

Appendix R

Energy Element Technical Background Report

HUMBOLDT COUNTY ENERGY ELEMENT APPENDICES: TECHNICAL REPORT



Prepared for:
Redwood Coast
Energy Authority

Prepared by:
Schatz Energy
Research Center
Humboldt State University

Principal Author:
Jim Zoellick

October 2005



Acknowledgements

Contributing Authors:

Schatz Energy Research Center

Dave Carter	Dustin Jolley
Charles Chamberlin	Peter Lehman
Richard Engel	Mark Rocheleau
Anand Gopal	Michael Winkler

Planwest Partners

George Williamson AICP Oona Smith

Center for Environmental Economic Development

Dan Ihara

We would like to thank the many people and organizations who helped provide information for this report. These organizations include: Redwood Coast Energy Authority, Humboldt County Planning Division, California Energy Commission, Pacific Gas and Electric Company, Humboldt State University, City of Eureka, DG Fairhaven Power Company, Pacific Lumber Company, Ultrapower 3, Stockton Pacific, Alternative Energy Engineering, Six Rivers Solar, Eureka Chevron Terminal, Institute for Sustainable Forestry, Six Rivers National Forest, Forest Stewardship Council, Humboldt Waste Management Authority, Ed Schillinger (surveyor), Kurt Kammerer (consultant), Footprint Recycling, Humboldt Bay Municipal Water District, North Coast Unified Air Quality Management District, Humboldt Association of Realtors, and local petroleum and propane suppliers. We apologize to any organization that we inadvertently omitted.

Copyright © 2005 Schatz Energy Research Center

Disclaimer:

Many of the numbers in this report are derived estimates rather than actual measurements. They are meant to provide an assessment of energy use across different sectors and end uses and to provide estimates of local energy supply opportunities.

Table of Contents

Acknowledgements	i
Table of Contents	ii
List of Figures	iii
List of Tables	iii
Glossary and List of Acronyms	iv
Executive Summary	1
Chapter 1 – Introduction	6
Chapter 2 – Background	10
Chapter 3 - Energy Demand Analysis	13
A. Energy Consumption and Cost	13
B. Electricity and Natural Gas Usage Characteristics	15
C. Electricity and Natural Gas Historic and Projected Use	16
D. Gasoline and Diesel Use	18
Chapter 4 - Numbers of Vehicles and Vehicle Miles Traveled	20
Chapter 5 - Energy Supply and Import Analysis	23
Chapter 6 - Inventory of Local Energy Producing Resources	30
A. Local Electrical Power Generators	33
B. Fossil Fuel Fired Electrical Generators	34
C. Wind Power	35
D. Wave Energy	39
E. Biomass	41
F. Natural Gas	46
G. Small Hydroelectric	47
H. Solar Electric	49
I. Solar Hot Water	52
J. Cogeneration and Distributed Generation	53
K. Biogas from Cummings Road Landfill	54
L. Biogas from Wastewater Treatment Facilities	57
M. Biogas from Dairies	59
N. Biodiesel	60
O. Waste-to-Energy Plants	61
P. Hydrogen and Fuel Cells	62
Q. Alternative Fuel Vehicles	63
R. Heat Pumps	65
Chapter 7 - Inventory of Energy Conservation and Efficiency Opportunities	67
Chapter 8 - Inventory of Existing Energy Transmission Systems	72
Chapter 9 - Inventory of Distributed and Back-up Generation for Disaster Preparedness ...	76
Chapter 10 - Opportunities and Constraints for Sustainable Energy Initiatives	77
References	80

List of Figures

Figure 1.	Humboldt County End Use Energy Consumption, 2003	13
Figure 2.	Humboldt County End Use Energy Expenditures, 2003	13
Figure 3.	Humboldt County Primary Energy Consumption, 2003	14
Figure 4.	Electricity Consumption by Sector	15
Figure 5.	Natural Gas Consumption by Sector	15
Figure 6.	Commercial and Residential Electricity Consumption by End Use	16
Figure 7.	Commercial and Residential Natural Gas Consumption by End Use	16
Figure 8.	Humboldt County Annual Electricity Consumption	17
Figure 9.	Humboldt County Annual Natural Gas Consumption	19
Figure 10.	Humboldt County Annual Gasoline Consumption	19
Figure 11.	Humboldt County Electricity Supply by Source, 2003	23
Figure 12.	Humboldt County Energy Flow Diagram, 2003	24
Figure 13.	Distribution of Humboldt County Energy Resources	30
Figure 14.	Humboldt County Electricity Generation Potential	32
Figure 15.	Humboldt County Wind Resource Map	38
Figure 16.	Eureka WWTP Inflows by Month for July 2001 through October 2003	58
Figure 17.	Humboldt County Electric Efficiency Savings Potential by Sector	69
Figure 18.	Humboldt County Electric Efficiency Savings Potential by End Use	69
Figure 19.	Humboldt County Natural Gas Efficiency Savings Potential by Sector	70
Figure 20.	Humboldt County Natural Gas Efficiency Savings Potential by End Use	70
Figure 21.	Humboldt County Housing Stock Age Distribution	70
Figure 22.	Northern California Natural Gas Transmission Lines	72
Figure 23.	Northern California Electrical Transmission Lines	73
Figure 24.	Humboldt County Electrical Transmission Lines	74

List of Tables

Table 1.	State Energy Resource Development Priorities	8
Table 2.	County Population Forecasted Changes	11
Table 3.	Humboldt County Projected Electricity Use – 2023	18
Table 4.	Consumption of Local Versus Imported Energy Sources, 2003	23
Table 5.	Potential Local Energy Resources for Humboldt County	32
Table 6.	Electrical Power Generators in Humboldt County (2003)	33
Table 7.	Small Hydroelectric Facilities Serving Humboldt County	48
Table 8.	Summary of Alternatives Analyzed in the SCS Energy Report	56
Table 9.	Average summer monthly inflow, estimated ADG production, and estimated electric power production for WWTP’s in Humboldt County	58
Table 10.	Nationwide Energy Efficiency Estimates (percent savings)	67

EXECUTIVE SUMMARY

Introduction

California state law requires each city and county to adopt and periodically update a general plan, which serves as a local blueprint for future physical development and guides most land use decisions. The Redwood Coast Energy Authority is assisting Humboldt County's Community Services Development Department in the preparation of an "Energy Element" as part of the County's current General Plan update process.

The need for local energy planning is evident. This is particularly true for an area like Humboldt County that is somewhat remote and isolated from the rest of the energy grid. Uncertainty in the supply, reliability and affordability of energy, a shift toward decentralized electricity generation, and the associated land use, health, and safety issues all need to be considered by local planners. There is a close link between energy consumption and production and the physical development of land. Land use development policies strongly impact how much energy is consumed, and zoning and development strategies can affect the ability to develop and transport future energy resources. The development of an Energy Element for Humboldt County's General Plan update can help ensure that policy decisions made now, which will guide the County for the next twenty years, take into account the region's need for long-term energy sustainability.

Humboldt County has a number of unique features with respect to energy. It is isolated at the end of the electricity and natural gas transmission lines, and the capacity of these lines is not great enough to import all of the county's required energy. Related to these capacity constraints is the fact that the county currently produces a large portion of its electricity locally and also supplies some of its own natural gas needs. Add to this the fact that the county has a tremendous amount of potential local energy resources, in the form of wind, wave, biomass, hydroelectric and solar power. And finally, there is a lot of local interest and expertise and a strong desire to develop long-term energy sustainability for the region.

What will a sustainable energy plan look like? It is likely to feature policies that will ensure energy supply continuity, reduce energy demand, increase energy efficiency, and advance the use of clean, efficient and renewable energy resources, especially those that are local. If the county develops long-term energy sustainability plans for the community, the benefits will be significant.

Energy Use and Cost

In Humboldt County, energy is used as a transportation fuel and as electrical and heat energy in homes, businesses, industries, and agriculture. In 2003 it is estimated that Humboldt County spent \$319 million to meet local energy demands, the majority of which left the county.

Approximately half of the energy was used as a transportation fuel (gasoline and diesel), with large amounts also used to meet end use electrical demands and end use natural gas heating demands. It is estimated the county's end use energy consumption totaled about 17.4 trillion Btu's. Because of inefficiencies in the generation and transmission of electricity, it is estimated that the county's primary energy consumption totaled about 24.4 trillion Btus. Primary energy sources were comprised mainly of natural gas, gasoline, diesel, and biomass (wood waste and firewood).

Humboldt County electricity use in 2003 totaled 940 GWh. This was used primarily in the residential, commercial, and industrial sectors. Lighting and refrigeration were the primary end uses served in the residential and commercial sectors. Natural gas use in Humboldt County totaled an estimated 93.9 million therms, with almost half of this being used to generate electricity at both the Pacific Gas and Electric Company (PG&E) Humboldt Bay Power Plant and the Samoa pulp mill. The remaining natural gas was used primarily in the residential, industrial and commercial sectors. It was used primarily as a space heating and water heating fuel in the residential and commercial sectors.

Electricity use in Humboldt County between 1990 and 2000 increased by about 1.3% per year. Between 2000 and 2003 electricity use in the industrial sector (primarily timber) declined by 24%, causing a slight dip in total consumption. Based on past behavior it is expected that growth in electricity demand over the next 20 years will range from about 0.5% per year to 1.5% per year. Natural gas use in Humboldt County between 1990 and 2003 decreased at a rate of 1.0% per year, with most of the decrease occurring in the industrial sector. The statewide estimate for growth in natural gas demand is about 1% per year. Based on historic trends, one might expect lower growth rates in Humboldt County.

Gasoline and diesel consumption in Humboldt County in 2003 was about 71 million gallons. Between 1997 and 2003, consumption rose at 1.5% per year. The use of transportation fuels is closely linked to the number of vehicle miles traveled (VMT). Due to its rural nature, the county tallies more VMT than many more densely populated areas. Efforts to reduce VMT are critical to a secure energy future with respect to transportation fuels, and this can primarily be addressed through wise land use planning.

Local and Imported Energy Sources

The majority of primary energy used in Humboldt County is imported, with the exception of biomass energy. Essentially all of the county's transportation fuels are imported. Although the majority of electricity is generated in the county, a large portion of it is generated using natural gas. The county imports about 90% of its natural gas; the rest is obtained locally from fields in the Eel River valley. The county has the capability of generating all of its own electricity. In fact, in 2001 during the California electricity crisis, Humboldt County was a net exporter of electricity. PG&E is currently soliciting offers to replace the aging 130 MW Humboldt Bay Power Plant. Replacement of this plant with local energy resources and perhaps a new, more efficient natural gas fired generator will be critical to the county being able to continue to meet its electricity needs.

