

Chapter 6: Other Renewable Resources

Summary

As presented in the previous chapters, solar and wind are the most abundant renewable resources in the San Diego region; other more limited, yet still important resources in the Region include biomass and small hydro energy. As summarized in Table 6.1, the Region could potentially generate, on annual average, a technical potential of roughly 40 to 100 MW (300 to 800 GWh) from urban wood wastes, and 4 to 6 MW (27 to 45 GWh) from forestry wood wastes. The technical potential from agricultural wastes is negligible due to more economically valuable use as fertilizers. In addition, the Region's landfill gas generation technical potential is estimated at 72 MW (505 GWh) from the seven operational plants and two new identified candidate sites. As for small hydro, due to insufficient indigenous water resources in the Region, the Region currently has 8.32 MW (15 GWh) of hydro-generated power plants.

6.1 Biomass Energy

6.1.1 Biomass Energy Potential in California

When organic matter, called biomass, is used to produce energy, the most common approach is for it to be burned directly in a boiler to produce steam, which then turns a turbine to produce energy. Biomass can also be converted into a combustible gas, commonly referred to as bio-fuel, allowing for greater efficiency and cleaner performance. Currently, 2.2% of the State's electricity derived from biomass and waste-to-energy sources.¹

Biomass electricity generation facilities use a range of organic waste material as fuel. Solid biomass fuels include woody agricultural, urban, and forest wastes. Biogas fuel sources include landfill gas, animal manure, and sewage wastewater facilities. Municipal solid waste (MSW) and bio-diesel facilities have limited eligibility in California's Renewable Portfolio Standards (RPS) under PUC Section 383.5. Here, bio-diesel is a combination of bio-fuel and conventional diesel fuel.

Producing electricity from controlled combustion of solid organic waste materials at a facility with appropriate pollution control equipment greatly reduces emissions of particulate matter and other air pollutants that would result from uncontrolled burning and reduces the amount of waste that is sent to landfills. Generating electricity from waste wood and other solid biomass such as agricultural residues (e.g., orchard pruning) and forest waste (e.g., mechanical thinning of undesirable undergrowth) reduces air pollution from open burning of agricultural residues for disposal, and from either controlled burning of forests or accidental forest fires.

Forest-derived waste wood is, by a small margin, the most commonly used biomass for power generation, due to its availability in the State, especially in the central and northern regions. Urban wood wastes are available in substantial quantities in the heavily

¹ CEC "Comparative Study of Transmission Alternatives" Background Report, June 2004.

urbanized regions of the State, especially the greater Los Angeles and San Francisco areas. In California's Central Valley, agricultural residues are the most common form of biomass power plant fuel. In all, the wood and other biomass wastes consumed in California for power generation total about 6 million tons per year, roughly evenly divided among urban, agricultural, and forest-derived biomass. However, the most efficient source of biomass energy seems to be landfill gas. Generation cost from most landfill gas plants is around 4 cents/kWh. Most of the waste we generate ends up in landfills, where it decomposes and produces landfill gas. Landfill gas released into the air smells bad, contributes to local smog, and is an explosion hazard if concentrated. Additionally, landfill gas is about 50% methane, a potent greenhouse gas that reportedly contributes to global climate change. However, this methane is also a reliable fuel source that, if not collected, goes to waste. All modern landfills have, by law, a landfill gas collection system. The collected gas is either flared or used for energy generation.

The National Renewable Energy Laboratory (NREL) reports that researchers are studying the use of pyrolysis to convert biomass to a substance called "pyrolysis oil" through anaerobic heating. It may be possible for this process to be developed as a solid waste conversion technology that is eligible for RPS; however, the NREL suggests that the greater economic rewards for the technology may be found outside of the electricity sector. Pyrolysis oil can also be refined in ways similar to crude oil; it may also be more valuable as a source of bio-fuels and bio-based products than for bio-power generation. Unlike direct combustion, co-firing, and gasification, this technology is not yet commercially available.

The California Energy Commission (CEC) states that electricity produced from bio-diesel is eligible for the RPS if it is derived from either 1) a biomass feedstock or residue and consists of no more than 25 percent fossil fuel or 2) an eligible "solid waste conversion" process of MSW. Currently, bio-diesel is made from recycled cooking oil and soybean oil and is used as a fuel blend with petroleum diesel fuel in some transit fleets and tourist boats. Similarly, SB 1038 contains a lengthy section containing a general definition and a list of 8 criteria that must be met for a solid waste conversion technology to be eligible for the RPS. The general definition is "a technology that uses a non-combustion thermal process to convert solid waste to a clean burning fuel for the purpose of generating electricity." One of the 8 criteria that must be met is "the technology does not use air or oxygen in the conversion process, except ambient air to maintain temperature control." The CEC estimates the technical potential of biomass in the State at close to 4700 MW.² According to California Biomass Energy Alliance (CBEA), currently, there are 28 biomass power plants, totaling 570 MW, in operation in California, and 13 idle plants with additional 150 MW of capacity. A number of biomass plants have been dismantled due to financial difficulties arising from high fuel costs.

