such as water, cellulose, methane, and higher order hydrocarbons. Depending on its form the energy required to separate hydrogen can be quite high. To reformulate hydrogen from water for example, is only about 60 to 80 percent efficient. In other words, it takes about 1.6 units of energy to produce 1.0 unit of usable hydrogen. Hydrogen is the simplest and most common element in the universe. It has the highest energy content per unit of weight (52,000 Btu per pound) of any known fuel. Moreover, when cooled to a liquid state, this low-weight fuel takes up 1/700 as much space as it does in its gaseous state. This is one reason hydrogen is used as a fuel for rocket and spacecraft propulsion, which requires fuel that is low-weight, compact, and has a high energy content. Hydrogen is also a very desirable fuel from an environmental prospective since its combustion produces only water and a small amount of nitrogen oxides. If used in a fuel cell the by-product is only water and no greenhouse gases. In fuel cells, electrolysis is reversed by combining hydrogen and oxygen through an electrochemical process, which produces electricity, heat, and water.

Hydrogen can be viewed as an energy storage medium in that it can be linked with intermittent and non-storable sources of energy such as windmills or photovoltaic systems to yield a useable fuel for both electric production and as a vehicular fuel. Certain desirable synergies can be achieved by combining renewable resources with hydrogen production and then using the fuel in generating technologies such as fuel cells. In fact, some researchers believe the hydrogen produced from photo-electrochemical water decomposition is the most promising application of these technologies.[18]

A HYDROGEN APPLICATION

The Schatz Energy Research Center (California) has designed and built a stand-alone solar hydrogen system. The system uses a 9.2 kW photovoltaic (PV) array to provide power to compressors that aerate fish tanks. The power not used to run the compressors runs a 7.2 kW bipolar alkaline electrolyzer. The electrolyzer can produce 53 standard cubic feet of hydrogen per hour (25 liters per minute). The unit has been operating without supervision since 1993. When there is not enough power from the PV array, the hydrogen provides fuel for a 1.5 kW proton exchange membrane fuel cell to provide power for the compressors. By extension, when the sun is shining, PV systems can provide the electricity needed to "make" hydrogen. The hydrogen could then be stored and burned as fuel, or to operate a fuel cell to generate electricity at night or during cloudy periods.

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[18] Bak, T., J. Nowotny and C.C. Sorrell. "Photo-electrical hydrogen generation from water using solar energy. *International Journal of Hydrogen Energy,* 27(2002) 991- 1022.

CHAPTER III

COSTS and OTHER ECONOMIC CONSIDERATIONS

It is generally recognized that renewable technologies are, in most instances, more costly than more traditional generation technologies. Opinions vary as to which costs should be considered when comparing traditional generation technologies to their renewable counterparts. This chapter will focus primarily on those costs considered by the Florida Public Service Commission in its proceedings, for example, the determination of need proceeding for new generating capacity. Information was gathered from many sources, including: the presentations of speakers at two Commission workshops; responses to a Commission sponsored questionnaire; the research findings of Florida utilities and renewable industry representatives, recent need determination filings, and government and industry web sites.

The fuel costs for many renewable technologies, such as solar, wind, hydroelectric and ocean energy are zero or negligible. However, in determining the cost impact of increased use of renewable technologies, these cost savings must be balanced against potentially high capital costs. Operations and maintenance (O&M) costs may also be higher for certain renewable generation technologies per unit of energy produced. For example, fuel preparation and transportation costs may increase, because fuels such as biomass and municipal solid waste have a lower heat value than traditional fuels. Therefore higher volumes of these fuels are required to produce the same quantity of energy as that produced by fossil fuels.

Costs of many renewable technologies are also highly dependent on site characteristics and resources. As discussed earlier, solar, wind, geothermal, and hydroelectric capabilities vary widely across regions of the United States. Other non-cost attributes of a particular generating resource may also have an impact on the value of the resource to the Florida electric market. For example, the value of a generating resource is increased if it can be dispatched by a utility and if the resource is available during peak electric demand periods. If not, energy storage may be added at an additional cost, so that the energy can be used when most needed. Adding renewable resources to the generation mix may also impact environmental compliance costs. Displacing traditional generation with renewable generation may reduce sulfur dioxide emissions and therefore reduce the number of sulfur dioxide allowances required to achieve a certain level of energy production. These indirect cost savings should be considered in any exhaustive evaluation of the costs of deploying additional renewable generation resources.

Several other economic issues are impacted by the deployment of additional renewable resources. The increased use of renewables will increase the fuel diversity of generation within Florida. In general, the cost of renewable fuel is less volatile than the price of natural gas and oil. Thus increased use of renewables may partially offset the risk associated with fuel price increases. Several of the workshop participants also stressed that increasing renewable generation may benefit Florida by avoiding expenditures on fossil fuels, which must be purchased outside the state. A study by Dr. Robert Cruz was presented which estimated a net positive economic impact on state employment, income, GDP, and tax proceeds, from diverting funds which would have been used to purchase fossil fuels outside the state to increased biomass fueled generation.

Dr. Cruz stated that the higher cost of renewable technologies should be balanced against the potential for increased employment and tax dollars within Florida.[19]

Cost Calculation and Pricing Issues

Cost estimates for generating capacity, and renewable capacity in particular, are highly dependent on the underlying assumptions, such as site location, size, unit efficiency level, fuel quality, etc. To the extent possible, such parameters have been standardized in the cost comparisons of different technologies discussed below. These cost estimates were recently developed by Black and Veatch and are based on industry assessments, and actual costs at similar Black and Veatch projects. Where appropriate, specific cost estimates for Florida are provided based on the questionnaire responses received and the research and development projects of Florida's electric utilities and other industry representatives.

The costs per kWh provided below are levelized costs. These calculations include: capital costs, allowed return on investment, fuel costs, and fixed and variable O&M costs over the expected life of the generating unit. A levelized annual cost is calculated by converting booked costs into a constant annual cost with the same present value as the actual annual capital revenue requirements. Levelized costs per unit of energy are then determined by dividing the annual levelized cost by the estimated energy produced each year.

Levelized costs are a useful tool for comparing alternative generating technologies in some circumstances. However, in Florida's current regulatory environment, some entities have the authority to price wholesale energy sales at whatever the market will bear, rather than on the costs to produce the energy. Therefore the final impact on customer rates will be determined not just by the cost to produce the energy, but by the price a utility must pay for the energy. However, in most cases, an investor owned utility must calculate customer rates for energy produced by its own generation based on costs, using a revenue requirements calculation. In simple terms, this calculation provides for a regulated utility to recover all prudently incurred costs of the resource, plus an allowed rate of return on the capital investment. Certain purchased power contracts must also be based on costs. Pursuant to PURPA, the payments to qualifying facilities are determined based on the cost of the utility's next planned generating unit, commonly referred to as the utility's avoided cost.

Costs for Traditional Technologies

As a benchmark of comparison, Table 7 (page 42) provides estimates for the construction and operation of both coal-fired and natural gas-fired, utility size, baseloaded power plants. These are assumed to be greenfield plants located at a central Florida location.

Currently, due to the lower capital costs and modular construction schedules, natural gas combined-cycle generators are the preferred, traditional technology choice. While they have lower

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[19] Cruz, Dr. Robert D., The Washington Economics Group, *The Potential Economic Benefits of a Renewable Policy Standard for Florida*, Presentation to the Florida Public Service Commission at the August 28, 2002 Renewables Assessment Workshop.

capital costs, the fuel component is subject to greater volatility. Conversely, a new coal unit has higher capital costs but more stable fuel costs. The most recent utility planning documents illustrate the utility preference for natural gas-fired plants. Over the next ten years, some 13,680 MWs of new capacity will be added in Florida (exclusive of repowering at existing sites). Of this amount, 97 percent will be gas-fired and only 3 percent will be coal-fueled.[20]

To ensure that comparisons can be made between traditional technologies and non-traditional, renewable technologies a levelized cost analysis is required. While capital and O&M costs are well documented for these traditional plants based on extensive utility experience, it is the fuel cost that is more problematic for benchmarking. To develop total levelized cost, some projections of future fuel costs must be incorporated. For this exercise, the natural gas and coal forecasts for delivered prices used as inputs for the fuel costs were taken from the DOE/EIA *Annual Energy Outlook 2002*. The DOE/EIA forecasts projected natural gas to increase at 2.2 percent per year over the thirty year time frame for the analysis. Coal prices are projected to decline from $1.35 per million BTU in 2002 to $1.12 in 2020. For purposes of the analysis, the last coal price was held constant from 2020 to 2032. As a sensitivity, a high band scenario was used with natural gas prices escalating at 4.4 percent annually and coal escalating at 2.0 percent annually. The resultant production costs for traditional generation are portrayed in Table 7.

TABLE 7

PRODUCTION COSTS FOR
Traditional Technology

	COMBINED CYCLE	PULVERIZED COAL
Plant Capacity	514 MW Net	446 MW Net
Plant Heat Rate	7,000-7,800 btu/kWh	9,979-12,4631 btu/kWh
Capacity Factor	Baseload	Baseload
Capital Cost	$565 per kW	$1268 per kW
Fixed O&M	$6.17 per kWyear	$14.89 per kWyear
Variable O&M	$3.59 per MWh	$3.92 per MWh
Levelized Cost	3.9 - 4.4¢	5.2 - 5.5¢

Biomass

Direct Combustion

According to the U.S. National Renewable Energy Laboratory, there are more than 350 biomass power plants in the U.S. today, with over 7,500 MW of capacity, enough to serve several million homes. Currently, most biomass plants use direct combustion technology. Direct combustion systems are similar to fossil-fuel fired power plants, and replace fossil-fuels with biomass to produce steam. Stand-alone biomass generators can be made available for dispatch by utilities, providing energy at peak periods of demand when it is most needed.

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[20] *Review of the Electric Utilities 2001 Ten Year Site Plans*, Florida Public Service Commission, December, 2001, p. 8.

Florida may have an advantage over many states in the availability of waste biomass, as well as the ability to grow biomass crops for closed-loop biomass systems. The state's growing population creates an increased need for construction and road development. Waste from this construction, along with the state's nine paper mills, timber industry, and agricultural processing plants provides a steady stream of biomass which can be used as fuel. Florida's extended growing season also increases the feasibility of producing crops such as switchgrass and eucalyptus strictly to be used as fuel. Forested land is most prevalent in the Northern region of the state, which implies a higher potential for the use of wood waste to fuel electricity generation in this portion of the state. The estimated quantity of Florida's wood waste which is currently used to fuel electric generation ranges from 10 to 25 percent.

As in any application of biomass, fuel costs can vary widely depending on the fuel source, quality, and transportation requirements. The ability to obtain low cost fuel is critical in achieving a cost-effective biomass energy source. Waste biomass is typically less costly than crops which are grown specifically for fuel, although the cost of such crops can be reduced if the most productive crop for a specific site is chosen. The quality of biomass fuel is also key to achieving generation efficiency and reduced O&M costs. While the avoided disposal cost can reduce the initial cost of waste biomass, all biomass must be prepared and transported prior to combustion. Preparation costs are increased if a biomass waste stream: 1) must be sorted to remove potential contaminants; 2) requires extensive shredding; or, 3) must be dried due to high moisture content. In addition, according to the National Renewable Energy Laboratory, the alkali content in certain forms of biomass can increase the cost of energy production by contaminating boilers and reducing efficiency. Biomass fuels have a low energy density relative to fossil-fuels, so much higher volumes of biomass must be burned to achieve the same energy production. Therefore, transportation costs also play a vital role in determining the final cost of energy production. Estimates of the maximum distance biomass can be transported cost-effectively range from 25 to 100 miles.

Due to the high cost of transport, the size of biomass generation plants is typically limited by the stream of biomass produced within the vicinity. The capacity of stand alone biomass plants is relatively small, ranging from 10 to 50 MW, with the majority of plants under 20 MW. In general, such small capacity plants do not achieve the efficiency levels of much larger plants, because high-cost efficiency measures cannot be economically justified with lower levels of energy production. Typical natural gas-fired combined cycle units can have twice the thermal efficiency of stand-alone biomass units, with a heat rate of approximately 7,000 compared with a range of from 13,000 to 15,000 Btu per kWh for stand-alone biomass technology. It follows that the value of minimizing transportation costs by deploying small capacity plants must be balanced against the loss of generation efficiency associated with these smaller plants.

Black and Veatch provided Table 8, with cost and performance data for a 50 MW capacity stand alone biomass plant using urban wood waste as fuel. Fuel costs are estimated at 75 cents per MBtu.