Inventory of Local Energy Resources

It is estimated that the total electricity generation from local renewable resources could provide as much as 1500 MW of generating capacity and over 6000 GWh per year of electrical energy. This includes power from the waves, wind, biomass, small hydroelectric and solar. This is over six times the county's current electricity consumption rate. However, there is a lot of uncertainty about how much of these resources can realistically be developed. For example, over 75% of the estimated renewable electricity resource would come from wave power, a technology that is in its early stages of development and therefore is quite uncertain. Even for well proven resources like wind, solar, and hydropower, there are many potential barriers that could impede

development, including high costs, regulatory hurdles, lack of financing, siting and transmission access issues, and lack of public support. Nonetheless, the potential of these local resources is large and offers significant economic development potential. Using local resources to meet local energy needs would keep energy dollars circulating in the local economy, and exporting local energy resources to surrounding communities could bring in a new source of income to the county.

Opportunities to Reduce Energy Use

The results of statewide energy efficiency potential studies were used to estimate the efficiency potential in Humboldt County. It is estimated that in ten years, electricity savings in Humboldt County could total 85 GWh per year (8% of the county's projected total electricity use), and natural gas savings could total 2.6 million therms per year (5% of the county's projected total natural gas use). This represents a total retail value for electricity cost savings of \$11.9 million per year and for natural gas of \$1.8 million per year. While these energy savings estimates are more conservative than some studies indicate are possible, attaining these levels of savings would require a much more aggressive effort than is currently being pursued.

Efforts to reduce energy consumption in the transportation sector are also critical to the establishment of a secure energy future for the county, and decreasing the number of vehicle miles traveled is probably the most effective measure for reducing transportation energy use. Implementing land use planning that locates housing, jobs, and shopping in proximity, and provides bicycle, pedestrian, and public transit access will encourage alternative transportation modes and result in reduced vehicle travel. Replacing the importation of goods and exportation of waste with increased production and consumption of local goods (such as locally grown food) and local waste processing (through recycling, reusing, and composting) can also help reduce vehicle miles traveled. Increasing the proportion of energy-efficient vehicles can lower vehicle energy consumption, and alternative fueled vehicles may serve to diversify the energy resources upon which the transportation sector relies.

Existing Energy Transmission Systems

Humboldt County is remotely located at the end of the electrical and natural gas supply grids, and this limits both energy supply options and system reliability. PG&E owns the natural gas and electricity transmission and distribution systems in Humboldt County. There is one major natural gas supply line that serves the county and four electrical transmission circuits. The total electrical transmission capacity into Humboldt County through the existing lines is approximately 70 MW, which is less than half of the county's current peak demand. Therefore, local electrical generators are critical to meeting local electricity needs.

According to PG&E, along with existing local electrical generation the electrical transmission system is adequate to meet the county's needs for the next ten years. However, PG&E is planning to retire the Humboldt Bay Power Plant. This local electrical generating capacity will need to be replaced or the electrical transmission capacity serving the county will need to be increased in order to continue to meet local electricity needs. In addition to PG&E's plans to replace its local generating plant, the utility has conducted a study to examine the option of increasing the electrical transmission capacity serving Humboldt County. New local generation, increased energy efficiency and demand response, and added transmission capacity should all be

considered when assessing the options for meeting Humboldt County’s long-term electrical energy needs.

Trends in the Electricity and Natural Gas Markets

California faced serious electricity supply constraints in 2001, resulting in rolling blackouts throughout the state. Although the situation has improved, future supply constraints are forecasted if adequate planning and implementation efforts are not carried out. In order to meet future energy demands, the State of California has developed energy policies that favor energy conservation and efficiency first, renewable energy and distributed generation second, and clean, central station fossil fuel generation and improvements to the electricity transmission and distribution system last.

Starting in 1998 the State of California attempted to deregulate the electric utility industry with the goals of using competition to increase electricity supply and reduce costs for customers. Under deregulation, the investor-owned utilities in California were required to sell off their generating capacity and allow customers to buy electricity directly from suppliers of their choice (referred to as “direct access”). Unfortunately, the combination of poorly structured deregulation laws and major fraud and manipulation by suppliers resulted in power outages and billions of dollars in increased costs for customers. Deregulation, including direct access, was suspended in September of 2001. At this time it is uncertain what form of electricity industry regulation/deregulation will prevail in California.

In 2002, the California legislature passed Assembly Bill 117, the community choice aggregation law. This legislation allows local governments, alone or jointly, to aggregate the retail electric customers in their jurisdictions for the purpose of purchasing power. The utility still provides billing services and remains the default provider for any customers who choose to “opt out” of the program. This legislation allows communities to choose from whom they buy electrical power and what type of power to buy, as well as allowing them to negotiate how much they pay. Assembly Bill 117 also allows local governments, or other entities, to apply to administer energy efficiency programs in their jurisdictions. Although no jurisdictions in California have yet instituted a CCA program, many are pursuing the opportunity.

California began deregulating the natural gas market in the early 1990’s. Today both large industrial users and power plants (non-core gas customers) and residential and small commercial customers (core customers) can purchase natural gas directly from competitive suppliers.

The demand for natural gas in the U.S. continues to grow, with use for electrical power generation being the prime driver. As a consequence, the U.S. will likely become increasingly reliant on natural gas from Canadian and overseas liquefied natural gas (LNG) imports to meet growing demand. Prices for natural gas will likely rise faster than inflation due to growth in gas demand, restricted supply, and the expense of developing new gas wells and pipeline capacity.

Opportunities and Constraints

Humboldt County is a relatively sparsely populated rural county that lacks the strong financial resource base often associated with more metropolitan areas. It is located in a remote, rural corner of the State of California. These characteristics pose numerous constraints, including:

electricity and natural gas transmission issues, fuel supply and reliability issues, limited access to energy programs, limited access to capital resources, and limited buying power in energy markets.

However, Humboldt County's remote, rural locale offers many opportunities as well, including a potential wealth of local renewable energy resources, a strong interest in developing local energy resources, and a desire to make wise and efficient use of energy resources and to be as energy self-reliant as possible. Humboldt County is known for its strong independent spirit, and that spirit extends to the area of energy supply and demand. Opportunities for the development of sustainable energy resources in the county include: the development of local renewable energy resources and distributed generation, increased energy efficiency efforts, the development and implementation of county-wide strategic energy planning, local management of energy supplies and services, and upgrades of energy transmission facilities.

CHAPTER 1 - INTRODUCTION

California state law requires each city and county to adopt and periodically update a general plan, which serves as a local blueprint for future physical development and guides most land use decisions. By law, general plans must include seven required focus areas, called “elements.” These include topics like land use, circulation, housing and conservation. In addition, jurisdictions are encouraged to include optional elements that help to give clarity to other important local issues, such as an Energy Element. The Redwood Coast Energy Authority (RCEA)¹ is assisting Humboldt County's Community Services Development Department in the preparation of an “Energy Element” as part of the County’s current General Plan update process.

Why an Energy Element?

The importance of local planning has been well understood for issues like transportation, land use, waste management, water supply, and housing, but energy planning has not traditionally been a part of the county planning process. In the past, planners would forecast growth and utility companies would accommodate it in their resource plans. However, in today’s environment of constrained energy resources, the need for local energy planning is becoming evident. This is particularly true for an area like Humboldt County that is somewhat remote and isolated from the rest of the energy grid. Uncertainty in the supply, reliability and affordability of energy, a shift toward decentralized electricity generation, and the associated land use, health, and safety issues all need to be considered by local planners.

There is a close link between energy consumption and production and the physical development of land. Land use development policies strongly impact how much energy is consumed. More compact communities result in lower energy consumption; sprawl increases energy consumption. Zoning and development strategies can also affect the ability to develop and transport future energy resources, like wind or wave power. The development of an Energy Element for Humboldt County’s General Plan update can help ensure that policy decisions made now, and which will guide the County for the next twenty years, take into account the region’s need for long-term energy sustainability.

Humboldt County has a number of unique features with respect to energy. It is isolated at the end of the electricity and natural gas transmission lines, and the capacity of these lines is not great enough to import all of the energy that is needed. Related to these capacity constraints is the fact that the county currently produces a large portion of its electricity locally and also supplies some of its own natural gas needs. Add to this the fact that the county has a tremendous amount of local renewable energy resources, in the form of wind, wave, biomass, hydroelectric and solar power. And finally, there is a lot of local interest and expertise and a strong desire to develop long-term energy sustainability for the region.

What will a sustainable energy plan look like? It is likely to feature policies that will ensure energy supply continuity, reduce energy demand, increase energy efficiency, and advance the

¹ The Redwood Coast Energy Authority (RCEA) was formed in 2003 as a Joint Powers Association, representing seven municipalities including the Cities of Arcata, Blue Lake, Eureka, Ferndale, Fortuna, Trinidad and Rio Dell, and Humboldt County. RCEA's purpose is to develop and implement sustainable energy initiatives that reduce energy demand, increase energy efficiency, and advance the use of clean, efficient and renewable resources available in the region

use of clean, efficient, and renewable energy resources, especially those that are local. If long-term energy sustainability is achieved for the local community, the benefits will be significant. Benefits will likely include the ability to:

- Retain more energy dollars in the local economy;
- Ensure more reliable and secure energy supplies;
- Reduce the county’s dependence on imported energy sources;
- Reduce the county’s susceptibility to energy price shocks;
- Create jobs and diversify the economic base;
- More effectively incorporate the concerns of local citizens in energy decisions;
- Improve/maintain the quality of the environment;
- Address local and global environmental issues such as climate change; and
- Respond thoughtfully to energy projects that are proposed for the area².

Although energy planning efforts at the county level have not been common up to this point, energy planning efforts are not new to Humboldt County. A study completed by the Humboldt County Energy Advisory Committee (1981) recommended two major actions to decrease the amount of energy dollars leaving the county – conserve energy and develop alternative energy. A follow-up study conducted for the Humboldt County Project Independence Committee (Smyser and Agnello, 1983) assessed the near term potential for the development of local renewable resources, quantified the economic impacts, and suggested policy actions to speed development. This report stressed the economic development benefits associated with local energy resource development. The county can learn from these earlier studies and should build upon them in its current energy planning efforts.