Some biomass electric generation facilities are subject to some seasonal variation in fuel availability (especially woody agricultural wastes). This seasonal variation could be dealt with by on-site fuel storage at the biomass plant. Most solid fuel biomass plant capacities

² CEC "Biomass Resource Assessment in California", in support of the 2005 Integrated Energy Policy Report, Draft Consultant Report, April 2005.

are in the 10 to 25 MW range, with the average size California solid biomass plant just over 20 MW. Landfill gas plants are small, in the 3 to 10 MW range, with the single exception of the Los Angeles County Department of Sanitation, Puente Hills plant at 50 MW. There are three 50 MW biomass power plants in the State. A biomass power plant, typically operates as base-load capacity (biomass plants have capacity factors of 80-95%), but can also be designed for a limited range of dispatchable generation on a weekly or seasonal basis. The latter configuration may be of particular importance in meeting the state's goal of "least cost best fit" in the renewable resource program if fuel storage can be accomplished economically. This latter point is the biggest impediment to dispatchability, as project economics are greatly enhanced when operated in a baseload fashion.

6.1.2 Biomass Resources in San Diego Region

There are four main categories of biomass fuels in the San Diego region: urban wood wastes mostly extracted from MSW (note here that MSW has a separate definition in California and Federal Law, and is not eligible for most renewable energy categorization, with the exception of the Stanislaus County MSW plant), forestry wood wastes, agricultural wastes, and landfill gas.

The San Diego County Landfill Division jurisdictional reported total county disposal at 3.626 million tons for 2002, and 3.861 million tons for 2003. Using California Biomass Energy Alliance's (CBEA) estimate that roughly only 10% to 20% of the total waste disposed of in municipal landfills could be economically separated for energy generation use, total annual energy technical potential from MSW is about 0.3 to 0.8 million MWh. That is, the San Diego urban wood waste stream could potentially support approximately 40 to 100 MW of biomass-fueled power generation.

Although San Diego County is the third most important agricultural region in the state, a vast majority of agricultural wastes is converted to soil, manures and fertilizers. Animal wastes are directed to more economically valuable use as fertilizers. Huge demand for fertilizers, political opposition due to environmental pollution concerns, high water content, and high costs to transport the fuels to biomass energy generation facilities are all factors limiting potential for using agricultural waste for energy production. Of note here is that animal feed lot manures are not generally usable for energy production, either by direct combustion or any other form of gasification. This is because the length of time for which the manures lay in the feed lots results in substantial loss of volatiles and thus energy.

According to survey and study conducted by the USDA (the U.S. Department of Agriculture) Forest Service, total forestry wood wastes for the County are estimated at 75,000 to 100,000 green tons for 2004, 64,000 to 85,000 green tons for 2005, and 38,000 to 50,000 green tons for 2006. Again, applying CEBA's conversion factors, total energy technical potential from forestry wood wastes is about 40,000 to 68,000 MWh for 2004, 34,000 to 57,000 MWh for 2005, and 20,000 to 33,000 MWh for 2006. However, the sustainability of forestry wood wastes is highly uncertain and hard to predict over the long run. The prolonged drought conditions in the region, coupled with the forest death

caused by the bark beetle infestation, has resulted in high tree mortality in the Southern California forests, and may lead to greater amounts of forest-derived wastes becoming available as these dead trees are removed. The biomass power plant in the Coachella Valley (Riverside County) has been receiving substantial amounts of wood from tree removals in the Arrowhead and Idyllwild areas since January 2004.

The San Diego region has 7 operational landfill gas generation plants. The total current capacity of these 7 plants is between 17.75 to 18.95 MW, and technical potential of these plus two identified candidate sites is estimated at 72 MW.³

The table below summarizes the biomass potential in the Region by source category as discussed in this section:

Table 6.1: San Diego Region Biomass Energy Potential

Source Category	Capacity and Energy Potential
Urban Wood Wastes	40 - 100 MW, or 300 – 800 GWh, per year
Agricultural Wastes	Negligible, more economically valuable use as fertilizers
Forestry Wood Wastes *	5 - 8 MW, or 34 – 57 GWh, in 2005
	3 - 5 MW, or 20 – 33 GWh, in 2006
Landfill Gas	72 MW, or 505 GWh
* The sustainability of forestry wood wastes is highly uncertain and hard to predict for the long run.	