TABLE 8

PRODUCTION COSTS FOR
50 MW Biomass Generator

Plant Capacity	50 MW
Net Plant Heat Rate	13,500 to 15,000 Btu per kWh
Capacity Factor	60 to 80 percent
Capital Cost	$2,000 to $3,450 per kW
Fixed O&M	$50 to $70 per kWyear
Variable O&M	$6 to $10 per MWh
Levelized Cost	6.3 to 11.8 cents per kWh

Questionnaire responses were received from the representatives of three stand alone biomass generators within Florida, with plant capacities ranging from 9 MW to 72 MW. Ages of the units were not provided. Cost and performance data is comparable to the Black and Veatch data above. Heat rates for the units ranged from 14,000 to 14,500 Btu per kWh, with capacity factors of between 75 and 88 percent. However, the capital cost estimates provided of $1,000 to $1,650 per kW, were substantially below the Black and Veatch estimates. Fixed and variable O&M costs were estimated at $20 per MW and $30 per MWh, respectively. Each of the three generators is designed to burn biomass waste. Costs to obtain fuel ranged from $0 to $10 per ton, with added fuel costs of $.10 per ton mile. An estimated fuel cost of $1.40 per Mbtu was also cited.

Note, the assumed fuel cost for the calculation of levelized production cost was $.75 per Mbtu and respondents provided a reported average of $1.40 Mbtu. In addition, information was supplied to the authors by Fred Beck of the Renewable Energy Policy Project. Table 9 provides a supply curve for biomass materials. This table includes wood waste, switch grass production, and some agricultural waste.[21] While the delivered cost per Mbtu is competitive with fossil fuel costs, recall that the more efficient heat rates in utility fossil fuel generators provide a lower production cost per MWh.

TABLE 9

Florida Biomass Fuel Supply Curve ($1999)

FUEL COST ($/Mbtu)	WOOD RESIDUE (bone dry tons)	ENERGY CROPS (bone dry tons)	TOTAL (bone dry tons)
$.50	248,995		248,995
$1.00	1,092,247		1,092,247
$1.50	1,333,882		1,333,882
$2.00	1,351,602	493,505	1,845,107
$2.50	1,381,136	1,279,925	2,661,061
$3.00	1,422,484	1,361,426	2,783,909

A study by the Washington Economics Group was provided to the Commission which evaluated the economic impact of biomass generation on the Florida economy. The study compared the cost of generating power using biomass with the cost of using natural gas fuels and analyzed the flow of expenditures for the two alternatives. A key finding in the study is that over 85 percent of the dollars spent to operate a typical biomass plant are spent in Florida. By contrast, the study concluded that over 85 percent of the dollars spent to operate a typical state of the art, gas fired combined cycle unit are spent outside of Florida, mostly in the form of fuel expenditures.

Co-firing Biomass Solids in Existing Coal Units

Co-firing biomass feedstock in existing coal units appears to be a relatively low cost and low risk method to increase the use of biomass fuels in Florida. U.S. Department of Energy states that co-firing "is the most economic near-term option for introducing new biomass power generation," and in some cases, co-firing can actually reduce energy production costs at existing coal plants.

[21] Post workshop comments of Fred Beck, Renewable Energy Policy Project, November 14, 2002.

According to DOE, "A typical existing coal fired power plant produces power for about 2.3 cents per kWh. Co-firing inexpensive biomass fuels can reduce this cost to 2.1 cents per kWh." DOE reports that co-firing compares favorably to stand-alone biomass plants, which it estimates have an average energy cost of 9 cents per kWh. Co-firing takes advantage of the high efficiency levels of coal generators, leading to a conversion of biomass to energy in the 33 to 37 percent efficiency range, an over 30 percent increase in efficiency compared to stand-alone biomass plants. Capital costs per kW appear to be significantly lower for co-firing compared to stand alone biomass plants. Co-firing also reduces coal usage and the associated sulfur dioxide and nitrogen oxide emissions. This can provide a revenue stream from sulfur dioxide emission allowances, partially offsetting the increased capital and O&M costs of co-firing. However, co-firing may result in reduced unit efficiency, and reduce the long-term effectiveness of selective catalytic emission reduction devices. Co-firing may also reduce the marketability of the ash resulting from the combustion process because, in many cases, the ash can no longer be used in the production of cement.

The data from co-firing tests within Florida indicate that DOE's estimate of reduced costs resulting from co-firing are overly optimistic. For co-firing to compete favorably with coal on a cost basis, the fuel savings from inexpensive biomass, dumping (or tipping) revenue, and emission allowance revenues must offset the increased capital and O&M costs. The data provided by workshop attendees and questionnaire responses indicates that the actual capital costs necessary for efficient fuel processing and increased O&M costs due to added labor and plant maintenance, may offset any savings attributable to low-cost biomass.

Tampa Electric Company (TECO) provided information on its co-firing test at the Gannon station. TECO's Gannon Unit 3 has a net summer rating of 152 MW, and is permitted to burn up to five percent biomass fuel by weight. Wood waste was obtained from Consolidated Resource Recovery, a contractor for Hillsborough County Solid Waste, for prices ranging from $16 to $20 per ton. A one percent blend of biomass at Gannon Unit 3 requires approximately one ton of biomass per hour. The average quality of the fuel was 5,600 Btu per pound, or 0.9 MWh per ton. TECO has burned 793 tons of biomass at the site, resulting in 690 MWh of biomass derived energy. To minimize the impact on the unit's reliability and availability, TECO limited biomass input to a range of one-half to two percent of fuel input. The unit is capable of accepting biomass pieces up to 2 inches in size. TECO experienced some pluggage in the fuel chutes which required operator intervention, due to the introduction of oversized biomass pieces. TECO also noted that the unit's boiler was subject to overpressure conditions, due to a large bulk of biomass in the coal feeder. TECO found that co-firing was highly labor intensive, requiring added labor and equipment for offloading, fuel sampling, handling, and obstruction removal. Due to the added labor costs, higher fuel costs, and special equipment required, TECO estimates that the cost to produce energy from co-firing with biomass were approximately 50 percent higher than for coal fired generation. The Gannon station will no longer be available for co-firing after 2003 when the unit will be re-powered to burn natural gas rather than coal.

One additional questionnaire response was received for a biomass co-firing project, with a net capacity rating of 300 MW. The project expects to produce energy from 45 MW of the plant with local biomass waste. Capital costs are estimated at $1,500 per kW, with fixed and variable O&M of $10.00 per MW and $5.00 per MWh, respectively. Fuel costs are estimated at $1.5 to $2.0 per Mbtu (million btus).

Gasification of Biomass Solids

Biomass gasification systems convert biomass into a gas in a high temperature, oxygen-starved environment. This gas can then be converted to energy using various technologies, such as gas turbines or reciprocating engines. According to the Biomass Development Company (BDC), biomass gasification will be the preferred method in the future for increasing biomass usage by co-firing in existing coal- and oil-fired boilers. BDC stated that co-firing with this gas reduces many of the problems associated with co-firing with biomass, including efficiency reductions due to boiler fouling. This implies that a higher percentage of biomass can be co-fired if it is first converted into a gas.

Tampa Electric Company provided information on its co-firing experiment at the Polk Unit 1 integrated gasification combined cycle (IGCC) generator. IGCC technology first converts solid fuels, such as coal and petroleum coke into a clean burning gas, which is then used to fuel a combined cycle generating unit. TECO has recently conducted a test of the costs and operational characteristics of adding biomass to the fuel mix at Polk Unit 1. The closed loop biomass crop is a crop of eucalyptus trees planted by Common Purpose, Inc. Ten percent of the crop (60 trees) was felled and processed in December 2001, producing 8.8 tons of material with the consistency of coarse sawdust. Although the harvesting and processing of the crop was labor intensive on an experimental basis, large scale harvesting and processing would substantially reduce the cost per ton of biomass. One ton of eucalyptus has approximately half the Btu content of one ton of coal. The fuel provided 1.2 percent of the unit's fuel needs over an 8 and a half hour period, generating approximately .860 MW of power or 7.31 MWh of energy during the test period. TECO stressed that the biomass feeding process used was highly labor intensive. TECO did not provide estimates of the increase in labor costs. TECO estimates that an automated fuel handling system, which would reduce labor requirements, would cost between $1.5 and $2 million. Fuel quality is also key to the success of the gasification effort. TECO experienced problems with pluggage during the gasification process, due to introducing oversized pieces of the biomass. This can result in reduced efficiency of the gasification system, increasing the costs of fuel production. TECO believes that an increase in the percentage of biomass introduced to the unit could result in reduced efficiency of the unit on an ongoing basis.

Municipal Solid Waste

Mass Burn MSW Technology

According to Integrated Waste Services Association, Florida currently has over 500 MW of MSW direct combustion capacity installed. These facilities provide disposal for over one-third of Florida's waste. The primary driver behind a municipality's decision to install a MSW facility is the disposal of waste, due to dwindling landfill space. The generation of electricity is a secondary consideration.

MSW can be converted to energy with numerous technologies. The costs of energy produced vary depending on the technology used to convert the MSW to electricity, and the avoided cost of disposal. The degree of processing of MSW to be used as fuel is also dependent on the conversion technology used.

Black and Veatch provided Table 10 which lists typical ranges of performance and costs for a facility directly burning 2,000 tons of waste per day.

TABLE 10

PRODUCTION COSTS FOR
50 MW MSW Generator

Plant Capacity	50 MW
Net Plant Heat Rate	16,000 Btu per kWh
MSW tons per day	2,000
Capacity Factor	60 to 80 percent
Capital Cost	$2,500 to $4,600 per kW
Fixed O&M	$100 to $175 per kWyear
Variable O&M	$25 to $50 per MWh
Levelized Cost	3.5 to 15.3* cents per kWh

This assumes a $25 per ton tipping fee. Information presented by Integrated Waste Services Association indicates that for Florida plants a $50 per ton fee is more typical and thus production costs could be closer to 2¢.

Questionnaire responses were received from the representatives of 12 operating direct combustion MSW generators within Florida, as well as one potential site. Net summer plant capacity ratings of the units ranged from 10 MW to 75.5 MW. Most questionnaires indicated that it is technically feasible to dispatch the unit. However, several cited contract provisions which currently prevent the unit from being dispatched, or make it uneconomical for the generator to do so. Only one of the responses included cost data, citing a $6,500 per kW capital cost. Performance data is comparable to the Black and Veatch data above. Heat rates for the units ranged from 13,300 to 18,000 Btu per kWh, with capacity factors of between 78 and 95 percent. MSW plants have negative fuel costs in that they are paid to take waste materials. Each respective municipality pays a tipping fee to the generator to deliver MSW. One response provided a fuel cost of negative $4.23 per Mbtu, indicating a tipping fee is received by the generator from the municipality.

Landfill Gas

Landfill gas is one of the more mature options for obtaining energy from municipal wastes. Many landfill sites within Florida already have gas collection technology installed in order to meet Federal Clean Air and New Source Performance Standards. Energy Developments, Ltd., stated that for every 1 million tons of municipal solid waste in a landfill, enough gas is produced to fuel approximately 1 MW of generating capacity, yielding about 8,500 MWhs.[22] The capital costs for landfill gas projects is dependent on site characteristics, the conversion technology used, and the extent of the collection systems already in place. However, according to Black and Veatch, the payback period for landfill gas sites is often between 2 and 5 years. Capacity factors can vary greatly depending on the technology used to convert the landfill gas into electricity. Data provided by workshop participants and on questionnaire responses indicates that landfill gas projects are not available for utility dispatch.

[22] David R. Wentworth, Energy Developments, Ltd., *Landfill Gas to Electricity Development in the State of Florida.* Presentation at the FPSC Staff Renewable Assessment.

Black and Veatch provided Table 11, with cost and performance data for a 10 MW capacity landfill gas internal combustion engine. Gulf Power provided energy costs of from 5.0 to 6.5 cents per kWh for Florida landfill gas conversion, which mirrors the information for the generic project provided in Table 11.

TABLE 11

PRODUCTION COSTS FOR
10 MW Landfill Gas Engine

Plant Capacity	10 MW
Net Plant Heat Rate	8,500 to 13,000 Btu/kWh
Capacity Factor	60 to 80 percent
Capital Cost	$1,000 to $1,725 per kW
Fixed O&M	$1.00 to $1.35 per kW year
Variable O&M	$6 to $20 per MWh
Levelized Cost	2.4 to 6.3 cents per kWh

Energy Developments, Ltd. provided cost and performance data on the conversion of landfill gas to energy with reciprocating engine generator sets. These facilities are located at landfill sites and are interconnected to the regional transmission grid. Net capacity ratings for the units are approximately 2.3 to 3.5 MW, with a capacity factor of 90 percent. Capital costs range from $750 to $1,250 per kW, with fixed O&M costs of from $9 to $11 per MWh. Similar units provide energy from up to 9 megawatts of capacity in Florida. This data is confirmed by the questionnaire responses received for similar operating landfill gas conversion systems, and one potential site. Energy Developments also stressed that landfill gas facilities can be placed in service in a relatively short time, from 9 to 18 months.