County energy planning efforts, while they must be unique to the energy characteristics of the local community, must also be informed by and integrated into state energy policy. Current California energy policy is outlined in two documents, the *State of California Energy Action Plan* (California Energy Commission, California Power Authority, California Public Utilities Commission, 2003), and the *Integrated Energy Policy Report 2004 Update* (California Energy Commission, 2004a). This state level planning aims to “ensure that adequate, reliable, and reasonably-priced electrical power and natural gas supplies, including prudent reserves, are achieved and provided through policies, strategies, and actions that are cost-effective and environmentally sound for California’s consumers and taxpayers.” The Action Plan identifies a “loading order” that establishes priorities for the development of energy resources in the State. The loading order is shown in Table 1.

The Action Plan also specifies the following six action items:

1. Optimize energy conservation and resource efficiency;
2. Accelerate the State’s goal for renewable generation;
3. Ensure reliable, affordable electricity generation;
4. Upgrade and expand the electricity transmission and distribution infrastructure;
5. Promote customer and utility owned distributed generation; and

² Numerous energy development projects have been proposed for Humboldt County over the last few years, including a coal power plant, LNG terminal, wind power development, and wave power development. By working to develop a local energy plan the community will be better prepared to deal with and respond to the next big proposed energy project that comes along.

6. Ensure reliable supply of reasonably priced natural gas.

Table 1. State Energy Resource Development Priorities

<i>Priority</i>	<i>Action</i>
1 st Priority	Increase conservation and energy efficiency to minimize increases in electricity and natural gas demand.
2 nd Priority	Meet new generation needs first with renewable energy resources and distributed generation.
3 rd Priority	Meet remaining new generation needs with clean, central station fossil fuel generation and improvements to the bulk electricity transmission grid and distribution infrastructure.

One energy topic that is generating increasing concern is the concept of “Peak Oil” (also called “The End of Cheap Oil”). According to this theory, global oil production follows a roughly bell-shaped curve with the peak occurring when approximately half the oil has been extracted (Campbell and Laherrere, 1998). If Peak Oil theory is correct and global oil production goes into rapid decline, it will likely have serious consequences for Humboldt County and the world. Declining global oil production will result in much higher energy prices and potential supply disruptions, and may have significant economic and social impacts. The proponents of this theory are not all staunch environmentalists. A recent report prepared for the U.S. Department of Energy (Hirsch et al., 2005) concludes that world oil peaking is going to happen; only the timing is uncertain. The report goes on to say that a very significant transition effort with a twenty year lead time will be necessary in order to avoid massive disruption. Even if the dire predictions prove to be overblown, it is very likely that energy prices will continue to rise as petroleum resources become scarcer and energy related environmental impacts become more severe. Wise energy planning for Humboldt County can help reduce the severity of these impacts while also offering the many other benefits listed above.

One place to look for an example of energy policies and developing energy markets that aim beyond a fossil fuel based economy is Japan (Bihn, 2005). Japan has accepted global warming as a real threat, so carbon reduction has begun to play a serious role in their energy planning. In addition, 100% of the fossil fuels used in Japan come from increasingly volatile parts of the world, and electricity and gasoline prices are nearly twice what they are in the U.S. Finally, nuclear power has become increasingly unpopular. Japan’s energy policy is therefore focusing on energy efficiency and renewable energy. The private sector has embraced these policies because energy efficiency, renewable energy and smart energy policy sell in Japan. This has given rise to many new markets, and these markets are not limited to Japan. Japan’s auto industry is poised to benefit from a carbon-constrained global economy. Two of its top manufacturers are dominating the hybrid electric vehicle market, with Toyota recently licensing over 200 hybrid technologies to Ford for use in their new hybrid Ford Escape. Japan has been the leading manufacturer in the solar electric market since 1999, with a global market share that exceeded 40% in the year 2000. This strong economic activity in Japan shows us that energy efficiency and renewable energy do not have to mean the demise of our economy, but instead can be the focus of renewed economic activity.

Organization of This Report

This Humboldt County Energy Element Background Technical Report is intended to provide background information that will be needed to develop the Energy Element for the Humboldt

County General Plan Update. The information in this report may also be useful in guiding ongoing efforts for energy planning in Humboldt County. The report describes how much energy is currently used in Humboldt County, how that energy is used, and where it comes from. In addition, the report examines the local energy resource base that exists in the county and characterizes some of the options that may be used for meeting future energy needs in a sustainable manner.

The report is organized as follows: Chapter 1 is the introduction. Chapter 2 covers background information. Chapter 3 examines historic, current and projected energy demands in the county. Chapter 4 looks at the transportation sector and assesses the historic and projected number of vehicles and vehicle miles traveled. Chapter 5 outlines the local supply and import of energy resources. In Chapter 6, an inventory of local energy resources is compiled. Energy efficiency opportunities are examined in Chapter 7. Chapter 8 examines the natural gas and electricity transmission systems that serve the county. Chapter 9 discusses potential data sources for identifying distributed and back-up electricity generators that could be used in the event of a local disaster. Finally, Chapter 10 examines opportunities and constraints for the development and implementation of sustainable energy initiatives in Humboldt County.

CHAPTER 2 - BACKGROUND

Long-term energy use trends are driven by many factors, the most significant being economy, population, commercial building and new housing. In addition, climate, geography, and land use patterns can have significant effects on energy use characteristics. This chapter briefly characterizes Humboldt County in terms of these energy demand drivers. This chapter is based largely on information presented in the draft Humboldt County Energy Report prepared for the Redwood Coast Energy Authority (Kammerer, 2004).

Geography

Humboldt County is set in a rural environment distant from any major urban areas. It is bounded on the north by Del Norte County; on the east by Siskiyou and Trinity counties; on the south by Mendocino County and on the west by the Pacific Ocean. The county encompasses 3572 square miles, 80 percent of which is forestlands, protected redwoods and recreation areas.

Climate

Climate plays one of the most significant roles in driving energy demand. Humboldt County is a region with moderate temperatures and considerable precipitation. Average temperatures along the coast vary only about 10 degrees from summer (58°F) to winter (48°F), although a greater range is found over inland areas. Maximum temperatures on the coast typically do not exceed 80°F, while inland areas may reach 100°F or greater. Temperatures of 32 degrees or lower are experienced nearly every winter throughout the area, and colder temperatures are common in the interior. Because of its moderate summer temperatures, Humboldt County's electricity demand peaks in the winter, rather than the summer when the peak is reached in most of California. In most years, rainfall is experienced each month of the year, although amounts are minimal (approximately 5%) from June through September. Annual totals average near 40 inches in the drier areas, and exceed 100 inches in the zones of heavy precipitation. Precipitation does not play a major role in energy consumption, but contributes significantly to the availability of renewable hydropower resources.

Population

The 2000 population of Humboldt County was 126,500 (Dyett and Bhatia Urban and Regional Planners, 2002). The majority of the population lives in close proximity to the Humboldt Bay area, with nearly half the population residing in the incorporated cities of Arcata, Blue Lake, Eureka, Ferndale, Fortuna, Rio Dell and Trinidad. The population density in Humboldt County is sparse, at just 35 persons per square mile versus 217 per square mile for the State of California. Sparse population densities can mean that people have further to drive when traveling. In addition, Humboldt County has a large number of independent minded people living in remote locations disconnected from the main electrical grid.

The 2025 estimated Humboldt County population is 143,100 (Dyett and Bhatia Urban and Regional Planners, 2002). This population growth rate of 0.5% per year trails the State of California expected growth rate of 1.9% per year (Campbell, 1997). The primary growth areas of the county are around the unincorporated community of McKinleyville and the cities of Arcata and Fortuna. Table 2 details county population projections over the next two decades, including estimates for several of the incorporated areas.

Table 2. County Population Forecasted Changes (Humboldt County, 2002)

<i>Location</i>	<i>1998 Population</i>	<i>2010 Population</i>	<i>2020 Population</i>
Eureka	27,750	28,870	29,830
Arcata	16,330	18,180	20,000
Fortuna	10,140	12,560	15,000
Humboldt County	124,000	131,600	140,000
Unincorporated	67,400	67,800	68,140

Housing Trends

Housing is a primary driver of energy load growth. Humboldt County had 53,680 households in 2002 and is projected to add about 6,190 households by 2025 (Humboldt County, 2003). The county has a home ownership rate comparable to the state average (about 57%). The county has a much lower percentage of housing units in multi-unit structures, 18.1 percent versus 31.4 percent for the State of California (U.S. Census Bureau, 2005). This would tend to increase the energy consumption per household, as multi-unit housing tends to be more energy efficient.

Economy

In many places economic factors are a secondary driver of energy consumption. This may not be the case in Humboldt County. With a large percentage of electricity consumption being attributable to industry, economic factors are likely to be more significant. In addition to the production from the commercial and industrial sectors, personal income drives residential energy demand through the increased use of electrical appliances such as computers, printers, additional televisions, or refrigerators. Humboldt County's median household income in 1999 was \$31,226, 34% lower than the state average. The number of businesses and the square footage of commercial building space largely drive commercial energy demand. Other factors influencing commercial energy use are vacancy rates and taxable sales. The retail sales per capita in Humboldt County in 1997 were \$8350, nearly identical to the state average. Industrial energy use is driven by employment and the output of manufacturing plants as measured in the value of shipments. Manufacturers' shipments per capita in 1997 in Humboldt County were valued at \$8325 per person. This was substantially lower than the state average of \$11,207 per person (U.S. Census Bureau, 2005).

During the past 25 years, Humboldt County has experienced a gradual transition in employment from the timber industry to more service-related industries. For example, between 1976 and 1999, employment in the goods producing sectors fell 10% while employment in service producing sectors rose 10% (as a percent of total employment). The employment decline in the goods producing sectors was due to declining employment in lumber/paper products manufacturing. In 1976, county employment in lumber/paper products manufacturing was 7,325 (18 percent of total employment), while in 1999 it was 3,900 (8 percent of total employment). Employment in other goods producing sectors, (mining, construction, other durable manufacturing, and non-durable manufacturing), taken together, as a percentage of total employment, remained constant from 1976 to 1999. (Kammerer, 2004)

Fuel Choices

In rural areas such as Humboldt County, the choice of residential heating fuels is often different than in more densely populated urban areas. The population is more spread out, with a larger portion of people living in more remote areas. Because of this, the energy distribution infrastructure, such as electrical lines and natural gas lines, does not reach a substantial portion of the population. These people typically choose to use wood and/or propane as heating fuels. According to the 2000 Census, of the 51,238 occupied housing units in Humboldt County 62% use natural gas as their primary heating fuel. The remaining portion of households used wood heat (18%), electric heat (10%), propane heat (8%), and oil or kerosene heat (1%) (U.S. Census Bureau, 2000). It should be noted that a large portion of the households using wood as a space heating fuel might use propane as a water heating and cooking fuel. It is also important to note that the percentage of households using wood as their primary heating fuel dropped from 26% to 18% between 1990 and 2000.