6.1.3 The Cost of Biomass

The cost of energy from biomass is directly related to the cost of the fuel resource. For instance, landfill gas is typically available in one place at a steady rate until it is used up. The material cost for solid biomass combustion varies. Sometimes urban residues will be cheaper than forest residues. Other times forest residues will be cheaper. In general, a cost of \$42 per ton of biomass translates into a gas cost of about \$2.50 per mmbtu (fuel cost only). Biomass plants on average consume 1-1.25 bone dry ton of wood residue to generate 1 MWh electricity, and 1 green ton forest wood waste equals to about 2/3rd bone dry ton. Urban wood wastes are dryer, with moisture contents generally in the 18% to 25% range (California Biomass Energy Alliance, CBEA).

Biomass plants are very labor intensive. For example, the 50 MW plant in Riverside employs more than 50 employees in operating the plant, and additional 75 people in collecting and transporting the fuels.

³ San Diego Regional Energy Infrastructure Study: Final Report, December 31, 2002. Page 5-15 and 5-16.

Electricity from landfill gas is an economically competitive and mature technology with a high capacity factor. According to the CEC and NREL, the levelized cost of energy from a 2-megawatt landfill gas facility is estimated to be 4.4 cents/kWh in 2005, and 3.7 cents/kWh by 2017, the installed cost is estimated at \$1,200-1,500/kW.

California Biomass Energy Alliance (CBEA) estimates the capacity cost from solid biomass combustion plants at about \$2,500/kW, and the generation cost at 7-8.5 cents/kWh for a large plant with 40-50 MW capacity and debt component of 80%. For plants with debt fully paid-off, the generation cost would be 1-1.5 cents/kWh less. For small plants with 10-15 MW capacity, the generation cost is higher, at 8-10 cents/kWh with 80% debt financing.

6.1.4 Limitations to Developing Biomass Technical Potential

Although considered a renewable resource, biomass, like burning any organic, will produce pollutants, which must be mitigated at extra cost. Another problem is the availability of reasonable cost fuel in the long run. Fifteen to 20 percent of the total mass of incoming logs in a sawmill becomes waste usable for energy. For urban waste, 10 to 20 percent of the material disposed of in municipal landfills is clean, separable waste wood, and tipping fees at landfills can range up to \$100 per ton, depending on the jurisdiction. Transportation costs are approximately \$20 per ton for 100 miles, the effective maximum distance that biomass fuels could be cost effectively transported for energy utilization. The most available fuels, such as forest trimmings and wooden construction debris only accumulate at a given rate. If these are depleted there are other fuel options such as growing biomass fuels on agricultural land, which may be more expensive or uneconomical altogether. Agricultural residues in the San Diego area are relatively more expensive than other biomass fuels because farmers must be compensated for the loss of the fertilizer value of the residues and because collection and transportation costs are higher as the resource is less dense, and availability of these wastes is often seasonal. Similarly, landfill gas accumulates at a certain rate and will eventually be depleted when the organic matter has decomposed.

There are a number of disadvantages of using biomass as a source of energy:

- Intentionally growing biomass for fuel, e.g. by fast rotation wood farms, could be counterproductive, since it competes with food production, which requires the same scarce resources of land, water, and nutrients. In addition, growing biomass for use as energy fuel is inescapably more expensive than using wastes that others have generated. The costs of land, water, silviculture, and harvesting for an energy growth plantation are always additive to the costs of processing (chipping or grinding) and transportation. There has never been a commercial-scale biomass plantation.
- Due to its relatively low heat of combustion per unit volume, and the less dense resource as compared to fossil fuels, as well as the fact that biomass is solid, the cost of biomass as an energy source will always be high, if the cost for collection and transportation are included.
- Biomass availability is subject to seasonal variation, at least in some parts of California. This would, in general, not be true in the San Diego area.