The Orlando Utilities Commission (OUC) also provided data on a co-firing landfill gas operation in Orange County, Florida. Orange County collects the gas from a 200 acre waste site. The gas is then delivered to OUC to be co-fired in either of its coal-fired boilers at the Stanton Energy Center. Stanton burns approximately 5,200 Mcf of gas per day, which provides a 3 percent reduction in coal burned at the units, and provides electricity for 10,000 homes. OUC estimates that the cost savings are $1.25 million per year, based on the cost differential between landfill gas and coal. OUC stated that there are also indirect savings due to reduced coal handling costs and environmental treatment costs. OUC also received $4 million in federal funding and tax incentives to develop the co-firing project.

Gasification of Municipal Solid Waste

MSW may also be converted to a synthesis fuel gas, or syn-gas. This technology is less developed than direct combustion or landfill gas processes for MSW. As in direct combustion technologies, costs will be highly dependent on avoided landfill costs. Brightstar Environmental provided information on its design for a solid waste and energy recycling facility. The facility serves a dual purpose of capturing additional recyclable material, and converting the remaining organic waste to a syn-gas. This syn-gas can then be converted to electricity in a variety of ways, such as co-firing in an existing gas plant. The system is modular and can be designed to fit the waste management needs of any size community. In 2001, Brightstar Environmental began commercial operation of its first solid waste and energy recycling facility located in Wollangong, New South Wales. The unit processes 150,000 tons of MSW annually, resulting in enough syn-gas to power 15 MW of reciprocating generator sets. These generators are subject to utility dispatch. The syn-gas is combusted in reciprocating engine generator sets to produce electricity. Brightstar expects the facility to achieve over a 90 percent capacity factor. Brightstar did not provide cost data for the facility.

Geothermal Energy

Geothermal generating units are powered with steam produced from hot water reservoirs deep beneath the earth's surface. Geothermal generation is limited to those areas of the country with geothermal reservoirs. According to the National Renewable Energy Laboratory, most of the geothermal reservoirs in the United States are located in the western states, Hawaii, and Alaska. As is to be expected, costs for geothermal units are highly dependent on site characteristics, due to the depth of the geothermal reserves, the geological characteristics of the site, and the number of exploratory wells which must be drilled. Geothermal energy is not a viable option for Florida as there are no known geothermal reservoirs within the state. Therefore no specific cost data for this technology is provided.

Solar Energy

Photovoltaics

Capital and installation costs for PV systems are quite high, and in general, appear to be the highest on a per kW basis of all currently developed renewable technologies feasible for meeting part of Florida's energy needs. However, in certain cases, PV may actually be the least cost option, such as for isolated homes or lighting applications, which would require high transmission costs to be connected to the power grid. Capital cost estimates provided were similar across sources, while O&M costs varied widely. Without the addition of energy storage capacity, PV systems cannot provide dispatchable energy to meet the grid's needs during periods when solar energy is not available. As expected, the solar energy produced from a PV system begins in the morning and peaks in late afternoon. While these hours coincide with the summer peak hours for the utility system, there is little coincidence with winter peak hours. Thus, it is difficult to assign firm reliability value to these systems. The addition of battery storage capacity to a PV system can alleviate this issue, but will add additional capital and O&M costs.

TABLE 12

PRODUCTION COSTS FOR Fixed Tilt PV System

Plant Capacity	.01 to 10 MW
Capacity Factor	20 to 22 percent
Capital Cost	$3,600 to $8,050 per kW
Fixed O&M	$5.7 to $8.2 per kW year
Variable O&M	$0.5 to $1.5 per MWh
Levelized Cost	19.4 to 47.4 cents per kWh

The National Renewable Energy Laboratory estimates that efficiency levels of PV systems have risen from 4 percent in the 1950's, to over 15 percent today. This increase in efficiency has significantly reduced the costs per unit of energy produced. Current capital and O&M costs vary widely depending on the PV system design. Black and Veatch provided Table 12, with cost and performance data for a fixed tilt, single crystalline photovoltaic system.

There were a variety of sources for current data on installed solar cost. The U.S. Department of Energy and the solar industry have set a goal of reducing installed PV costs to $3,000 to $4,000 per peak kW by 2010 and $1,500 per peak kW by 2020. (PV industry road map). Currently, the FSEC PV Database reports that the average total installed cost for a grid-connected PV system in Florida is $9,720 per peak kW. This is based on data collected from 114 systems. Costs vary greatly, however, depending on the level of equipment customization and dealer/installer mark up. For instance, the City of New Smyrna Beach installed the majority of their PV systems for $5,760 per peak kW, which were packaged designs using standard roof mounting hardware, while JEA experienced an average installed system cost of $12,400 per peak kW, using custom system designs and mounting hardware. The Florida Solar Energy Center has compiled more than one year of unscheduled maintenance data. The majority of maintenance events involved inverter reliability problems (63 percent). Once inverter technology has been improved, FSEC predicts that there will be relatively few unplanned maintenance events for grid-connected PV systems. More detailed O&M information for grid-connected PV systems may be found on the FSEC PV database at www.fsec.ucf.edu/pvt.

Florida Power Corporation (FPC) provided preliminary cost and performance data from a research effort on the operation of PV systems in manufactured homes. FPC has installed PV systems with capacities ranging from .8 kW to 1.3 kW in six Palm Harbor manufactured homes. These homes will be monitored for at least one year, providing FPC with more detailed information on system performance, and O&M costs. FPC noted the benefits of installing PV systems on new homes, rather than retrofitting existing homes. This allows a manufacturer to streamline the installation process by adding structural changes necessary to support the PV system, as well as wiring upgrades. FPC estimates that installation cost savings of approximately 50 percent can be achieved if PV systems are placed on new, rather than existing manufactured homes. Total system costs, including installation costs, have averaged $7,000 for an 1.08 kW PV system, or $6,480 per kW, on new manufactured homes. These systems have produced an average of 3 kWh per day. FPC calculates the cost per kWh at 31 cents over the life of the unit, if only start-up costs are included. However, FPC has experienced problems with inverter reliability. Since these are prototype units with the attended higher startup costs, one could reasonably expect mass installation to lower the per unit costs.

JEA currently has 162 kW of PV capacity installed on public high schools and many of JEA's facilities. JEA reports total up-front system costs, including installation costs, of $12,400 per kW. JEA attributes this high cost largely to structural considerations due to high wind loading design requirements.

Six questionnaire responses regarding PV projects in Florida were received, with aggregate capacities ranging from 2 kW to 218 kW. Capacity factors for the systems without battery storage ranged from 15 to 25 percent, while one project with battery storage cited a capacity factor of approximately 90 percent. Capital and installation costs for the Florida PV systems were higher than those estimated by Black and Veatch, ranging from $7,000 to $17,000 per kW. Little information was provided on O&M costs.

Solar Thermal

It appears that solar thermal generation applications have lower capital costs on a per kW basis than photovoltaic systems. In general, solar thermal systems have a higher capacity factor than PV systems.

Black and Veatch provided Table 13, with cost and performance data for an 80 MW capacity parabolic trough solar thermal plant.

TABLE 13

PRODUCTION COSTS FOR
80 MW Solar Thermal Unit

Plant Capacity	80 MW
Capacity Factor	34 percent
Capital Cost	$2,700 to $4,600 per kW
Fixed O&M	$24 to $46 per kW year
Variable O&M	$3 to $5 per MWh
Levelized Cost	10.8 to 18.7 cents per kWh

Wind Energy

United States Department of Energy data indicate that the cost of wind energy production in certain regions of the U.S. has dropped from 80 cents per kWh in 1979, to a range of 4 to 6 cents per kWh in 2000. These cost reductions are primarily attributed to increased turbine size, research and development advances, and manufacturing improvements. Wind energy projects are also eligible to receive a U.S. federal production tax credit. The credit is currently 1.7 cents per kWh and escalates on an annual basis to account for inflation.

However, wind energy production efficiency and therefore the cost per kWh, are highly dependent on the wind velocity at a site. Gulf Power provided estimates from the EPRI Renewable TAG document which indicate that capacity factors of wind turbines vary from approximately 5 percent to 40 percent depending on wind velocity. A wind speed of approximately 35 miles per hour provides a capacity factor of 35 percent at a cost of 8 cents per kWh. However, Florida's average on-land wind speed is 12 to 14 miles per hour, which translates into a 5 percent capacity factor at a cost of 57 cents per kWh. U.S. DOE data indicates that the potential for offshore wind energy development is also low for Florida. Therefore, given current wind turbine technology, Florida's wind resource is not sufficient to produce economical power. Workshop participants identified Cape Canaveral as the only site within Florida with wind energy potential.

Hydroelectric Power

Hydroelectric power is considered to be a mature renewable technology. Capital costs for hydroelectric projects are generally high and vary widely by site. Specific site information is generally needed to provide estimates of unit size, performance, and costs. Capacity factors can also vary widely by site. Capacity factors for the same site may also vary throughout the year, due to changes in rainfall and temperature. Due to the seasonal nature of energy produced from a given level of capacity at these facilities, additional capacity may be needed in order to maintain reliability goals.

As noted previously, Florida currently has two hydroelectric facilities. There was a general level of agreement at the Commission's workshops that Florida does not have the potential for additional large capacity hydroelectric facilities. However, a representative of Black and Veatch reported that practical options do exist for some increase in hydroelectric capacity within the state. These options include utilizing existing dams, and unit upgrades on existing systems. Capital cost estimates vary from $1,300 to $5,980 per kW. The lowest cost options involve upgrades at existing sites, with levelized cost estimated at from approximately 2 to 4 cents per kWh. Levelized costs for new facilities may range from 4 to 14 cents per kWh. No reliable cost estimates specific to Florida sites were provided.

Ocean Energy

Ocean Mechanical or Ocean Current

Future potential exists for the conversion of the Gulf Stream current to create energy. However, the necessary technology appears to be in the early stages of development and specific cost and operating characteristics cannot be provided at this time.

Currently, multiple separate but similar ocean turbine designs are in development. A representative of Florida Hydro reports that he has developed a working model of an open center turbine, which can use the energy of the Gulf Stream ocean currents to drive a generator. The electricity produced would be delivered to shore using a buried cable. The model is ten feet in diameter, but the proposed commercial units would be 46 feet in diameter, requiring deep water for installations. The developer estimates that the first production model could be built within the year with a capital outlay of $1 million.

Testing of various ocean turbine technologies has occurred since the 1980's with limited degrees of success. However, a representative of Black and Veatch reports that encouraging data has been collected from a test site of an ocean turbine design similar to the Florida Hydro unit off the coast of England.

Ocean Thermal

Ocean thermal technologies use variations in ocean temperature for many applications, including the generation of electricity. Ocean thermal generation technology is still in the developmental stages; however, capital costs are expected to be relatively high. As in ocean current generation, ocean thermal systems may also have high associated transmission and O&M costs. Tropical and subtropical areas appear to have the highest potential for economic ocean thermal generation. Several 50 to 200 kW demonstration projects are under way in Hawaii. Black and Veatch estimates levelized costs for typical ocean thermal systems of 10 to 22 cents per kWh. However, no estimates of the potential for ocean thermal generation along the Florida coast were provided in the Commission's workshops or in response to the questionnaire.

Waste Heat

Questionnaire responses were received from the representatives of several existing Florida phosphate operations, with a total generating capacity of 430 MW. Cost and operational data was also provided for additional potential sites. Plant capacities of existing sites ranged from 10 MW to 60 MW, with capacity factors of between 60 and 80 percent. Heat rates for the units are not available nor are they especially meaningful because the process does not consume fossil fuel. However, because waste heat is used to produce electricity and thermal energy for process use, waste heat cogeneration is very efficient. Capital costs were estimated at $1.4 million per MW. Fixed and variable O&M costs, which are very low, are difficult to estimate as the conversion of waste heat to steam and electricity is responsible for only a very small portion of the total fixed and variable O&M costs for a fertilizer plant. There are no fuel costs for the process.