CHAPTER 3 - ENERGY DEMAND ANALYSIS

A. Energy Consumption and Cost

Energy is used in three primary ways in Humboldt County: 1) as a transportation fuel, 2) as electrical energy in homes, businesses and industries, and 3) as heat in homes, businesses and industries. In 2003 it is estimated that Humboldt County used 17.38 trillion Btu's of energy across all three of these areas³. Figure 1 shows that 49% of the energy was used for transportation (diesel/gasoline), 33% was used as heat (natural gas, propane, wood), and 18% served electrical end use needs. The total retail cost associated with this energy use is estimated to be about \$319 million per year⁴, the majority of which left the county. This is 13% less than what the county paid for energy in 1980 (Smyser and Agnello, 1983)⁵. Figure 2 shows how these energy expenditures were distributed across the three areas. Gasoline and diesel fuel used for transportation accounted for about 43% of the total expenditures (similar to their share of total energy). However, electricity, which only accounted for 18% of the total energy used, accounted for 42% of the total expenditures. This emphasizes the high relative cost of electrical energy. Heating fuels (natural gas, propane, wood) make up the remaining 15% share of the total expenditures.

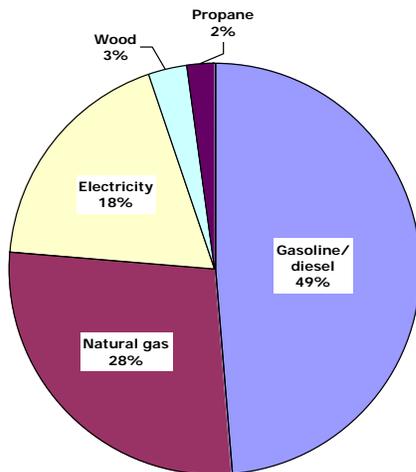


Figure 1.
Humboldt County End Use Energy Consumption, 2003 (17.38 trillion Btu's)

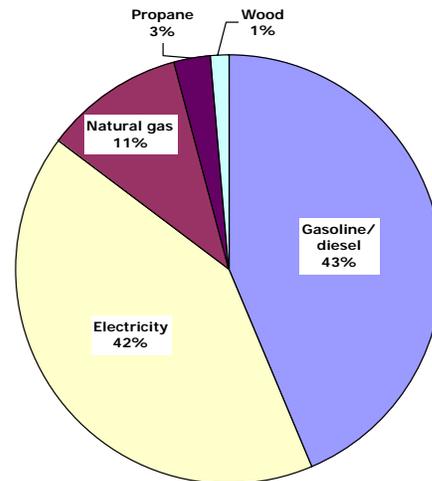


Figure 2.
Humboldt County End Use Energy Expenditures, 2003 (\$319.4 million)

³ This is an estimate of total end use energy consumption. It does not include energy associated with wood waste burned for process heating (this information was not readily available). Gasoline and diesel fuel, natural gas, and electricity related energy consumption estimates all come from sources cited in this report. Energy consumption associated with wood and propane fuel were estimated based on house heating fuel statistics from the 2000 U.S. Census. It was assumed that homes that heat with wood use 2.5 cords per year. Propane fuel use for space heating was estimated based on the typical energy use for a home that is heated with natural gas. Propane fuel use for water heating, cooking, and clothes drying was based on the typical energy use for a home that uses natural gas to fuel these end uses. It was assumed that 66% of the homes that heat with wood use propane fuel for water heating, cooking and clothes drying (the other 34% use electricity or some other fuel). Heating oil and kerosene use in Humboldt County was assumed to be negligible.

⁴ Energy costs were calculated based on the following estimated average fuel costs: gasoline = \$1.93/gal (Humboldt County Economic Index), diesel = \$2.00/gal (California Energy Commission), natural gas = \$0.72/therm (PG&E, weighted average by customer class), electricity = \$0.14/kWh (PG&E, weighted average by customer class), wood = \$200/cord (local vendor quotes), propane = \$2.00/gal (local vendor quotes).

⁵ The Humboldt County Plan to Accelerate Economic Development of Local Energy Resources (Smyser and Agnello, 1983) estimated that Humboldt County energy expenditures in 1980 totaled \$151 million. The 2003 estimate of \$319 million is equivalent to \$131 million 1980 dollars when adjusted using the Consumer Price Index for the San Francisco area.

But this does not tell the whole story. The energy use quoted above is the energy used to actually serve end use needs (e.g. power cars, power light bulbs, heat homes). But in many cases, it takes more energy to meet end use needs than the amount used at the end use. For example, if you use 4000 kWh per year of electrical energy at your home (equivalent to 13.7 MMBtu), it will likely require about 43 MMBtu of energy to generate and transport the electricity to your home (assuming a 35% power plant thermal efficiency and 9% transmission and distribution losses). Consequently, the estimated total primary energy consumption in Humboldt County in 2003 was 24.35 trillion Btu's⁶. This accounts for gasoline and diesel fuel used for transportation, propane used as a heating fuel, natural gas used as both a heating fuel and for electricity generation, biomass fuel used for electricity generation and for space heating, locally generated hydro, wind, and solar electricity, and imported electricity. Note that the primary energy source for the imported electricity is likely comparable to PG&E's 2004 projected electrical power mix of 42% natural gas, 23% nuclear, 19% large hydro, 13% renewable, and 3% coal (Pacific Gas and Electric Company, 2004a).

Figure 3 shows that 38% of the primary energy consumed in 2003 was in the form of natural gas. Natural gas takes up a much larger portion of the primary energy pie than it does of the end use energy pie because a large portion of the natural gas consumed (approximately half) is burned to produce electricity. Transportation fuels (gasoline and diesel) account for 35% of the primary energy pie, and biomass fuel (wood and wood waste) accounts for 21%. Since energy use and costs are primarily associated with the use of transportation fuels, electricity and natural gas, these are important areas to consider in energy planning efforts.

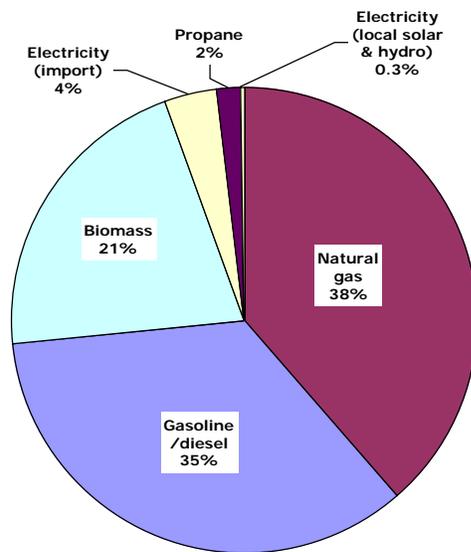


Figure 3. Humboldt County Primary Energy Consumption, 2003 (24.35 trillion Btu's)⁷

⁶ Calculated based on end use energy consumption. Estimated biomass use for electricity generation at Fairhaven Power Plant and PALCO assuming 22% thermal efficiency and 5.74 MMBtu/green ton (USFS Forest Products Lab). Estimated natural gas use for electricity generation at Humboldt Bay Power Plant and Samoa pulp mill assuming 25% thermal efficiency

⁷ Does not include wood waste burned for process heat. Local electricity includes hydro, solar, and wind. Estimated output for hydroelectric is 18,700 MWh (based on actual data and estimates from (Oscar Larson & Associates,1982). Estimated output for solar and wind based on actual number of grid-connected systems (California Energy Commission, 2005a) and estimated number of off-grid systems (Katz, 2005).

B. Electricity and Natural Gas Usage Characteristics

Electricity and natural gas are used in the residential, commercial, industrial and agricultural sectors. Figures 4 and 5 show the amount of electricity and natural gas, respectively, consumed in each sector in 2003 (Gough, 2005). Total electricity consumption was 940 GWh (Gough, 2005; Kammerer, 2005; and Pan, 2005), and total peak electrical demand was 158 MW⁸ (Casuncad, 2005a). This comprises approximately 0.3% of the State total (note that Humboldt County's population accounts for 0.4% of the State total). Due to its proximity to the ocean, Humboldt County is one of the few areas in the State where electricity use peaks in the winter rather than in the summer. Electricity use was divided up almost evenly between the residential, commercial and industrial sectors, with a remaining 2% consumed in the agricultural sector. Electricity use per capita for Humboldt County and for the State of California as a whole are both in the range of 7000 to 7500 kWh per year.

For natural gas, the total amount consumed was estimated at 93.9 million therms⁹ (Gough, 2005; Marruffo, 2005; and Pan, 2005). This comprises approximately 0.34% of the State total. Almost half that amount was burned to generate electricity, and the remainder was used primarily in the residential (22%), industrial (18%) and commercial (10%) sectors. The peak demand for natural gas occurs in the winter months.

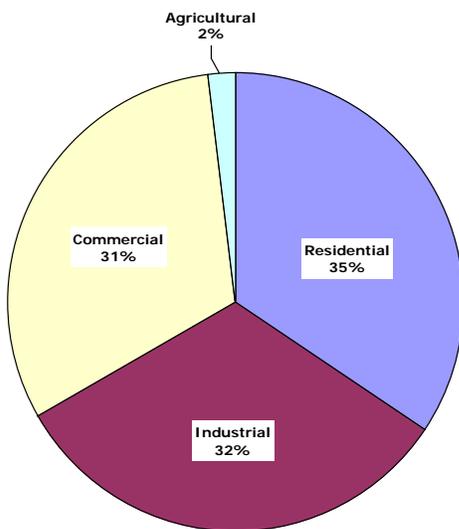


Figure 4.
Electricity Consumption by Sector
(940 GWh)

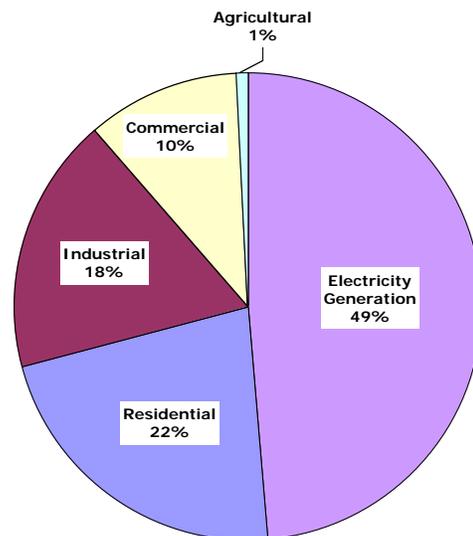


Figure 5.
Natural Gas Consumption by Sector
(93.9 million therms)

⁸ This peak demand likely does not include the electrical demand that is supplied using on-site generation at the PALCO and Samoa pulp mill facilities. PG&E claims the on-site peak demand for these facilities is about 12 MW, whereas CEC data indicates a combined peak demand from these facilities of about 20 MW.