6.2 Small Hydroelectric

6.2.1 Small Hydro Energy Potential in California

Small scale hydropower projects generate electricity by converting the power available in flowing water in rivers, canals, pipelines, or streams. The definition of “small scale” hydropower varies from country to country and state to state. Although a value of up to 10 MW total capacity is becoming the generally accepted definition, in the U.S., SB 1038 lists small hydroelectric generation of 30 MW or less as meeting the criteria for an “in-state renewable electricity generation technology,” but it must meet certain additional requirements to be eligible for support from the Energy Commission’s Renewable Energy Program. SB 1078 states that the output of a small hydroelectric facility procured or owned by an electric utility, as of September 12, 2002, is only eligible for establishing the RPS baseline for the utility. The bill also states that a new hydroelectric facility is not an eligible renewable energy resource if it requires new or increased appropriation or diversion of water.

California depends on large and small hydroelectric power to meet a portion of its electricity needs, with about 15 percent of the electricity used in the state coming from this source. In 2002, the CEC estimates that small hydroelectric power provided about 1.6 percent of electricity generated in California.

The principal requirements for a small hydropower plant are: a suitable rainfall catchment area, a hydraulic head, a means of transporting water from the intake to the turbine such as a pipe or millrace, a turbine house containing the power generation equipment and valve gear needed to regulate the water supply, a tailrace to return the water to its natural course, and an electrical connection to the load to be supplied.

In California, hydroelectric power falls into three categories: storage, pumped storage, and run-of-the-river. Only storage and run-of-the-river stations qualify as renewable power under the State’s RPS. Run-of-river hydroelectric plants produce electricity at levels that vary with the amount of annual rainfall and snowfall. Small hydroelectric facilities divert the natural flow of water through a channel or conduit to spin the turbine of an electrical generator and return the water downstream of the turbine.

Hydroelectric power provides clean, renewable electricity and frequently other benefits such as habitat for fish and wildlife and opportunities for recreation. Despite this, generating electricity from the natural flow of water comes with negative environmental impacts. Changing water level, water temperature, and water quality can affect fish, plant, and animal life. Diversion structures and changes in water levels have an effect on fish movement. Internationally, e.g. in Europe, the resistance to additional hydropower has prevented building new dams, because of the damage done to the habitat, in particular by the periodic change of the inundation level, which is more serious for shallow valleys. The Federal Energy Regulatory Commission (FERC) licenses hydroelectric power facilities for a 30 to 50 year period. The lengthy process is governed by laws and regulations that require extensive planning, environmental studies, and public input. The

FERC licensing process ensures that communication occurs between relevant agencies and organizations and that the necessary studies are conducted. It also aims to minimize damage to the environment from hydroelectric projects. The FERC has recently revised its regulations for licensing hydroelectric facilities with the Final Rule published in the Federal Register on August 25, 2003. With the new process, an applicant's pre-filing consultation and National Environmental Policy Act scoping is conducted concurrently (and not sequentially), which increases the need for coordination, identification of issues, and early public participation.

6.2.2 Small Hydro Resources in San Diego Region

Due to insufficient indigenous water resources in the Region, hydro-power constitutes a small percentage of total regional power supply, and will likely remain so. The Region currently has 8.32 MW of hydro-generated power plants.

6.2.3 The Cost of Small Hydro

The typical installed cost of a low impact power plant from 100 kW – 30 MW, is between \$1700 and \$5000/kW depending on site conditions and permitting/licensing requirements. The cost ranges between 8 and 9 cents per kWh, which is expected to drop by about a cent by 2013.

6.2.4 Limitations of Small Hydro

The challenge for small hydro is to find the right balance between efficiency through customized design and cost reduction through standardized design. Rainfall characteristics typically dictate capacity factors for run-of-river systems, which are generally not dispatchable. This means that, like wind energy, run-of-river hydropower must be part of a portfolio of energy sources. Conduit pipeline hydro tends to have more constant, predictable energy supply characteristics.

Even if it is possible to increase hydropower production in the state, there may be important issues preventing it. In determining whether or not to develop hydropower resources, a state or community must take into account values such as historic and cultural sites; fisheries; wildlife habitat; legal issues; and geologic, recreational, or scenic attributes.

Protection of fish is often the most contentious issue in planning hydro discussion. Generally national legislation requires that a minimum flow be maintained in the river to ensure the viability and reproduction of fish. For example, dams block the natural flow of rivers and streams, changing the quantity and quality of the water and preventing the passage of migratory fish. Many fish species have very specific habitat requirements, which can be destroyed by altering the stream flow, the turbidity, the water temperature, and the concentration of gases in the water. Land resources, wildlife habitat, and vegetation are lost when the ground is inundated. There are numerous ways to mitigate the impacts to fisheries, the cost for such mitigation, however, often makes small run-of-river projects uneconomic. The best opportunities for small hydro are small pipeline or aqueduct systems where many of the environmental impacts would not exist.