Hydrogen

Hydrogen can be used as a fuel in various applications including fuel cells and in a traditional boiler. Costs are expected to vary widely depending on fuel production methodologies and generation technologies. Several participants in the Commission's workshops stated that the long term potential for energy generation fueled by hydrogen is high. However, this industry is not fully developed. Many steps must be taken in Florida before this fuel source can be used to meet a significant part of the state's energy needs. Further developments in hydrogen conversion, storage technologies, and industry infrastructure must take place before hydrogen can compete on a cost basis with other fuels. Due to the early stage of development of this industry, and the expected wide variations in costs for various fuel conversion and generation technologies, no reliable cost data is available at this time.

CHAPTER IV

POLICIES and MECHANISMS TO PROMOTE RENEWABLES

Vertically integrated electric utilities that operate under the regulatory authority of public service commissions generally have a continuing obligation to obtain generating resources that provide safe, reliable service at the lowest possible cost. Utilities in states that have allowed retail access for customers are forced by competition to add similarly defined resources. In either instance, recovery of costs for providing electric services are disciplined either by regulatory oversight or market competition. With the exception of hydro resources, renewable energy is not generally the least cost resource addition. Therefore implementing significant additional renewable generation capacity is not compatible with the goal of minimizing electric rates. Utility reluctance to implement renewable technologies may be further exacerbated by the emerging competitive environment in the electric market, which has intensified the importance of the possible rate impacts. Because renewables are not currently cost competitive, significant additional renewable generation will not be implemented without additional incentives or regulatory changes.

A variety of incentive programs have been devised by government and industry representatives to promote the addition of more renewable resources. There are at least three strategies that have been adopted to encourage renewable energy: market driven programs, financial based incentives, and renewable energy purchase mandates. These programmatic approaches generally reflect a continuum from least prescriptive to most prescriptive. Market driven incentives include programs like green power pricing and tradeable renewable energy certificates, which largely rely on customers' desire to differentiate the type of electricity they purchase. In addition, states can facilitate the introduction of renewable technology into the market place by removing institutional or legal barriers to the installation of these technologies. For example, states can remove tax subsidies for conventional energy technologies, grant legal access rights to direct sunlight, or provide credits in building codes for the installation of specified equipment.

Financial based incentive policies include tax-credits, production payments, rebates, and subsidized loans. Such programs can be funded through tax incentives, general revenue, or dedicated funding sources such as system benefit charges (SBC). SBC programs typically impose a fee on all customers' bills to directly fund certain defined programs.

Finally, the most prescriptive approach to encouraging greater utilization of renewables is by use of governmentally mandated resource acquisition levels. These are generally called renewable portfolio standards (RPS). Under RPS mandates, companies that generate electricity or utilities who purchase electricity for resale are required to either produce or purchase a prescribed percentage of the product from approved renewable resources. These strategies are discussed in more detail below.

Education Efforts

One of the first concerns of any organization that initiates programs to encourage renewables is the need for consumer education and outreach. Because many of these technologies are relatively new to consumers, broad public acceptance may require some upfront efforts to make the public familiar and more accepting of these technologies. While some renewables probably have some inherent public attractiveness - solar comes to mind - others are not cloaked with such a high level of immediate acceptance. Education efforts could help make the siting and construction of some of these technologies easier. In addition, for some programs that are directly targeted to consumers, education would be needed in order to successfully market renewable programs.

While most utilities conduct their own marketing campaigns to solicit customers to participate in certain renewable programs such as green pricing programs, it might be more effective if collaborative approaches were considered. Such advertising strategies might include multiple utilities targeting their campaigns or use of a third party agent that perhaps would be viewed more impartially, such as a public or private sector agency.

Market Driven Programs

Green Pricing Programs

Some utilities offer green pricing programs to allow their customers to purchase "green" power which adds renewable energy to the utility's energy mix. Since current renewable energy sources are often more expensive than electricity generated from traditional methods, these green pricing solutions offer consumers the option to pay extra for clean energy. Essentially, green power pricing programs create an "end user" or consumer market for clean energy with the option of paying a premium for that product. In a typical green pricing program, a ratepayer who volunteers to participate would pay either a specified dollar amount or percentage in addition to his/her bill. These funds are then used by the utility to acquire additional renewable capacity which would not have otherwise been included in the utility's least cost resource planning process. While the physical characteristics of the electrical system prevent the consumer from receiving only electricity generated by renewable resources, the portion funded by the consumer is added to the utility's overall resource mix.

However, experience to date indicates that while a substantial number of customers express a willingness to purchase premium priced renewables, once the program is actually implemented a much smaller percentage of customers actually enroll in the program. In addition, administration and marketing expenses can take a substantial portion of any renewable funds collected. The advantage remains, however, that green pricing programs offer an alternative to imposed systems benefit charges for encouraging specific renewable energy fuel types. Further, unlike a systems benefit charge, which is assessed to all ratepayers, green pricing programs are only supported by those consumers interested in advancing renewable energy projects. For this reason, green pricing programs can result in increased utility and customer knowledge about renewable technologies and in increased utility investment in such technologies with minimum rate impacts for the general body of ratepayers. Green pricing programs may also increase the loyalty of customers who are interested in environmental issues. This may be one strategy electric utilities employ to increase customer choice and differentiate their product.

Consumer Education: The National Renewable Energy Laboratory reports that market research and the education of consumers is critical to the success of green pricing programs. Approximately 30 percent of consumers typically indicate a willingness to pay a portion of the added costs of increased deployment of renewable generation sources. However, data from utilities offering these programs shows that average participation levels in green pricing programs are much smaller, ranging from less than one percent to three percent of eligible consumers.[23] Several workshop participants, including a representative of the City of Tallahassee stated that customer research indicates that customers may be predisposed to support solar energy over other renewable generation technologies.[24] Such market research may be necessary to determine the specific types of renewable technologies, willingness to pay, and payment options favored by each utility's customer base. Gulf Power stressed the importance of designing programs to meet a utility's consumers' preferences to increase the value of green pricing programs as well as participation levels. However, success of green pricing programs is also dependent on a basic level of understanding by consumers concerning the value of renewable technology options and the cost of these technologies relative to fossil fuel generation. It may reduce education costs and increase program participation if utilities join together in a broad based effort to educate Florida's consumers on the basic characteristics, costs and benefits of renewable generation technologies. Florida's municipal utilities have already preliminarily engaged in such a program. (See the discussion of SunSmart in Chapter V).

Payment Options: Two general methods have been suggested for setting a price premium calculated as a percentage of the program participant's electric bill. The first, or "market approach," sets the premium percentage according to an estimate of program participants' willingness to pay, as indicated by a utility's market research. The second approach, or the "planning approach," sets the premium percentage according to the projected cost of the renewable resources required to fulfill the expected customer demand. As an alternative to obtaining funds by setting a premium calculated as a percentage of program participants' bills, funds can be obtained by requesting donations from customers. These donations may be a set dollar amount each month, or a one-time donation of an amount chosen by the consumer. These donations are often tied to a specified kWh level. Monthly premiums and donations, rather than one-time donations, encourage greater participation with less effort on the part of consumers. Administrative costs per dollar collected may also be reduced if a green pricing program allows monthly premiums or donations.

Green Power Certification and Fuel Source Disclosure

Green pricing programs are often coupled with disclosure requirements such that utilities provide their customers with additional information about the source of the energy they are supplying. This information often includes fuel mix percentages and emissions statistics. Fuel mix information, for example, can be presented as a pie chart on customers' monthly bills. "Certification," a related issue, refers to the assessment of green power offerings by government representatives or an independent third party to assure that they are indeed using the type and amount of renewable

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[23] *Policies and Market Strategies for Supporting Renewable Resource Development,* Presentation by Lori Bird of the National Renewable Energy Laboratory at the Florida Public Service Commission July 2, 2002 Renewables Assessment Workshop.

[24] *Implementing a Green Power Program in Tallahassee,* Presentation by Gary Brinkworth of the City of Tallahassee at the Florida Public Service Commission August 28, 2002 Renewables Assessment Workshop.

energy as advertised. One example of green power certification is the Green-e stamp offered by the Center for Resource Solutions. Both disclosure and certification are designed to help consumers make informed decisions about the energy and supplier they choose. Indeed, disclosure is often thought of as a good policy to help educate customers about electricity and thereby to prepare markets in advance of retail competition. It is worth noting, though, that two states that have not moved ahead with retail choice, Florida and Colorado, have enacted disclosure provisions. Florida provisions disclose fuel mix but not emissions.

Contractor Licensing and Equipment Certification

Many states have rules regarding the licensing of renewable energy contractors. Contractor licensing requirements typically have been enacted for solar water heat, active and passive solar space heat, solar industrial process heat, solar thermal electricity, and photovoltaic. These requirements, where they do exist, are designed to ensure that contractors have the necessary experience and knowledge to properly install systems.

Statutes requiring renewable energy equipment to meet certain standards are generally seen as a tool for reducing the chance that consumers will be sold inferior equipment. Beyond being a consumer protecting measure, equipment certification benefits renewables by reducing the number of problem systems and the resulting bad publicity. Both licensing and equipment certification are designed to minimize fraud and help ensure a positive experience on behalf of consumers who purchase solar equipment.

Solar and Wind Access Laws

States can also implement laws to provide for solar or wind easements or access rights. Easements allow for the rights to existing access to a renewable resource on the part of one property owner to be secured from an owner whose property could be developed in such a way as to restrict that resource. This easement is transferred with the property title. Access rights, conversely, automatically provide for the right to continued access to a renewable resource. Solar easements are the most common type of state solar access rule. Furthermore, some states prohibit neighborhood covenants that preclude the use of renewables. At the local level, communities use many different mechanisms to protect solar access, including solar access ordinances, development guidelines requiring proper street orientation, zoning ordinances that contain building height restrictions, and solar permits.

Construction and Design Policies

Construction and design policies include state construction policies, green building programs, and energy codes. State construction policies are typically legislative mandates requiring an evaluation of the cost and performance benefits of incorporating renewable energy technologies into state construction projects such as schools and office buildings. Many cities are developing “Green Building” guidelines that require or encourage consideration of renewable energy technologies. Some guidelines are voluntary measures for all building types, while others are requirements for municipal building projects or residential construction. Local energy codes are used to achieve energy efficiency in new construction and renovations by requiring that certain building projects surpass state requirements for resource conservation. Incorporating renewables is one way to meet code requirements.

Financial Incentive Programs

Federal Financial Incentives

While the regulatory mandates in PURPA helped to advance the investment in renewable energy capacity, the bulk of federal programs designed to encourage the use of renewable energy resources are financial incentives such as tax credits and production incentives. Beginning in 1978, the Energy Tax Act (ETA) provided both residential and business tax credits for renewable energy equipment purchases. ETA offered residential energy income tax credits for solar and wind energy equipment expenditures at a rate of 30 percent of the first $2,000 and 20 percent of the next $8,000. For business expenditures, there was an income tax credit of 10 percent for investments in solar, water, geothermal, and ocean technologies.

Following the ETA, the 1980 Crude Oil Windfall Profits Tax Act (WPT) increased the ETA's residential energy income tax credits for solar, wind, and geothermal technologies from 30 percent to 40 percent of the first $10,000 in expenditures. The WPT also increased the ETA business energy income tax credit for solar, wind, geothermal, and ocean technologies from 10 percent to 15 percent and extended the credits from December 1982 to December 1985. Finally, the WPT allowed tax-exempt interest on industrial development bonds for the development of solid waste to energy (WTE) producing facilities, for hydroelectric facilities, and for facilities producing renewable energy. In 1986, the Tax Reform Act eliminated the tax-free status of municipal solid waste (MSW) powerplants and WTE facilities financed with industrial development bonds. The 1986 Tax Reform Act also extended the WPT business energy tax credit for solar, geothermal, ocean thermal, and biomass property through 1988. The business energy tax credit for wind systems was not extended and, thus, expired on December 31, 1985.

The next major tax provision affecting renewable energy was the Energy Policy Act of 1992 (EPACT). EPACT established a permanent 10 percent business energy tax credit for investments in solar and geothermal equipment and established a 10-year, 1.5 cents per kilowatt hour (kWh) production tax credit (PTC) for privately owned, as well as investor-owned, wind projects and biomass plants using dedicated crops (closed-loop). When originally established, the PTC was available to wind power generators brought on-line between January 1, 1994 and June 30, 1999, and closed-loop biomass power plants brought on-line between January 1, 1993 and June 30, 1999. In March of 2002, a two year extension of the PTC was included for new wind, closed-loop biomass, and poultry waste facilities. This new law extends the PTC from the end of 2001 to December 31, 2003 and indexed the credit to inflation. The credit is currently 1.7 cents per kWh.