⁹ Estimate based on CEC retail consumption data and estimate of gas used to generate electricity at Samoa pulp mill and Humboldt Bay Power Plant. Assumed 25% thermal efficiency for natural gas power plants.

Figures 6 and 7 show the end use categories where the majority of electricity and natural gas, respectively, are likely used (based on statewide data) in the both the commercial and residential sectors¹⁰ (Rufo and Coito, 2002). Lighting and refrigeration account for the majority of electricity consumption, whereas space heating and water heating account for the majority of natural gas consumption. Electricity use in the industrial sector is primarily in saw mills, with a small amount used in food and kindred products and durable and non-durable goods industries. Similarly, natural gas use in the industrial sector is almost entirely associated with saw mills (for drying wood), with the remainder being used in the food and kindred products and non-durable goods industries.

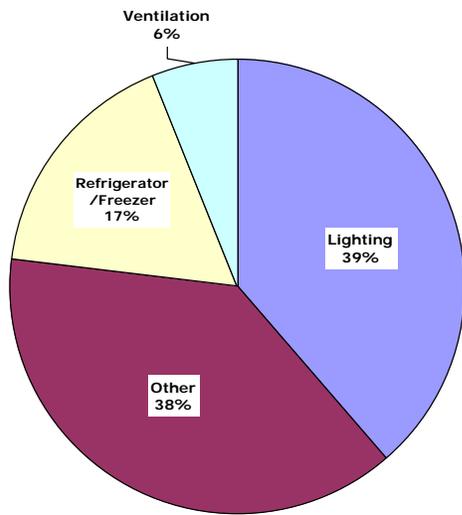


Figure 6.
Commercial and Residential Electricity Consumption by End Use (619 GWh)

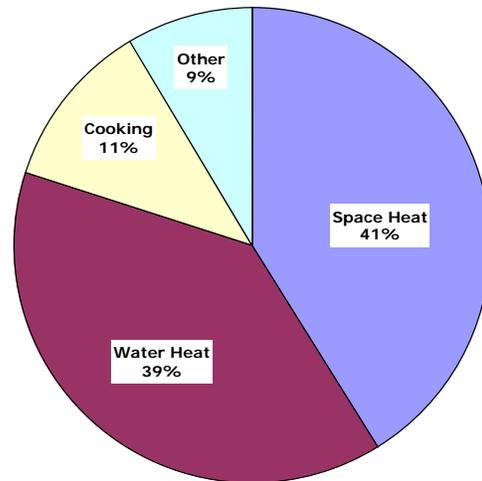


Figure 7.
Commercial and Residential Natural Gas Consumption by End Use (30.6 million therms)

C. Electricity and Natural Gas Historic and Projected Use

Electricity and natural gas use in Humboldt County showed modest change over the period of 1990 to 2003 (Gough, 2005). Between 1990 and 2000, total electricity use increased 1.3% per year, on average, and use in all sectors (residential, commercial, industrial, agricultural) increased slightly. During this same period the gain in the county’s population was 0.6% per year. However, between 2000 and 2003, electricity use in the industrial sector (mainly the timber industry) declined by 24%, causing a slight dip in total consumption. Figure 8 shows the electricity consumption in the county over the period 1990 to 2003¹¹. For comparison, during the period 1990 to 2000 within the State of California electricity use rose by 1.5% per year, with nearly all gains occurring in the residential and commercial sectors. State population growth during this same period was 1.3% per year.

¹⁰ Based on the California average for year 2000.

¹¹ Not including electricity generated and used on-site.

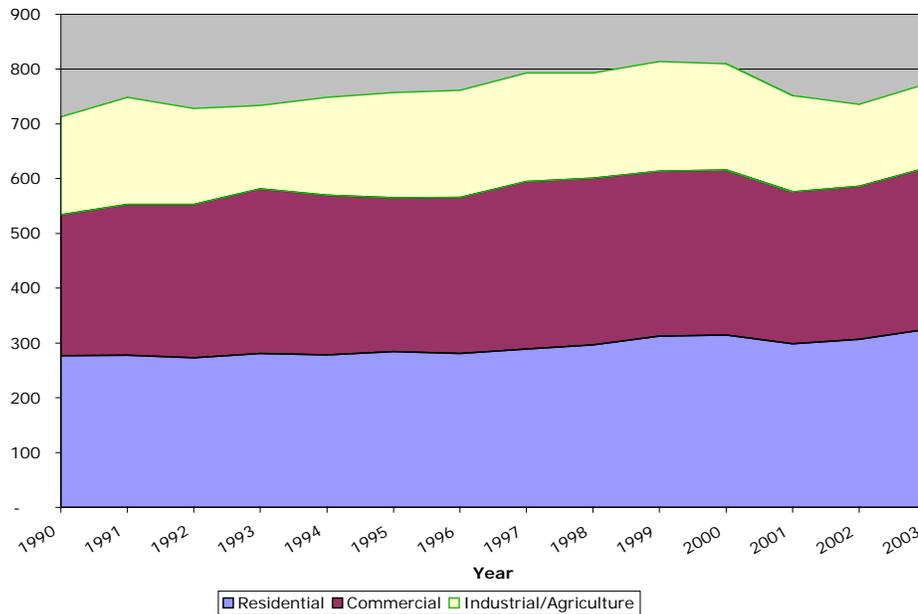


Figure 8. Humboldt County Annual Electricity Consumption¹¹

It can be instructive to examine the change in electricity consumption separately within the residential, commercial, and industrial sectors. Residential electricity usage in Humboldt County increased 17.3% from 1990 to 2003 for an annual growth rate of 1.2%, while Humboldt County population increased 7.4 % during the same period for an annual growth rate of 0.6%. In other words, for every 1% increase in the annual population growth rate, electricity usage increased 2.1%. California residential electricity use increased 12.7% from 1990 to 2001 for an annual growth rate of 1.1%. With California population growing 1.3% annually during the same period, residential electricity use for California grew 0.8% for every 1.0% increase in population. Consequently, Humboldt County residential electricity use grew 2.6 times more per percentage increase in population than for California as a whole.

From 1990 to 2003, commercial electricity usage in Humboldt County increased 14.3% (an annual rate of 1.0%). This means that commercial electricity use in Humboldt County grew 1.7% for every 1% increase in population during this period. From 1990 to 2001, California commercial electricity use increased at a rate of 2.0% annually. For California as a whole, commercial electricity use increased 1.5% for every 1% increase in population during this period.

Industrial use of electricity in Humboldt County decreased 19.8% from 1990 to 2003, or at an annual rate of -1.7%. For California as a whole for 1990 to 2001, industrial electricity use was nearly flat, increasing only 0.5% for this entire period, or 0.05% increase per year.

Future electricity use can be projected based on historic use. Such extrapolations often assume that relationships between variables, such as population growth and growth in energy demand, remain the same. Although the continuance of these relationships is not certain, the projection of future demand based on historic trends can provide a useful reference point for planning purposes.

Assuming that population growth rates continue at 0.6% per year in Humboldt County and that historic correlations between population growth and the change in commercial and residential energy demand remain constant, the following 20 year projection for electricity use in Humboldt County is derived (see Table 3). This projection assumes that industrial and agricultural electricity use remain constant.

Table 3. Humboldt County Projected Electricity Use - 2023

<i>Sector</i>	<i>2003 Electricity Use (GWh/yr)</i>	<i>Annual Electricity Use Growth Rate (%)</i>	<i>Projected 2023 Electricity Use (GWh/yr)</i>
Residential	325	1.24	416
Commercial	295	1.04	363
Industrial/Agricultural ¹²	153	0.0	153
Total ¹²	773	0.94	932

It is expected that electricity consumption in the county will grow modestly over the next 20 years. Based on past behavior, it is likely that the growth in electricity consumption will range from about 0.5% to 1.5% per year. If population growth rates reach 2% per year, growth in electricity demand could reach 2% to 3% per year. PG&E predicts the growth in electricity demand in Humboldt County will average 0.6% per year.

Natural gas use in Humboldt County between 1990 and 2003 decreased at an average rate of 1.0% per year¹³. Again, most of the decrease occurred in the industrial sector. Figure 9 shows the natural gas consumption in the county over the period 1990 to 2003. Statewide estimates for growth in natural gas demand (excluding growth for electricity generation) are about 1% per year. Natural gas demand growth in Humboldt County may be substantially lower.

D. Gasoline and Diesel Use

Gasoline consumption in 2003 in Humboldt County is estimated at 54.6 million gallons (California Department of Transportation, 2004a). This comprises approximately 0.4% of the State total. Diesel consumption is estimated at 16.8 million gallons (Parsons, 2005). Figure 10 shows the estimated gasoline consumption in Humboldt County for the years 1997 through 2003 (California Department of Transportation, 2004a). Consumption has risen 9.1% in the last 6 years, an average of 1.5% per year. For comparison, the State total has risen by 2.3% per year over the same period. Humboldt County's gasoline usage is about 420 gallons per year per capita, which is nearly the same as the State average per capita. This compares to a national average of about 460 gal per year per capita.

¹² This does not include the industrial electricity demand that is currently being met by on-site generation at Pacific Lumber Company and the Samoa pulp mill. In 2003 this amounted to 167 GWh/yr.

¹³ Not including gas used for electricity generation.