EPACT also instituted the Renewable Energy Production Incentive (REPI) which provides a 1.5 cents per kWh incentive, subject to annual congressional appropriations, for generation from biomass (except municipal solid waste), geothermal (except dry steam), wind, and solar from tax exempt, publicly owned utilities and rural cooperatives. Initial payments under the REPI program for fiscal year 1994, totaled $638,120 and were distributed among four state-owned and three city-owned facilities with a total of 42 million kWh. By fiscal year 1998, net generation eligible for REPI payments had reached 529 million kWh from 19 facilities at a price of $4 million. Finally, in fiscal year 2000, REPI payments totaled $3.991 million.

It is important to note that while the generation eligible for REPI payments increased more than twelvefold from 1994 to 2000, the number of facilities receiving REPI support increased only threefold, and that increase occurred during the first three years of the program. This could have occurred because the 1.5 cents per kWh was not sufficient to overcome initial cost barriers to market entry or because of the uncertainty associated with the year-to-year congressional appropriations.[25]

State Policy Support Mechanisms

In addition to Federal incentives, states have many opportunities to use financial incentives as an inducement to encourage investment in renewable energy technology. Financial incentives available to state governments include tax incentives, rebate programs, grant programs, low-interest loans, and industrial recruitment incentives. Generally, tax incentives encourage renewable energy and are designed to facilitate the purchase, installation, or manufacture of renewable energy systems and facilities. These tax incentive programs serve to reduce the investment costs of acquiring and installing renewable energy systems and equipment, and reward investors with tax credits or deductions for their support of renewable energy technology. Although tax incentive programs vary widely, the most common forms are income, corporate, property, and sales tax initiatives. With an income tax incentive, taxpaying state residents are offered an income tax deduction from their adjusted gross income to cover the expense of installing renewable energy systems. This tax deduction may have a time limit following the purchase of renewable energy equipment. Corporate tax incentives operate in much the same manner by allowing corporations to receive credits against the costs of installing renewable energy equipment. Although tax incentives may encourage investment in renewable energy equipment, investors who are unable to meet the initial project funding demands will be unable to participate in many tax incentive programs. Some states eliminate or reduce the sales tax on qualified renewable equipment. Finally, property assessments and millage rates can have a dramatic impact on the installation of renewable equipment especially for residential or small commercial firms. It was reported by the Florida Solar Industry Association that in Florida the installation of a photovoltaic system will increase property taxes more for a homeowner than the value of the electricity it produces.[26]

Appendix C provides a state-by-state identification of the programs in place to promote renewable energy.

Direct Incentive Programs

States have a variety of mechanisms to offer direct financial incentives to customers to encourage them to install qualified renewable technologies. These programs are generally funded directly from state funds such as general revenue sources or from monies collected directly from utility customers.

Regulated electric utilities have traditionally undertaken a set of “public purpose” programs in addition to selling electricity. These “public purpose” programs typically include low-income subsidies, demand-side management and energy efficiency programs, industry-wide research

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[25] Energy Information Administration. Office of Coal, Nuclear, Electric and Alternate Fuels. *Renewable Energy 2000: Issues and Trends.* February 2001.

[26] *Solar Energy in Florida: Policy Aspects, Status and Potential of Solar Thermal and Photovoltaics,* presentation by Colleen Kettles, Florida Solar Industry Association, July 2, 2002.

and development (R&D), and promoting renewable energy fuels. These activities have been possible due to government regulations which allow the utilities to recover program costs in the prices that they charge consumers. With the move toward a more competitive market for electricity, many of these programs are in jeopardy of being phased out as utilities face greater pressure to reduce costs. However, there is currently a debate over state policy mechanisms which can stimulate development in renewable energy technology, and other "public purpose" programs, in light of these growing market forces. A System Benefit Charge (SBC) is one mechanism that some states have adopted to encourage renewables.

A SBC is typically a small fee placed on all consumers' electricity bills which accumulates in a designated fund. Most states that have passed electric industry restructuring legislation are using a SBC to support renewable energy, energy efficiency, low-income customer programs, or other public-good functions which the competitive market is unlikely to provide. The SBC is designed to be competitively neutral, that is, paid by every customer regardless of who sells them electricity, and can be either assessed as a per kilowatt-hour fee or a flat fee per customer. The main benefit of a SBC is the ability to keep utility programs such as consumer education, demand-side management, and low-income customer assistance, often threatened under competitive markets. However, a SBC increases electric bills when the promise of competition and intent of restructuring legislation is meant to decrease energy bills. Finally, while a SBC that is intended to support or advance renewable energy is a very small part of the total electric bill, it may subsidize technologies which should be supported solely by the competitive marketplace.

Sixty-four percent of the states with active retail choice restructuring have implemented SBC programs, while only fifteen percent of the states with no retail choice restructuring have found these initiatives necessary to maintain public benefit programs. The SBC charges range from as low as .07 mills per kWh to a high of 3.76 mills per kWh.[27] The absence of an SBC program should not be interpreted as an indication that no public benefit programs are being offered in a particular state. It is likely that such programs continue to be offered under the auspices of the vertically integrated and regulated utility framework.

Rebate Programs

Rebate programs are offered at the state, local, and utility levels to promote the installation of renewable energy equipment. The majority of the programs are available from state agencies and municipally-owned utilities and support solar water heating and/or photovoltaic systems. Eligible sectors usually include residents and businesses, although some programs are available to industry, institutions, and government agencies as well. Rebates typically range from $150 to $4,000. In some cases, rebate programs are combined with low-interest or no-interest loans.

Grant Programs

States offer a variety of grant programs to encourage the use and development of renewable energy technologies. Most programs offer support for a broad range of renewable energy technologies, while some states focus on promoting one particular type of renewable energy such as wind technology or alternative fuels. Grants are available primarily to the commercial, industrial,

[27] A mill is 1/10 of a cent. Thus, 3.0 mills is equal to 0.3 cents per kWh. For Florida, with a typical electric bill of 1000 kWhs per month, a 3.0 mill fee would add $3.00 per month to the bill.

utility, education, and government sectors. Some grant programs focus on research and development, while others are designed to help a project achieve commercialization. Programs vary in the amount offered, from $500 to $1,000,000, with some states not setting a limit.

Loan Programs

Another option available to state governments to encourage investment in renewable energy technology is to offer low-interest loans to assist in the purchase of renewable energy equipment. By offering low-interest loans to individuals and organizations, states are able to encourage energy efficiency and diversify the mix of generation fuels. These loans are typically offered to residential, commercial, industrial, transportation, public, and non-profit organizations; and have fixed interest rates below the market rate with various repayment schedules. Benefits of low-interest loans include local control over the application process in defining the expected costs and benefits from a specific project, and offering local governments, utilities, and independent power producers the opportunity to upgrade existing power facilities.

Research and Development

An important aspect of advancing renewable energy technology is the research and development process. Here again, private venture capital will invest in technologies with very high potential payoffs such as fuel cells or in technologies that have near term commercial applications such as jet engine developments. It is the longer term, high risk R&D that the private sector is most unwilling to undertake. For this reason, direct government funding may be required to advance R&D in certain sectors of the renewable industry. Grant programs designed to encourage the use and development of renewable energy can be broad based covering all aspects of renewable energy, or aimed at a specific technology such as wind technology or alternative fuels. State funding programs can also aim to maximize federal investments in Florida through matching funds and other innovative ways to combine state and federal funds to further promote renewable energy. There are certainly issues of scope and scale where some research is so expensive, fusion is probably one example, that it would not be prudent for states to invest in this domain. The funding capability of multiple states through regional collaborations or perhaps better yet the Federal government, is best suited to undertake certain high cost, high risk type of projects.

Renewable Portfolio Standards (RPS)/Set Asides

Renewable Portfolio Standards (RPS) require that a certain percentage of a utility's overall or new generating capacity or energy sales must be derived from renewable resources, i.e., one percent of electric sales must be from renewable energy in the year 200x. Portfolio Standards most commonly refer to electric sales measured in megawatt-hours (MWh), as opposed to electric capacity measured in megawatts (MW). The term "set asides" is frequently used to refer to programs where a utility is required to include a certain amount of renewables capacity in new installations.

The recent development of RPS standards seems to be a result of the movement toward retail choice around the country. Some 41 percent of states with active retail choice restructuring have implemented RPS programs, while only eleven percent of states without retail choice restructuring have found these initiatives necessary. The specific amount of energy required by the RPS standards varies from state to state. Arizona has a goal of 1.1 percent by 2007, while California has a 20 percent goal by 2017. Maine has a 30 percent goal but already achieves this level due to its abundant hydroelectric resources. Appendix B shows a map of the various states with RPS standards and the mandated amounts.

The portfolio standard is designed to be competitively neutral, in that it imposes an equal obligation on any company selling electricity. However, this RPS requirement is usually designed as a tradable obligation. That is, one company with more than the required amount of renewable energy in its portfolio could sell credits to a company with a portfolio that was lacking those resources. While it is argued that RPS helps to diversify a state's energy supply and promote environmentally benign sources of electricity, it also raises energy costs to consumers for environmental benefits which often accrue outside the state. Additionally, although RPS may create a short-term market demand for infant technologies, this same demand may result in the transfer of wealth between states with indigenous renewable resources and those that do not have such resources. Therefore, the geographic scope of permitted trading could be limited to Florida to minimize such impacts.

Tradeable Renewable Electricity Certificates (T-REC)

A number of programs have been developed to implement renewable programs with respect to identifying the production source and the ultimate customer of renewable energy. Such programs involve various certifications to ensure that the energy meets the definition of "renewable" or "green" as is appropriate for that jurisdiction. Since the physics of the electric grid does not permit any single customer to receive specific electrons, an accounting or tagging program is needed to follow the renewable energy from a source to the sink. Tradable Renewable Electricity Certificates (T-REC's) also known as TAG's or simply as energy certificates is one such system. The development of these programs is occurring in some states under government or quasi-regulatory bodies, under the initiatives of private marketing companies in response to regulatory programs such as Renewable Portfolio Standards (RPS's) and sometimes at very small, local corporate levels when municipal power companies implement Green Marketing Programs.

Essentially T-RECs separate qualified renewable kWhs and separate them into two components — an energy component that is completely indistinguishable from other energy and an environmental or renewable attribute component. The energy flows over the grid as any other electrons, but the attribute certificate is a tradeable, financial instrument. Thus, people wanting to purchase renewable or green certified energy can purchase these and have assurance that the underlying green power was actually produced somewhere. The drawback with using financial instruments in lieu of actual in-state generation is that certain strategic energy objectives such as the reduction in a particular fuel source or creation of certain employment numbers within a state may not be achieved by use of tradeable certificates.

Policy Development

This chapter has provided a survey of programs both nationally and within Florida that have been initiated to increase the use of renewable energy resources. Each state has its unique set of energy issues and constraints and it is important for policymakers to define what objectives they want to achieve in promoting one set of policies over another. For example, a state with very high embedded electric costs, such as California, may pursue renewable programs as a means to moderate its electric prices. Other states may view renewables as an option to reduce the amount of fossil energy consumed or may want to promote indigenous high value, high technology industries such as solar manufacturing or research and development. Other states may have specific or general environmental goals to reduce certain identified pollutants.

The point to be considered is that strategic objectives should be clearly articulated by policy makers and then programs can be designed that most efficiently and cost-effectively achieve those objectives. For example, if petroleum reduction is the strategic objective, then perhaps renewable electric production is not the most efficacious strategy to achieve this goal. Florida's utilities only use about 14 percent of the petroleum consumed in Florida. Thus, a program designed to promote alternative transportation fuels or systems might be more effective in reducing petroleum use. On the other hand, if the goal is to promote more indigenous employment in a state, then a renewable goal might be designed that encourages the production and use of agricultural products that require more agricultural labor inputs.

Some states have promoted renewable resources as a means to reduce the price volatility of certain fuels such as natural gas. Clearly, natural gas is the preferred choice for new generating power plants. However, there are a variety of opinions on both the availability and price stability of the nation's gas reserves. Thus, some states are promoting renewable resources as a type of fuel hedge against either increasing or volatile costs of natural gas prices. All utility systems use an economic optimization system that at any given time, and subject to security constraints on grid reliability, dispatches generating units in order of their lowest operating costs regardless of fuel used. Thus, depending on system characteristics and the diversity of fuel types, some intermittent renewable resources may cause an existing generating unit to back out of the economic dispatch order. Depending on the fuel that is being burned in this unit, the inclusion of renewables may conflict with other stated fuel diversity objectives.