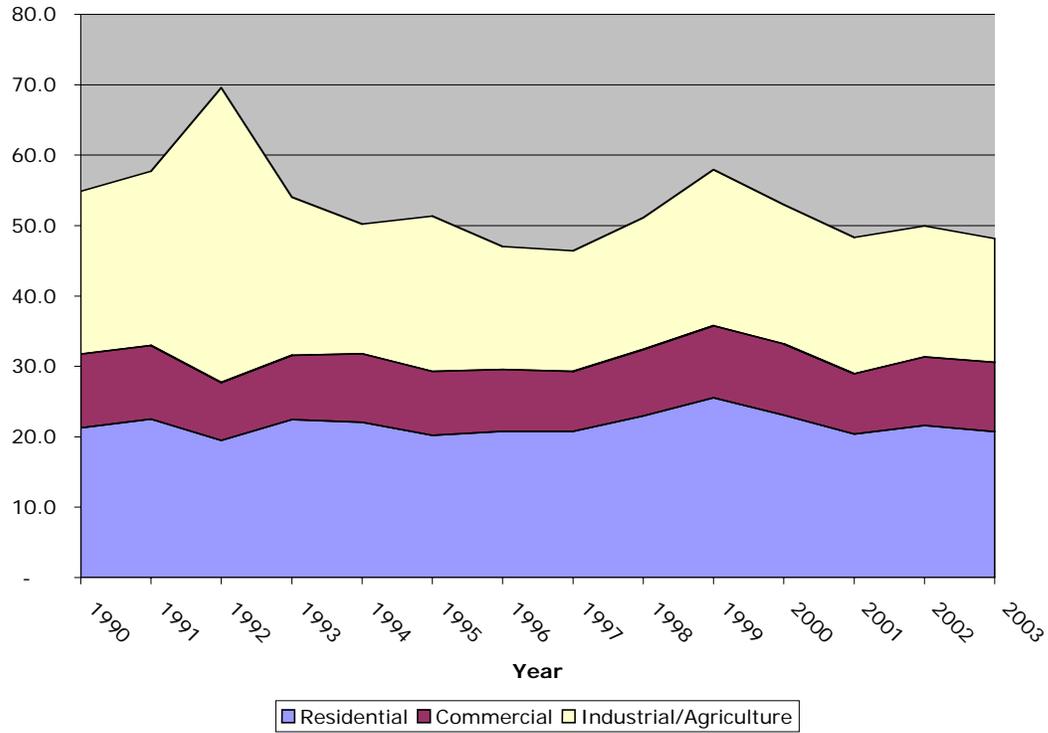


Figure 9. Humboldt County Annual Natural Gas Consumption¹²

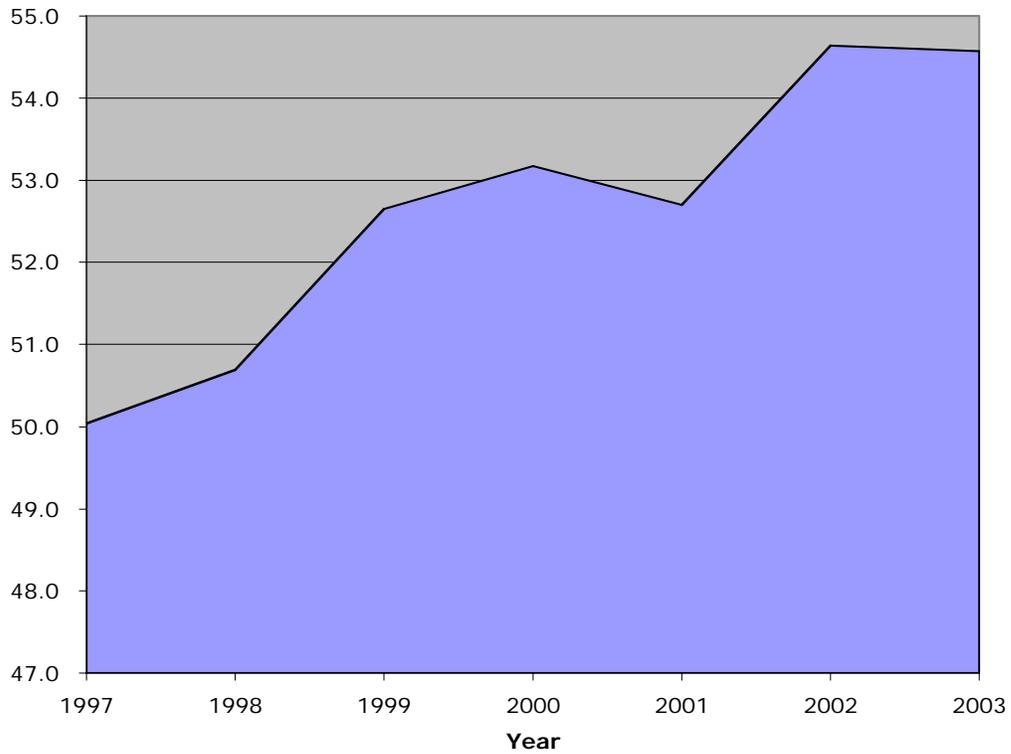


Figure 10. Humboldt County Annual Gasoline Consumption

CHAPTER 4 - NUMBERS OF VEHICLES AND VEHICLE MILES TRAVELED

As identified in the previous section, the use of energy for transportation in the form of gasoline and diesel fuel accounts for a tremendous portion of both the county's energy consumption and its energy expenditures. This makes energy use in the transportation sector an area of key importance. This section examines some indicators associated with the transportation sector (number of registered vehicles, vehicle miles traveled), and also briefly discusses policy and planning issues that can significantly affect transportation energy use, such as land use and development patterns and the availability of public transportation services.

The number of vehicles (autos, trucks, motorcycles) registered in Humboldt County in 2002 was 113,557 (California Statistical Abstract, 2003). This represents 0.4% of the State total. The number of registered vehicles per capita in Humboldt County is 0.9, as compared to a State average of 0.84 per capita.

Humboldt County is a very rural county, with a population density of only 35 persons per square mile. This compares to a density of 217 persons per square mile for the State of California as a whole. As would be expected, the vehicle miles traveled are typically higher for a more rural county than for more densely populated areas, and this is true for Humboldt County. In 2000, Humboldt County had about 9,600 highway vehicle miles traveled per capita (California Department of Transportation, 2004b). This is 6% greater than the State average for that year. According to the 2000 U.S. Census, 72% of the workers in Humboldt County drive alone to work, 13% carpool, 7% walk, 1% use public transit, and 6% work at home. The mean travel time to work is 18 minutes.

Humboldt County's relatively high level of vehicle miles traveled is due both to an increase in the number of personal vehicle miles traveled and the need to transport the majority of consumer goods into the county, and other materials (like municipal refuse) out of the county. Efforts to increase the local production and use of goods (such as growing food locally) and the processing of wastes locally (through recycling, reusing and composting) may help to lower the vehicle miles traveled in the county. Efforts to decrease personal vehicle miles traveled are also important. This can be accomplished through wise land use planning that encourages bicycle and pedestrian travel, reduces commute and shopping travel distances through anti-sprawl planning and mixed-use development, and supports public transportation modes (bus, train).

Land Use Patterns and Energy Use

A recent article on urban planning discusses the link between land use development and energy use (Hart, 2005).

“Between 1982 and 1997 the U.S. population grew by about 17 percent. During the same period, the amount of land consumed for urban development increased by 47 percent. Americans continue to spread themselves more thinly across the landscape. The results of these individual locational decisions are quantifiable by increased infrastructure costs to serve spread-out development, and by the increased amount of energy needed for transportation, community services, and buildings.

Reasonable people can disagree about the degree to which sprawl has been facilitated by the automobile, but it is clear that automobile travel has increased substantially over the past decades, far outpacing population growth. In fact, from 1980 to 1997, vehicle miles traveled (VMT, in traffic engineer jargon) grew by 63 percent, nearly three times the rate of population growth. The U.S. EPA reports that more than 60 percent of the increase in VMT has been due to an increasingly dispersed, low-density pattern of land development and "the fact that jobs and housing have become increasingly segregated from one another.""

Until the 1920's, land use was basically uncontrolled in the U.S. Then a U.S. Supreme Court gave governmental units, such as cities and counties, the right to define zones and allowable uses within zones. The original thinking for this was to separate residential areas from uses that were noisy and hazardous. The dominance of automobiles, starting in the 1920's, and the promulgation of a uniform nationwide land use code resulted in a separation of uses. Definitions of land use came under the control of professional urban planners. There were separate zones for industrial (light and heavy), commercial, residential and recreational uses. Since people moved primarily by car, lower densities became practical and common. This pattern of land use resulted in significantly increased travel and significantly increased energy use for transportation. This pattern of land use has also been criticized for a major reduction in the spontaneous contacts between people and the associated loss of community, as well as a decrease in physical exercise and its associated decrease in health benefits.

In the past 20 years there has been a movement in urban planning called "New Urbanism" or "Smart Growth." City planners following the philosophy of New Urbanism increasingly plan and design cities with mixed uses rather than single uses, and with higher densities and orientation towards public transit, bicycle, and pedestrian travel rather than private automobile transport. These planning objectives can serve to lower the energy demand in the transportation sector and can bring about many other benefits that lead to healthy, livable communities. A recent report from the Department of Environmental and Natural Resource Sciences at Humboldt State University titled "Room to Grow?" (Smith and Steinberg, 2005) found that Humboldt County can easily accommodate most rates of projected growth by developing residentially zoned lands within areas that already have water and sewer service, even when 60 percent of total available land is excluded due to various constraints. The key is that the county must be willing to develop new housing at a higher average density than it has historically, though this does not mean an 'urban' level of density. Denser development is certainly preferable to sprawl in terms of minimizing energy demands.

Rail Service

Until the 1950's, Humboldt County was served by both passenger and freight rail service. In the mid 1950's passenger rail ended. As a result of severe storms at the end of 1996, a section of the railroad along the Eel River washed out. The railroad has not operated since then. The North Coast Railroad Authority (NCRA) is still actively pursuing federal funding to maintain and eventually operate the railroad. It is not clear at this time how soon, if ever, there will be rail service again in Humboldt County. The long-term goals of NCRA are first to reestablish rail service from Mendocino County to Napa County and then reestablish rail service from Mendocino County to Humboldt County. The Timber Heritage Association, a non-profit

organization, is working to establish an excursion train in Humboldt County. If they are successful, this could help with the effort to reestablish regular rail service (freight or passenger) within the county.

Public Transit

Whether public transit saves energy depends primarily on population density and level of ridership. Higher density land use patterns and higher ridership levels improve the overall energy efficiency of public transit. There are currently three public transit systems operating in Humboldt County: Arcata & Mad River Transit System (A & MRTS) serves the City of Arcata, Eureka Transit System (ETS) serves the City of Eureka, and Redwood Transit System (RTS), operated by the Humboldt Transit Authority, operates from Scotia to Trinidad to Willow Creek. All three systems operate Monday through Saturday. Amtrak and Greyhound provide bus services in and out of the county. Amtrak's bus service is only available to passengers connecting to their rail system. Greyhound has recently made major service cuts on the North Coast, completely eliminating their Eureka, Crescent City, Fortuna, Garberville, Orick, and Trinidad stops ("Goodbye to a piece of our past," Eureka Times-Standard, June 22, 2005). Arcata and Rio Dell are the only remaining Humboldt County communities served by Greyhound.

CHAPTER 5 - ENERGY SUPPLY AND IMPORT ANALYSIS

The majority of energy consumed in Humboldt County is imported. Table 4 gives an estimate of the quantity of various energy sources consumed in the county in 2003, along with estimates of the portion imported versus the portion from local sources (Kammerer, 2005 and California Department of Conservation, 2003). Biomass energy, in the form of firewood used for space heating and waste wood used for electricity generation, comes principally from within the county, though occasionally a barge of hog fuel may be shipped in for use in electricity production. While the majority of electricity (73%) is generated within the county, a large portion of this locally generated electricity is generated using natural gas (PG&E power plant, Stockton-Pacific Samoa Pulp Mill), and the natural gas is primarily imported (89%). The rest of locally generated electricity is primarily produced from biomass (Pacific Lumber and Fairhaven), with the remainder coming from local hydroelectric facilities and a very small amount from distributed rooftop solar electric and wind energy systems. Figure 11 shows the proportion of electricity coming from each source (Kammerer, 2005). A portion of the power produced by local generators is used to serve on-site loads. For Pacific Lumber this accounts for about 15-25% of their generated power and for the Samoa pulp essentially all of their generated power. The Fairhaven plant provides all of their power to the electrical grid.

Table 4. Consumption of Local Versus Imported Energy Sources, 2003

<i>Source</i>	<i>Amount</i>	<i>MMBtu's</i>	<i>% imported</i>	<i>% local</i>
Gasoline	54,569,000 gal	6,275,435	100	0
Diesel	16,800,000 gal	2,184,000	100	0
Natural gas ¹⁴	93,860,628 therms	9,386,063	89	11
Electricity	940 GWh	3,208,220	27	73
Biomass ¹⁵	849,645 tons	5,182,919	0	100
Propane	4,210,900 gal	384,581	100	0

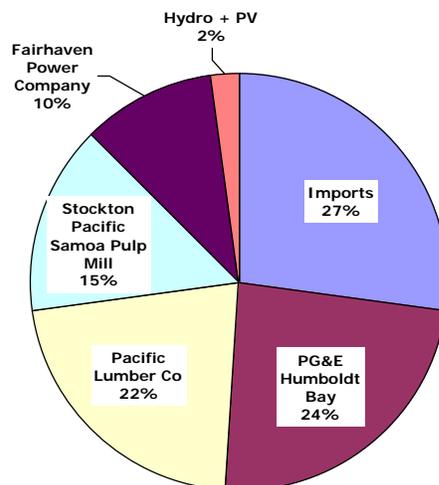


Figure 11. Humboldt County Electricity Supply by Source, 2003 (940 GWh)

¹⁴ Includes natural gas used for electricity generation and for all end uses.

¹⁵ Includes biomass burned for electricity production and residential space heating only; does not include biomass burned for process heating (e.g. wood drying kilns in sawmills).

Although the county currently imports 27% of its electricity, there is actually enough local generation capacity to meet all of its electrical energy needs. Pacific Gas and Electric's Humboldt Bay Power Plant, because it is old and relatively inefficient, is not run as much as it could be. If this plant were run consistently near full capacity, the county could produce an excess of electrical energy. In fact, in 2001 during the California electricity crisis Humboldt County was a net electricity exporter of 178 GWh. During that year the PG&E plant had a capacity factor of 56% (Pan, 2005). Local electrical generators are discussed in more detail in Chapter 6.

Figure 12 shows an energy flow diagram for Humboldt County for the year 2003. The left side of the diagram shows the primary energy sources and the right side shows the energy end use categories. The difference between the amount of electricity generated and the electricity output is due to the inefficiencies associated with thermoelectric power generation.

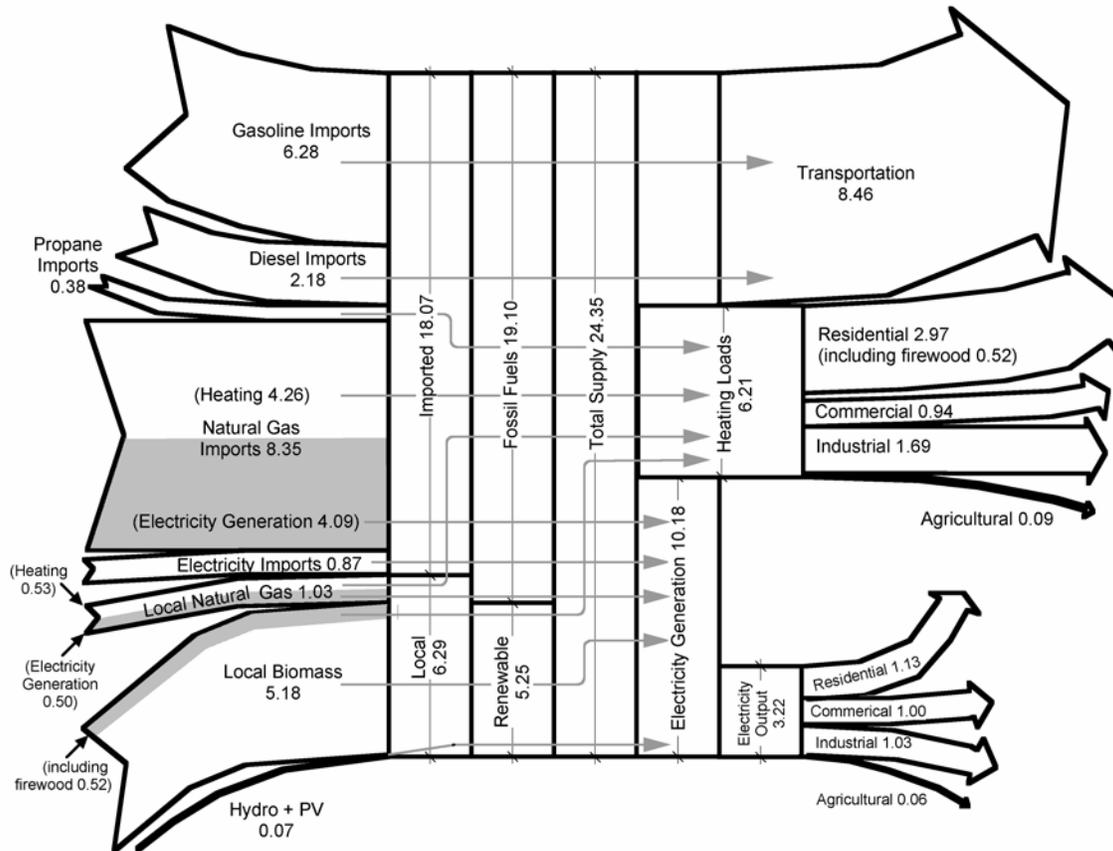


Figure 12. Humboldt County Energy Flow Diagram, 2003¹⁶ (in Trillion Btu's)

¹⁶ Does not include wood waste burned for process heat.

Recent developments offer opportunities for Humboldt County to meet a larger share of its electrical power needs with locally generated power. In February of 2005 Pacific Gas and Electric Company announced a request for offers to replace the power that is being generated at its 130 MW Humboldt Bay plant, thereby taking steps to ensure future long-term reliability of electric service for its customers on the North Coast. PG&E is seeking bids for 135 to 150 MW of new generating capacity (Pacific Gas and Electric Company, 2005a and Pacific Gas and Electric Company, 2004b). They recommend that the generation capacity be modular, with no single unit greater than 50 MW. This would improve system reliability should one unit go off line. The new generation may be located at their existing power plant location or at another site in the area, or may be in the form of power purchase agreements from new generation sources owned and operated by others.

If approved by the Public Utilities Commission, the replacement generation would be expected to be available by 2008. This clearly offers an opportunity for development of new local resources, perhaps in the form of wind or biomass energy. Alternatively, someone may propose to build a new, efficient natural gas plant at PG&E's existing site. According to Claudia Chandler of the CEC, a new natural gas power plant can be twice as efficient as those built a couple of decades ago and would likely emit half the air pollution of a plant built only ten years ago (Driscoll, 2005). There is a good possibility that the replacement generation will be more efficient and cleaner than the existing Humboldt Bay Power Plant. If this is the case, it will likely be run more consistently near its full capacity and will thereby lessen the county's dependence on imported electricity.

DG Energy Solutions of San Diego recently purchased the Fairhaven Power Plant. DG Energy Solutions primarily develops, owns and operates industrial, commercial and institutional cogeneration plants. They currently own and operate energy projects with 22 MW of electrical generation capacity and have more than 100 MWe of industrial cogeneration projects in development or pre-construction planning throughout the United States. They plan to add numerous upgrades to the Fairhaven biomass plant, including a fuel drying system that will improve plant performance, new environmental and fuel management systems, and turbine control upgrades. DG Energy is also interested in purchasing the Ultrapower biomass plant in Blue Lake and bringing it back on line, as well as developing other local energy resources, including wind, solar and wave power. They currently have room to add approximately another 25 MW of generation capacity to their connection at the PG&E substation. According to Steve Mueller, DG Energy's president, they are only interested in developing power projects that have broad community support (Mueller, 2005), and they are interested in the possibility of selling power directly to local communities under a Community Choice Aggregation arrangement.¹⁷

There are numerous issues to consider regarding energy supply and demand for Humboldt County. One key issue is the remoteness and isolation of the county. This has an impact on the availability and reliability of numerous energy sources. For example, because of the county's remote, isolated location, it is not well interconnected with the State electrical and natural gas supply grids. This affects both the county's energy supply options and its energy system reliability. Humboldt County is located at the end of a terminating spur of both PG&E's

¹⁷ See the Electricity Market Trends section for a discussion of Community Choice Aggregation.

electrical and natural gas grids. Neither the natural gas nor the electricity transmission lines into Humboldt County are capable of importing all of the county's required energy. According to PG&E's 2002 "Humboldt Long-Term Study," with the existing local electrical generation capacity the electrical transmission system is sufficient to serve the area load reliably for the next ten years (Pacific Gas and Electric Company, 2004b). However, if a significant amount of local generation were retired, this would not be the case. Hence, they conclude that maintaining the generation system or increasing the import capability to compensate for any generation retirement will be necessary to continue to serve the Humboldt area load reliably. Further issues regarding electric and natural gas transmission lines are discussed in Chapter 8.