Finally, there may be other strategies to achieve some energy related policy objectives. For example, energy efficiency or demand-side management may provide less costly avenues for success. Requiring greater diversification of power plant fuel inputs by requiring utilities to use financial instruments to hedge their purchases, building more capital expensive but more fuel stable plants such as coal, or requiring greater dependency on purchase power contracts where third parties assume fuel risk are three such methods. Promotion of renewable resources should be one tool in a tool box of programs to be considered in achieving a state's broader strategic objectives.

Metrics, Evaluation and Economic Impacts

Once policy objectives are articulated and programs are designed, it is important that indicators and benchmarks are identified to evaluate progress toward achieving the objectives. Any policy making body will want periodic reports and feedback on the successes and failures of the renewable programs adopted. As discussed in this report, renewable programs have an assortment of objectives including numerically defined resource acquisition levels. Other states have set goals based on funding levels and may have goals that are targeted toward end use customers such as direct rebates or incentives. The main consideration is some kind of tracking and evaluation component that allows necessary corrections be made to the goals, allows systematic feedback to policy makers, and holds responsible the program administrative agent such as utilities, state agencies, or economic development units.

General agreement exists that renewable technologies are usually more expensive than the traditional fleet of utility power plants. Given this axiom, several important policy determinations must be addressed in developing a renewable strategy. First and foremost is what are the limited factors in the actual amount of resources that can be obtained? Second, what incremental higher costs are you willing to impose on customers or taxpayers to achieve these potentials? And third, what are the various sector impacts of these decisions on customer bills, business decisions, and relative competitiveness across industries?

Clear directives are needed with respect to the level, duration, and source of funding necessary to achieve the strategic objectives. As described in this chapter, states have adopted a variety of funding sources to promote renewables including system benefit charges, general revenue funding and other charges such as utility sponsored research and development that has traditionally been included in electric rates. Florida utilities currently spend around $245 million per year on efficiency and demand-side management programs. This amounts to between 0.6 and 1.9 mills per kWh on existing bills. This equals between $.60 and $1.90 on a typical 1000 kWh per month residential electric bill. These funds are recovered on each customer's bill based on the number of kWhs they consumed using a recovery factor adjusted every year. Some of these funds are used for research and development on renewables. However, close to 70 percent of the $230 million is given back to the participating customers in the form of incentives or rebates largely to customers who participate in load control or interruptible demand programs. Additionally, all customers benefit from efficiency and demand-side management programs because each program for which an investor-owned electric utility receives cost recovery must pass a RIM (Rate Impact Measure) test, to ensure the rates will either stay the same or decrease.

Attention must also be paid to the industry impacts of particular funding sources. While electric utility customers provide a source for additional funding of renewable resources, some customers have the ability to shift the amounts and types of energy they use to avoid any additional charges. For example, large industrial customers may shift to natural gas for their energy needs engaging in what economists call substitution behavior. Residential customers will likely use less electricity. System benefit charges are not fuel source neutral, that is the surcharges are assigned based on the final product (i.e. kWhs consumed) and not assigned to the individual fuel inputs that produce those kWhs. Thus, such charges may have disproportionate impacts on the competitive posture of different industries.

Finally, it should be made clear that it is difficult, if not impossible, to monetize all the different attributes of renewables into a single cost dimension. While production cost is a relatively straightforward concept and is used as one benchmark to compare technologies, it is impossible to account for all the different attributes and the non-economic impacts of various technologies both renewable and traditional. For example, we know that municipal solid waste facilities can have air emission profiles not dissimilar to traditional generators, yet they provide a valuable public benefit in reducing trash volumes that would normally be deposited in landfills. Central station photovoltaic systems have very favorable air emission profiles and do not require water for cooling, but would require larger land areas than traditional power plants. Here again, attention must be given to the total set of attributes of specific technologies before assigning preferential rankings or deciding to select one technology over another.

The 2020 Study Commission offered guidance as to the conflict that government faces when promoting one technology over another.

THE FINAL REPORT STATED:

The development path of technology is not always predictable and the ultimate arbiter of the winners and losers is the market place. Technologies once viewed as promising often fail to achieve widespread adoption due to unresolved technical issues, failure of consumers to embrace the technology, or failure to meet cost or performance objectives that make them competitive with alternatives. Because of the dynamics of technological change, it is very difficult for government, with its obligation to protect the public purse, to identify successfully which of the competing industries and industry technologies should be awarded financial support.[28]

[28] *Florida... Energy Wise! A Strategy for Florida's Energy Future.* Final Report of the Energy 2020 Study Commission, December, 2001, p.101.

CHAPTER V

FLORIDA ACTIVITIES with RESPECT TO RENEWABLES

Since the 1970's, the State of Florida has enacted at least twelve laws and numerous rules intended to promote the growth and development of renewable energy. Most of these were designed to use market mechanisms to increase the utilization of renewable technologies with special encouragement to solar applications. Supported by a broad mandate under the State Comprehensive Plan (*Florida Statutes* 187.201), as well as specific directives in Chapter 366, *Florida Statutes*, the Florida Energy Office (FEO), now a part of the Department of Community Affairs, has extensive experience in administrating various renewable energy programs. In fact, the Energy 2020 Study Commission recommended a revitalized role for this office. One specific recommendation made by the Commission stated, " In an effort to encourage energy efficiency, the FEO should utilize existing and future resources to manage a broad program of investments in energy efficiency and sustainable generation technology." Most of these efforts historically have been funded by the use of Petroleum Violation Escrow (PVE) settlements. These funds also supported a large portion of the university research on renewables. However, these oil overcharge funds are nearly depleted and can not be expected to continue at their historical funding levels.

Solar Initiatives

Florida has long been a leader in establishing quality control and inspection standards for solar equipment and contractors. It is in large measure due to these efforts that Florida has a strong solar energy infrastructure. Other states may have strong incentives for solar energy deployment, but they lack the infrastructure which is required to create an industry base. The Solar Energy Standards Act of 1976 authorized the Florida Solar Energy Center (FSEC) to establish criteria for testing performance of solar energy systems and require disclosure of those performance results. This initiative has given the developing industry for solar equipment marketed for sale in Florida a sound regulatory basis for quality, performance and consumer confidence.

All solar energy systems manufactured or sold in Florida must be tested and certified to FSEC standards. Local building code jurisdictions require evidence of certification before a building permit will be issued, and the building department inspects the completed installation to assure compliance with the standards. Florida is the only state with its own solar system certification program. Other states have adopted the FSEC standards as their own, or have adopted the Solar Rating and Certification Program process, a national standards and certification program which is patterned after FSEC's and is administered by FSEC.

In addition, Florida is one of a few states which established a contractor license specific to the solar trade. The solar contractor is regulated by the Construction Industry Licensing Board of the Department of Business and Professional Regulation. The scope of work includes solar water heating, pool heating, and photovoltaics.

The Florida Building Code provides performance credits for solar energy installations based on various thermal performance standards. Solar energy systems will also be covered by the Florida

Building Commission's Product Approval process which is under development. The interrelationship of the standards, codes, licensing and inspection process which Florida has developed has been critical to the successful development of quality solar installations.

Florida has been a leader in establishing solar rights laws. Section 704.07, *Florida Statutes*, has authorized voluntary solar energy easements which create a property right of record which cannot be unreasonably infringed. This has contributed to the legitimization of solar energy as having potential value to the property owner that wishes to access it.

Section 163.04, *Florida Statutes*, essentially bans community association restrictions on access to available solar resources by providing residents in deed restricted communities with the ability to install solar energy systems without the unreasonable interference of community associations.

Finally, Section 235.212(2), *Florida Statutes*, requires that an assessment of the feasibility of solar water heating systems be required on future educational facilities.

Financial Incentives

Florida has had several successful financial incentive programs, most of which have expired or are set to expire. A sales tax exemption, established under Section 212.08, *Florida Statutes*, has reduced the initial capital cost of acquiring solar equipment and systems. This exemption is set to expire as of July 1, 2005.

While there still exists the constitutional authority for a property tax exemption, the enabling statute has expired. At this time, a photovoltaic system that is fully incorporated into the appraised value of the house will yield more in property tax liability than energy savings.[29]

More recently, the Florida Solar Energy Center with funding from the Department of Community Affairs administered a direct matching incentive program to encourage the installation of photovoltaic systems in residential and commercial buildings. Approximately 53 grid connected PV systems were installed through the Florida PV Rebate program, which offered $4 per watt to residential, commercial, and public PV systems. It offered up to $16,000 to residential customers and $40,000 for commercial customers and public buildings. In 2003, FSEC will administer a PV Rebate Program dedicated solely to installing PV systems on Florida schools. Approximately $525,000 was dedicated to this program effort. It is anticipated that at least 30 PV systems will be installed as a result of this new rebate program.

Education Initiatives

Florida has several successful education and information programs directed toward renewable energy. The Florida Solar Energy Center (FSEC) has education as part of its mission. This includes providing education and information dissemination. Partially funded under a Department of Energy grant, the FSEC has a strong K-12 education program, as well as a wide range of

[29] Presentation by Colleen Kettles at the FPSC Workshop on July 2, 2002 , *Solar Energy in Florida: Policy Aspects, Statutes, and Potential for Solar Thermal and Photovoltaic.*

continuing education programs for energy practitioners. FSEC maintains a public information office, a solar energy library, and a website featuring general information and specialized publications. FSEC is also supporting DOE plans to host a series of traveling briefings and equipment shows on distributed energy (addressing many renewable energy applications) which will visit locations in North, Central and South Florida in early 2003. Finally, the Cooperative Extension Service expanded its scope of services to include an energy education and training element. Originally funded under the Florida Energy Office, the program is now self supporting under the auspices of Institute of Food and Agricultural Sciences and operates in nearly every county in Florida providing a range of information on energy topics.

The Florida Solar Energy Industries Association (FlaSEIA) provides a toll-free hotline, a website, consumer literature, a newsletter, industry directory and participates in a variety of energy expositions. The Florida Solar Energy Research and Education Foundation (FlaSEREF) provides a toll-free hotline, websites, consumer literature, and specialized educational and marketing programs for consumers, home builders and plumbing contractors.

Florida has several current program initiatives designed to promote the development and application of renewable energy resources in the state. SunBuilt Marketing, an education program supported by the Florida Solar Energy Research Foundation and the Florida Home Builders, targets the new home construction market. Funded over multiple years by Petroleum Violation Escrow (PVE) funds by the Department of Community Affairs, this program paid for solar equipment costs to be installed in model homes for builders. The solar industry provided volunteer labor to install the equipment. Due to the expiration of PVE funding, support for this program was discontinued in 2002.

Zero Energy Homes and Building America, a program at the Florida Solar Energy Center (FSEC), funded by the U.S. Department of Energy, is designed to incorporate energy efficiency and solar energy into building designs as a way to qualify the building for an "Energy Star" ranking. Such a ranking implies that the building is at least 30 percent more efficient than one meeting the standard building code. Although the program is just ramping up, it shows great promise. The FSEC developed the prototype Zero Energy Home in Lakeland.

The Florida Green Building Coalition, a non-profit group associated with the Florida Solar Energy Industry Association and FSEC, is targeting sustainable building practices, ranging from single family homes to entire developments. Participants include key builders, developers, architects, universities, and interested stakeholders.

SunSmart, supported under the Department of Energy's Million Solar Roofs program, is working through the Florida Solar Industry Association, FSEC and the Florida Municipal Electric Association (FMEA) to develop generic marketing materials for utilities interested in promoting green pricing programs to their customers. The SunSmart program currently has 8 municipal electric utility members. It has received funding from the American Public Power Association, the U.S. Department of Energy through the Million Solar Roofs Initiative, and the Florida Energy Office. The program recently received additional funding to expand its scope and encourage further utility participation in green pricing programs.

Utility Initiatives

Florida electric utilities can support the development of renewable capacity in several ways, including building renewable resources, or by purchasing the capacity and energy from renewable generators. In addition, several Florida utilities have on-going research and development programs for various renewable technologies. Many Florida utilities are also beginning to provide renewable energy to interested customers through green-pricing programs. Utilities can also encourage the development of renewable technologies through customer education programs, and low interest loan programs offered to customers interested in purchasing photovoltaic and solar thermal systems. The specific activities of Florida's electric utilities will be discussed further below.

Florida Power & Light Company

Florida Power & Light Company (FPL) began its renewable efforts in the late 1970s. FPL worked with the Florida Solar Energy Center in the late 1970s, to explore the feasibility of residential solar PV systems. In 1984, FPL installed a 10 kW solar PV system at the Flagami substation. FPL installed several test PV projects in the 1980s and 1990s to collect cost and performance information. FPL also provided a solar water heating program between 1982 and 1987, which assisted 48,000 customers in installing solar thermal water heating systems. In the early 1990s, FPL also conducted a research and development program to evaluate using PV panels to power swimming pool pumps.

In 1998, FPL initiated the Solar Research Partnership program, a green-pricing program, to determine customer interest in supporting solar energy. Over 10,000 customers responded, with one-time contributions of from $5 to $200. FPL subsequently installed a 10.1 kW PV system at its Martin site. FPL is currently conducting customer market research to develop an ongoing green-pricing program, and has determined that there is sufficient customer interest to support the program. Approximately 30 percent of those surveyed have indicated an interest in supporting green energy. FPL expects actual participation to be much lower, ranging from one to ten percent. Further research is being conducted to determine the appropriate sources for this renewable energy, and the willingness to pay of potential participants. FPL has also issued a request for proposals for renewable resources to be supported by the program. Additional information on FPL's Solar Research Partnership Program is available on FPL's website, www.fpl.com.

FPL is also conducting the Photovoltaic Research and Development program to determine how solar PV systems actually perform in meeting specific customer needs. FPL plans to install seven PV systems in residential and commercial facilities and monitor these systems for a full calendar year. Five of the seven systems are installed, with two additional planned by the end of 2002. FPL will collect data on such issues as: the financial benefit to customers, the coincidence of the system with peak demand throughout the year, the actually energy generated, and actual operating and maintenance costs. FPL is also in the process of siting and installing five fuel cells around the state to determine the performance of this developing technology.

FPL is also purchasing energy from several qualifying facilities fueled by renewables. These facilities are fueled by biomass (including bagasse), waste heat, and municipal solid waste.

Progress Energy

Progress Energy (formerly Florida Power Corporation (FPC)) has joined with Palm Harbor homes, a manufactured housing company, to study the operation of PV systems in manufactured homes. The program has also been supported with a grant and technological assistance by the Florida Solar Energy Center. The objectives of the project are to increase customer awareness of PV systems, improve the efficiency of manufactured housing, research green power programs, and reduce labor costs associated with PV installation. Progress Energy has installed PV systems ranging from .8 kW to 1.3 kW in six styles of Palm Harbor Homes. These homes will be monitored for at least one year. Preliminary results show average system total installed costs of $7,000, with approximately 3 kWh per day produced. Average cost per kWh ranged from $0.31 for installation costs alone, to $1.31 per kWh including O&M costs. Progress Energy received the 2001-innovation award from the Interstate Renewable Energy Council for their research and development on photovoltaics.

Progress Energy continues to conduct research to fully understand the potential of photovoltaics at the Econolochatchee solar array in Orlando, which was originally commissioned in August of 1988. Additionally, Progress Energy has formed partnerships with Disney, installing 6.5 kW of photovoltaics at the Nature Conservancy and is currently coordinating the installation of photovoltaics on 20 BP (British Petroleum) stores, which will total 185 kW when completed.

Progress Energy has also increased its efforts to educate the public on PV systems. Progress Energy has worked with the Legal Environmental Assistance Foundation to develop an educational brochure on PV systems. Progress Energy has also developed a website at www.fpc.com/environment/solar.html which discusses PV systems and provides sources of additional information. Finally, Progress Energy has provided a $25,000 grant to finance the Solar Energy Education Program (SEEP). The SEEP program is estimated to impact 7,500 students, equip thirty schools with solar energy education kits, curriculum materials, and an interactive energy focused web site. Each school will have the opportunity to build and race a solar powered car in a statewide competition.

Progress Energy is currently purchasing 205 MW of MSW and biomass derived energy from several qualifying facilities.

Gulf Power Company

Gulf has been participating in the EarthCents Solar green pricing program with its sister company, Alabama Power, since December 1999. The program is designed to install 1 MW of solar generation as soon as customers commit to provide $6 per month for 10,000 100-watt blocks. Gulf has received less than 1,000 commitments for 100 watt blocks at this point, and will not begin charging customers for the program until enough commitments are obtained. Gulf has been advertising the program in bill stuffers and on its website. Gulf and its parent company, Southern Company, share the website, www.southerncompany.com, which is an excellent source of information concerning each type of renewable energy technology. The website also provides links to other websites with additional viewpoints on renewable technologies.

Southern Company has had numerous research and development programs in the last ten years on co-firing at existing coal plants with various forms of biomass, including sawdust, tree trimming wastes, and switchgrass. Research results reveal that lowest cost sources of biomass fuel will be waste wood in the immediate vicinity of each existing plant.

Southern Company also has two ongoing projects to evaluate fuel cells. One project is monitoring a 250 kW fuel cell demonstration plant. The other project is designed to study fuel cell performance under various conditions and applications.

Tampa Electric Company

Tampa Electric Company (TECO) launched its green-pricing program, Smart Source, in November 2000. The program allows interested customers to subscribe to 50 kWh blocks of energy for an additional charge of $5 per month. Both solar and biomass projects will be supported by the program. TECO has conducted market research for the program, including focus groups and customer surveys. TECO has advertised the program through bill stuffers, targeted mailings, and the website, www.smartsource.tampaelectric.com. TECO plans to increase customer participation to 1 percent of its customer base within the next five years, and will encourage commercial and governmental participation. Customers may subscribe on the website or by phone.

TECO's SmartSource resources currently include a PV installation and biomass. The PV system is an 18 kW array at the Museum of Science and Industry. TECO has also conducted biomass co-firing experiments at the Gannon station using yard waste collected by Hillsborough County. TECO also has a planned landfill gas generation site. TECO is also reviewing biomass gasification at the IGCC plant located at the Polk site.

Gainesville Regional Utilities

In 1997, Gainesville Regional Utilities (GRU) installed a 10 kW photovoltaic system on the roof of its system control facility. The PV panels provide energy for the equipment housed at this facility, and were purchased through government grants and customer contributions. GRU plans to install additional PV panels at the Gainesville/Alachua County Regional Airport during 2002.

GRU also provides customer rebates for the purchase of active and passive solar water heating systems. Rebates range from $300 to $450, depending on the type and capacity of the system. Information concerning GRU's PV installations and solar water heating system rebates is available on GRU's website: www.gru.com.

Jacksonville Electric Authority

Jacksonville Electric Authority (JEA) has committed to the Sierra Club and the American Lung Association to achieve 7.5 percent of summer peak capacity resources from clean power, by 2015. This includes 6 percent, or 200 MW, of renewable capacity, and 1.5 percent, or 50 MW, of equivalent clean capacity. The equivalent clean capacity will consist of power generation efficiency measures, pollution control additions, and demand-side management programs which will mitigate an equivalent amount of emissions from a conventional generating source. JEA believes that the benefits of this program are customer satisfaction, fuel diversification, and rate stability. JEA's internal goal is to have 4 percent clean capacity by 2007.

JEA currently has approximately 7.9 MW of renewable capacity, including approximately 162 kW solar PV capacity, 893 kW of solar thermal, 6,000 kW in landfill biogas, and 800 kW in digester biogas capacity. JEA has currently installed PV systems in all of the public high schools in Duval County, as well as many of JEA's facilities. Installation costs have been approximately $12,400 per kW. JEA attributes this high cost largely to structural considerations due to high wind loading design requirements. JEA has also entered into a 70 MW purchased power agreement with Biomass Industries, Incorporated. This developer will grow biomass crops (E-grass and bamboo) in order to provide JEA with the energy resulting from gasifying these crops.

JEA does not currently have a green pricing program. However, JEA meters the energy produced from each renewable facility so that green tags can be sold to produce additional revenue.

JEA began its Solar Incentive Program for residential and commercial customers in February, 2002. JEA's customers have installed 101 eligible systems since the program's inception, with a combined capacity of 539 kW. Customers must use solar providers which are pre-qualified by JEA. The program provides incentives of up to $4 per watt for PV systems and up to $20 per square foot of solar water heater collectors. JEA also provides an incentive of up to $500 to restore existing PV and solar hot water systems to working order. Incentive levels are higher in all cases when the customer uses a local vendor. JEA also provides an enhanced incentive for qualifying non-profit organizations and low-income families. The total incentive is limited to $50,000 per installation. Further details are available on JEA's website, www.jea.com, or by calling (904) 665-6000.

JEA's renewable efforts also include several research and development programs. JEA is currently managing and studying a 15 acre biomass energy farm. JEA has also developed a high-temperature solar collector that has the potential as an application for electric generation or in air conditioning. The utility has also contributed funding to the University of North Florida to establish a renewable energy research laboratory.

City of Lakeland

In 1998, the City of Lakeland collaborated with the Florida Solar Energy Center in the Zero Energy Homes research program. Two homes with identical floor plans and solar orientation were built under this program, a standard or control model, and an energy-efficient photovoltaic residence. The control home was built to the Florida Energy Efficiency Code for Building Construction. The energy-efficient PV model combined energy-efficiency measures with 4 kWs of solar PV cells. Data was collected from the homes for more than a year to determine the performance of energy efficiency measures and PV systems in reducing energy demand in Florida homes. Due to the positive results of this study, the program has been used as a model for a national Zero Energy Homes program. FSEC reports that in one year, the energy-efficient PV home used 6,960 kWh of energy, 5,180 kWh of which was provided by the PV system. For the same period, the control residence used 22,600 kWh. FSEC also found that the PV home placed nearly zero net peak demand on the grid during periods of peak demand. This indicates that the combined energy efficiency measures and PV system were coincident with system peak. FSEC stated that on the hottest day recorded in the Lakeland area, the energy efficient PV house met 70 percent of the cooling energy used, and 80 percent of the peak load compared with the control house. More information about this program can be found on FSEC's website at www.fsec.ucf.edu.

The City of Lakeland is a partner in a pilot Solar Thermal Billing program funded by the Florida Energy Office. The program's goal was to evaluate the effectiveness of using solar thermal water heating systems in the Lakeland area by installing solar water heating systems with special metering equipment at 50 Lakeland homes. The systems were installed at no cost to participants. Participants were billed for the energy produced by the system and used for water heating purposes. Lakeland received 418 responses, or a .4 percent response rate, from volunteers willing to participate in the program. The total installed system cost was $2,100, which included an 80 gallon storage tank, glazed collector, 5 watt PV/DC pump, meter and timer. Using a kWh rate of 7.5 cents, each system would produce $142 in revenue for a participating utility, indicating a 14.8 year payback period.

City of Lakeland is also participating in the SunSmart green energy program. This program uses partnerships with Florida municipal utilities, the U.S. Department of Energy, the Florida Energy Office, and the Florida Solar Energy Center, to provide education to utilities and consumers concerning renewable energy technologies. The goals of the SunSmart program include allowing any participating utility to offer a green pricing program, educating Florida consumers about renewable energy technologies, providing Florida schools with educational materials, and assisting municipal utilities with overcoming barriers to the installation of renewable resources. More information about the SunSmart program can be obtained at www.sunsmart.org.

City of Tallahassee

The City of Tallahassee (Tallahassee) currently has several renewable installations, including the 11 MW hydroelectric facility at the C.H. Corn Station, and an 18 kW solar PV system at the State Satellite Office Complex that was originally part of an electric vehicle charging station. Tallahassee's most recent renewable installation is a 10 kW solar PV system located at the Trousdell Gymnastic and Aquatic Center.

In the mid-1990s, Tallahassee initiated a Solar Water Heating Pilot Program. This program was partially funded by a grant from the State of Florida. As a result of the program, seven commercial solar water heaters were installed on city buildings. Fourteen residential solar water heaters were also installed.

Tallahassee has based its solar program, Green For You, on market research. This research has included a phone survey conducted 4 years ago, and several focus group sessions in June 2001. Tallahassee's market research found that there is an overall support for expanding the city's renewable resources, in particular, solar energy resources. Customers believed this effort should be combined with increased efforts to encourage energy efficiency and conservation. Customers also expressed concerns about being able to verify that city revenues are used to develop power resources which are actually considered to be green.

Green For You will be launched in November, 2002, and has been developed in partnership with Sterling Planet, a clean energy marketer, and the Legal Environmental Assistance Foundation. Tallahassee intends to provide 50 percent of the energy under the program from local solar resources. The other 50 percent will be obtained by purchasing Green Tags for renewable energy, such as biomass and wind energy, produced within the Southeast region. The initial webpage marketing campaign can be found at: http://talgov.com/citytlh/utilities/index.html.

Tallahassee has also worked to increase customer awareness of solar technologies. These efforts include the sponsorship of the Florida A&M, Florida State University College of Engineering solar car entry into the national solar car race, Sunrayce99. Tallahassee has also developed several mobile solar demonstration modules, including an interactive computer kiosk, to be used in Leon County schools. Tallahassee also provides information on renewable technologies and the programs offered by the city utility on its website, www.talgov.com.

Utilities Commission of New Smyrna Beach

The Utilities Commission of New Smyrna Beach (New Smyrna) has worked with the Florida PV Rebate program to offer their customers PV systems at a price of $1.82 per peak watt. The remaining cost of $4 per watt was paid for by the Utilities Commission and the State of Florida through the PV Rebate Program. The utility offered their customers financing at the prime rate for the PV installations, as well as a two-year system warranty. Eleven systems have been installed through the program. The Utilities Commission also offers a green-pricing program to their utility customers. Participants in this program can elect to pay an additional $2, $5, or $10 per month on their bill to support public PV installations in their city. Currently, the utility has installed two public PV systems: one on a municipal golf course and one on a local elementary school. The utility has plans to install two additional school systems in 2003.

FLORIDA RENEWABLE GENERATION

AS OF JANUARY 1, 2002

UTILITY /FACILITY	FIRM * CAPACITY SUM (MW)	NET * CAPABILITY SUM (MW)	FUEL TYPE
CITY OF TALLAHASSEE	11.0	11.0	Hydroelectric
FLORIDA MUNICIPAL POWER AGENCY			
Metro Key West	0.0	2.5	Municipal Solid Waste
US Sugar Corporation	0.0	26.5	Other Biomass Solids
FLORIDA POWER CORPORATION			
Bay County Res. Recov.	11.0	11.0	Municipal Solid Waste
Dade County Res. Recov.	43.0	43.0	Municipal Solid Waste
Lake County Res. Recov.	12.8	12.8	Municipal Solid Waste
Pasco County Res. Recov.	23.0	23.0	Municipal Solid Waste
Pinellas County Res. Recov.	40.0	40.0	Municipal Solid Waste
Pinellas County Res. Recov.	14.8	14.8	Municipal Solid Waste
Proctor & Gamble (Buckeye)	0.0	38.0	Wood/Wood Waste Solids
Ridge Generating Station	39.6	39.6	Wood/Wood Waste Solids
St. Joe Forest Products	0.0	0.0	Wood/Wood Waste Solids
Timber Energy	12.8	12.8	Wood/Wood Waste Solids
Jefferson Power	8.0	9.0	Wood/Wood Waste Solids
Cargill	15.0	15.0	Waste Heat - Exothermic
Potash Corp. of Saskatchewan	0.0	15.0	Waste Heat - Exothermic
Potash Corp. of Saskatchewan	0.0	27.0	Waste Heat - Exothermic
US Agrichem	5.6	44.1	Waste Heat - Exothermic
FLORIDA POWER & LIGHT			
BioEnergy	10.0	12.0	Municipal Solid Waste
Broward-North	49.0	56.0	Municipal Solid Waste
Broward-South	54.1	61.0	Municipal Solid Waste
Georgia Pacific	0.0	---	Wood/Wood Waste Solids
Okeelanta	0.0	---	Other Biomass Liquids
Osceola	0.0	---	Other Biomass Liquids
Palm Beach County	43.5	46.5	Municipal Solid Waste
US Sugar-Bryant	0.0	---	Other Biomass Liquids
Royster	9.0	9.0	Waste Heat - Exothermic
GULF POWER			
Champion	0.0	37.4	Wood/Wood Waste Solids
Champion	0.0	40.8	Wood/Wood Waste Solids
Stone Container	0.0	4.0	Wood/Wood Waste Solids
Stone Container	0.0	10.0	Wood/Wood Waste Solids
Stone Container	0.0	5.0	Wood/Wood Waste Solids
Stone Container	0.0	20.0	Wood/Wood Waste Solids
SEMINOLE ELECTRIC CO-OP			
Lee County Resource Center	30.0	30.0	Municipal Solid Waste

CONTINUED

FLORIDA RENEWABLE GENERATION

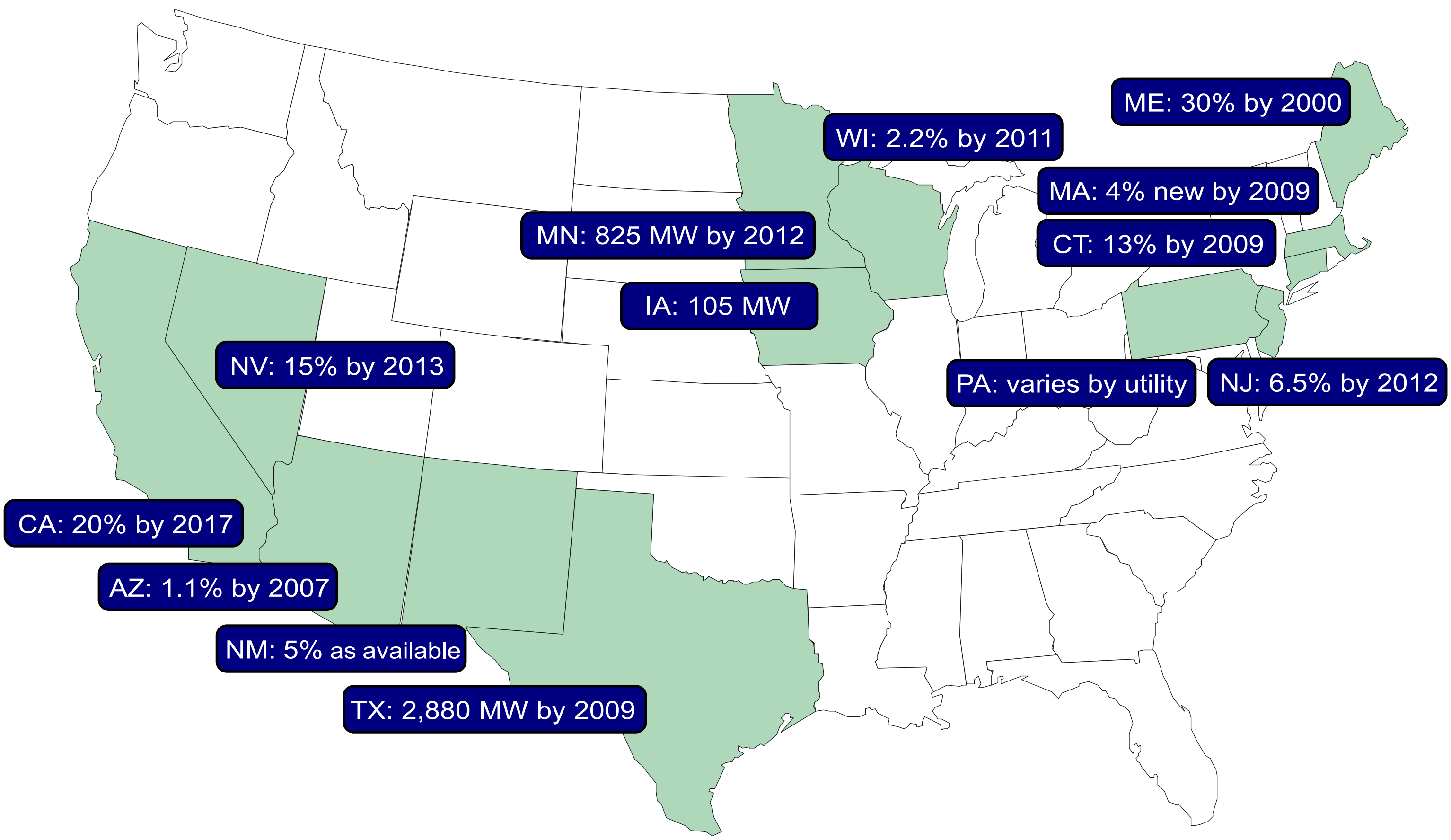
AS OF JANUARY 1, 2002

UTILITY /FACILITY	FIRM * CAPACITY SUM (MW)	NET * CAPABILITY SUM (MW)	FUEL TYPE
SOUTHEASTERN POWER ADMIN.	39.0	39.0	Hydroelectric
TAMPA ELECTRIC COMPANY			
City of Tampa - Refuse	18.0	18.0	Municipal Solid Waste
City of Tampa - Sewage	0.0	1.4	Other Biomass Liquids
Hillsborough CTY - Refuse	23.0	23.0	Municipal Solid Waste
Cargill Millpoint	0.0	41.0	Waste Heat - Exothermic
Cargill Ridgewood	0.0	57.1	Waste Heat - Exothermic
CF Industries	0.0	27.4	Waste Heat - Exothermic
Farmland Hydro	0.0	25.1	Waste Heat - Exothermic
IMC New Wales	0.0	50.8	Waste Heat - Exothermic
IMC South Pierce	0.0	28.5	Waste Heat - Exothermic
Mulberry Phosphates	0.0	0.0	Waste Heat - Exothermic
TOTAL	**512.2**	**1,028.1**	

** Firm Capacity refers to amount of output committed for delivery under firm contract to purchasing utilities. Net Capability refers to the output potential of the generator.*

State Renewables Portfolio Standards and Purchase Mandates

(13 States)



- **Approximately 30% of total U.S. load covered**
- **11 states have RPS**
- **Mandates in 2 states (MN and IA)**

Also, renewable energy "goals" established in Illinois, Minnesota, and Hawaii.

Map Information provided by: Ryan Wiser, Lawrence Berkeley National Laboratory

State Financial Incentives for Renewable Energy 2002*

All 50 states including the District of Columbia

Numbers in box indicate number of programs offered. ○ = STATE ☐ = UTILITY ● = LOCAL

(In the table: (n) = state, [n] = utility, ●n = local)

	PERSONAL TAX	CORP. TAX	SALES TAX	PROP. TAX	REBATES	GRANTS	LOANS	INDUST. RECRUIT	LEASING	EQUIP. SALES	PROD. INCENT.
Alabama	(1)					(1)	[1]				
Alaska			(1)				(1)				
Arizona	(2)		(1)		[2]					[2]	
Arkansas		(1)			(1)			(1)			
California	(2)	(1)		(1)	(4) [10]	(5)	(1) [1]	(1)	[2]	[1]	
Colorado	(1)	(1)									
Connecticut		(2)	(1)	(1)			(1)				
Delaware					(1)						
Dist. of Colum.											
Florida			(1)		(1) [2]	[1]			[1]		
Georgia											
Hawaii	(2)	(3)	(1)		(1) [3]		●1	(1)			
Idaho	(1)						(1)				
Illinois				(1)	(1)	(2)		●1			
Indiana				(1)		(3)					
Iowa		(1)	(2)	(3)		(1)	(3)				
Kansas				(1)		(1)					
Kentucky											
Louisiana											
Maine											
Maryland	(2)	(2)	(3)	(1)			(2)				
Mass.	(2)	(3)	(1)	(1)							
Michigan						(1)					
Minnesota			(2)	(1)	(1)	(1)	(2)				(1)
Mississippi							(1)				
Missouri		(1)					(1)				
Montana	(2)	(1)		(1)			(1)	(1)			
Nebraska					[1]		(1)				(1)
Nevada				(2)	[1]						
N. Hampshire				(1)							
New Jersey			(1)		(1)						
New Mexico		(1)									
New York	(1)	(1)		(1)	[1]	(1)	(1)				
N.Carolina	(1)	(1)		(1)			(1)	(1)			

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State Financial Incentives for Renewable Energy 2002*

All 50 states including the District of Columbia

Numbers in box indicate number of programs offered. ○ = **STATE** □ = **UTILITY** ● = **LOCAL**

	PERSONAL TAX	CORP. TAX	SALES TAX	PROP. TAX	REBATES	GRANTS	LOANS	INDUST. RECRUIT	LEASING	EQUIP. SALES	PROD. INCENT.
North Dakota	①	①	①	②							
Ohio		①	①	①			①				
Oklahoma		①									
Oregon	①	①		①	[4]		① [3]				①
Pennsylvania					❶	① ❸	❸				
Rhode Island	①		①	①	②	②					
S. Carolina					[1]						
South Dakota				①							
Tennessee							①				
Texas		①		①	[1]		[1]	①		[1]	
Utah	①	①									
Vermont			①	①							
Virginia				①				②			
Washington			①		①			①			[1] ❶
West Virginia		①		①			❶				
Wisconsin				①	① [1]	②	①				
Wyoming									[1]	[1]	
Total # of States with Programs	**15**	**20**	**15**	**24**	**19**	**13**	**22**	**9**	**3**	**4**	**4**
Total # of Programs	**21**	**26**	**19**	**28**	**45**	**25**	**33**	**10**	**4**	**5**	**5**

* *Source:* www.desireuse.org