Another aspect related to the county's remote, isolated location is that all of its propane fuel is imported by truck. There are only two key highway connections that can effectively handle this transport: Highway 101 and Highway 299. This can pose serious supply problems if highway travel is inaccessible, as is common in the winter months due to slides. Highway disruptions due to slides are common on both Highways 101 and 299. Gasoline and diesel fuels are imported by barge to the Chevron terminal on Humboldt Bay, and access to the Bay inlet can also be impaired during winter storms. These fuels are distributed by truck to local fueling stations.

Electricity Market Trends

California faced serious electricity supply constraints in 2001, resulting in rolling blackouts throughout the state. Although the situation has improved, future supply constraints are forecasted if adequate planning and implementation efforts are not carried out. Implementation efforts include the statewide development of new electrical generating and transmission capacity and aggressive energy efficiency efforts. In order to meet future energy demands, the State of California has developed energy policies that favor energy efficiency and conservation first, renewable energy and distributed generation second, and clean, central station fossil fuel generation and improvements to the electricity transmission and distribution system last.

Energy efficiency and conservation measures are favored because they can be implemented the fastest and they offer the greatest societal benefit, both economic and environmental. In terms of new generation, renewable energy sources are favored because they are sustainable over the long term. Renewable energy sources are not dependent on depleting resources, they present the fewest environmental impacts, and they can be locally generated.

Distributed generation is also being promoted and is gaining broader appeal. Distributed generation primarily refers to utility customers who install on-site generators to reduce the amount of electrical power they purchase from their utility company. The on-site generators are typically powered by solar, wind, hydro, biomass, biogas, or natural gas. They typically operate in parallel with the utility and are not used to sell power to third parties. Distributed generation can offer numerous advantages. It is modular and can be added in small increments. It can provide grid support and eliminate or reduce the need for transmission and distribution system upgrades. It eliminates losses in the transmission system. It can potentially provide the customer with lower energy costs, higher service reliability, higher power quality, increased energy efficiency, and energy independence. It allows for the use of local renewable energy resources and can utilize cogeneration systems that use energy more efficiently.

In an effort to promote the development of renewable energy resources, the California legislature passed SB 1078 in 2002, establishing a renewable portfolio standard (RPS). This legislation requires that all retail sellers of electricity increase their procurement of renewable energy resources by at least 1% per year until at least 20% of retail sales are procured from eligible renewable energy resources. Since California currently generates about 10% of its electricity using renewable energy resources, this legislation will approximately double the amount of renewable electricity generated in the state.

Starting in 1998 the State of California attempted to deregulate the electric utility industry with the goals of using competition to increase electricity supply and reduce costs for customers. Under deregulation, the investor-owned utilities in California were required to sell off their generating capacity and allow customers to buy electricity directly from suppliers of their choice (direct access). Unfortunately, the combination of poorly structured deregulation laws and major fraud and manipulation by suppliers resulted in power outages and billions of dollars in increased costs for customers. Deregulation, including direct access, was suspended in September of 2001. At this time it is uncertain what form of electricity industry regulation/deregulation will prevail in California.

Although there is no sign that direct access will return for individual customers anytime soon, in 2002 the California legislature passed AB 117, the community choice aggregation (CCA) law. This legislation allows local governments, alone or jointly, to aggregate the retail electric customers in their jurisdictions for the purpose of purchasing power. Local governments may not purchase or acquire the local distribution system, but may enter into contracts to provide the energy component of the electric bill. The utility still provides billing services and remains the default provider for any customers who choose to "opt out" of the program. This legislation allows communities to choose from whom they buy electrical power and what type of power to buy, as well as allowing them to negotiate how much they pay. AB 117 also allows local governments, or other entities, to apply to administer energy efficiency programs in their jurisdictions. Although no jurisdictions in California have yet instituted a CCA program, many are pursuing the opportunity. A pilot program being conducted by the Local Government Commission (LGC) is assisting communities in undertaking CCA feasibility studies. The LGC is also working to keep communities informed about the CPUC decision process on how to implement the CCA law.

An option that has long been available for local communities to have more control over their electricity provider is to form a municipal utility. Municipal utilities typically own the electrical distribution system. Some also own generating facilities; others purchase wholesale electricity. Municipal utilities can offer many advantages. They are owned by and accountable to the people they serve. They empower local communities to make their own decisions about their electric power. They can typically provide power to their customers at lower costs than investor-owned utilities, and they keep more of the energy dollars circulating in the local economy. In today's electricity environment it is typically a long, expensive, difficult effort to form a municipal utility, often involving a legal battle with the investor-owned utility that has been granted the existing electric franchise.

Another development in the electricity market is the possible repeal of the qualifying facility provisions of the Public Utility Regulatory Policies Act of 1978 (PURPA). This could affect the development of new renewable electricity generation plants, as well as existing facilities operating under PURPA contracts (including the Fairhaven power plant, PALCO power plant, Baker Creek hydroelectric facility and Mill and Sulphur Creek hydroelectric facility). PURPA was enacted by the federal government in 1978 to encourage cogeneration and the use of renewable energy. It is overseen by the Federal Energy Regulatory Commission (FERC). PURPA guarantees that qualifying facilities (QFs) that meet certain criteria (i.e. cogeneration facilities and electricity generators using renewable energy) will receive a guaranteed rate for their power equal to the utilities' avoided cost of not having to generate that power themselves or procure it elsewhere. There have been several attempts to repeal section 210 of PURPA, the part that requires the utilities to buy QF power. This is an ongoing legislative battle.

Natural Gas Market Trends

In the early 1990's, California began deregulating natural gas by allowing non-core gas customers (large industrial users and power plants) to buy natural gas in an open market with the objective of allowing them to get lower prices. Deregulation in the natural gas market has also been extended to residential and small commercial customers (core customers) who can now also purchase natural gas directly from competitive suppliers. Under this gas rate option, customers purchase their gas commodity from a competitive supplier, known as a Core Transport Agent (CTA). The local gas utility, such as PG&E, still owns and maintains the lines that deliver gas to the customer. Currently there are numerous CTAs offering core gas aggregation services to various commercial and residential customer groups (residential, small commercial, schools, municipalities, public agencies, etc.).

The demand for natural gas in the U.S. is expected to grow, with use for electrical power generation being the prime driver. The demand for natural gas is expected to grow throughout North America, and supplies are not as plentiful as previously expected. As a consequence, the U.S. will likely become increasingly reliant on natural gas from Canadian and overseas liquefied natural gas (LNG) imports to meet growing demand. Prices for natural gas will likely rise faster than inflation due to growth in gas demand, restricted supply, and the expense of developing new gas wells and pipeline capacity. The California Energy Commission (CEC) estimates that overall demand for natural gas in California will grow approximately one percent per year between 2003 and 2013 (California Energy Commission, 2003a). Within California, the CEC predicts that PG&E will need additional natural gas receiving capacity or storage after 2006.

Total natural gas consumption in the U.S. has remained essentially constant over the past decade at approximately 22 million cubic feet annually. Of this, approximately 19% is currently imported from outside the U.S. Traditionally, imported natural gas has entered the U.S. mainly via pipeline from Canadian producers. However, a significant new trend is the increasing importation of LNG by tanker from overseas producers. While LNG only made up about 3% of total 2004 U.S. natural gas consumption, this was up from just 1% only five years earlier. The trend toward LNG is expected to continue with anticipated long-term declines in North American gas production and a shift toward natural gas as the fuel of choice for electricity generation (Energy Information Administration, 2005a and 2005b).

Because of its low energy density compared with liquid fuels, it is not economic to ship natural gas in its normal gaseous state. LNG is approximately six hundred times as dense as natural gas at atmospheric pressure and temperature. While LNG itself cannot explode, it quickly vaporizes when released to the atmosphere, thus creating the potential for a fire or explosion. The hazardous nature of LNG has created controversy around existing and planned LNG terminals in the U.S. As of 2004, there were only five LNG terminals in the U.S., none of them on the West Coast (Easthouse, 2003).

To date one serious proposal has been put forth to build a local LNG import terminal on Humboldt Bay. The interested company, Calpine, withdrew its proposal in March 2004 in the face of outspoken local opposition. A map of proposed LNG terminals in a November 2004 LNG industry publication shows all the Pacific Coast sites located in Southern California, Oregon, British Columbia, and Mexico. Only one site, in Baja California, has been officially approved (Thompson, 2004).

An LNG terminal on Humboldt Bay would presumably be a regional facility bringing in quantities of natural gas significantly in excess of Humboldt County's demand. However, the facility could benefit the county by providing a new source of natural gas for local use and perhaps, as Calpine proposed, an electric generation facility to replace the aging Humboldt Bay PG&E plant as part of the project package.

Those opposed to a local LNG facility have cited safety concerns, such as the possibility of a catastrophic explosion or fire, either accidental or caused by terrorists. However, compared to most other West Coast ports Humboldt Bay is less densely populated, making it a relatively attractive terminal site from a regional-level security perspective. LNG opponents also argue that, like oil, natural gas resources are declining globally, and major investment in and increased reliance on this fuel make for poor energy policy. Concerns have also been expressed about local environmental impacts of building and operating an LNG terminal.

Local proponents of a Humboldt Bay LNG facility have noted the opportunities for job creation, increased tax revenues, and rejuvenation of Humboldt County's energy infrastructure. Some have also observed that by welcoming such a facility, Humboldt County can "do its part" to help meet national energy needs.

Challenges for any developer of a Humboldt Bay LNG terminal will include difficulty in garnering public support, isolation from major energy markets, the expense of building a long pipeline across rugged terrain to connect to major natural gas pipelines in the Central Valley, and inaccessibility of the harbor during severe winter weather.

CHAPTER 6 - INVENTORY OF LOCAL ENERGY PRODUCING RESOURCES

This section of the report examines the availability of existing and potential energy producing resources in the county. Each resource is briefly described and an assessment is made of the potential quantity available locally, how likely it is that the resource will be developed, and how big of a contribution it might make toward meeting local energy needs. Figure 13 presents a graphical picture of the energy resources available in Humboldt County. Some of these resources are currently being developed and utilized; others offer future potential.

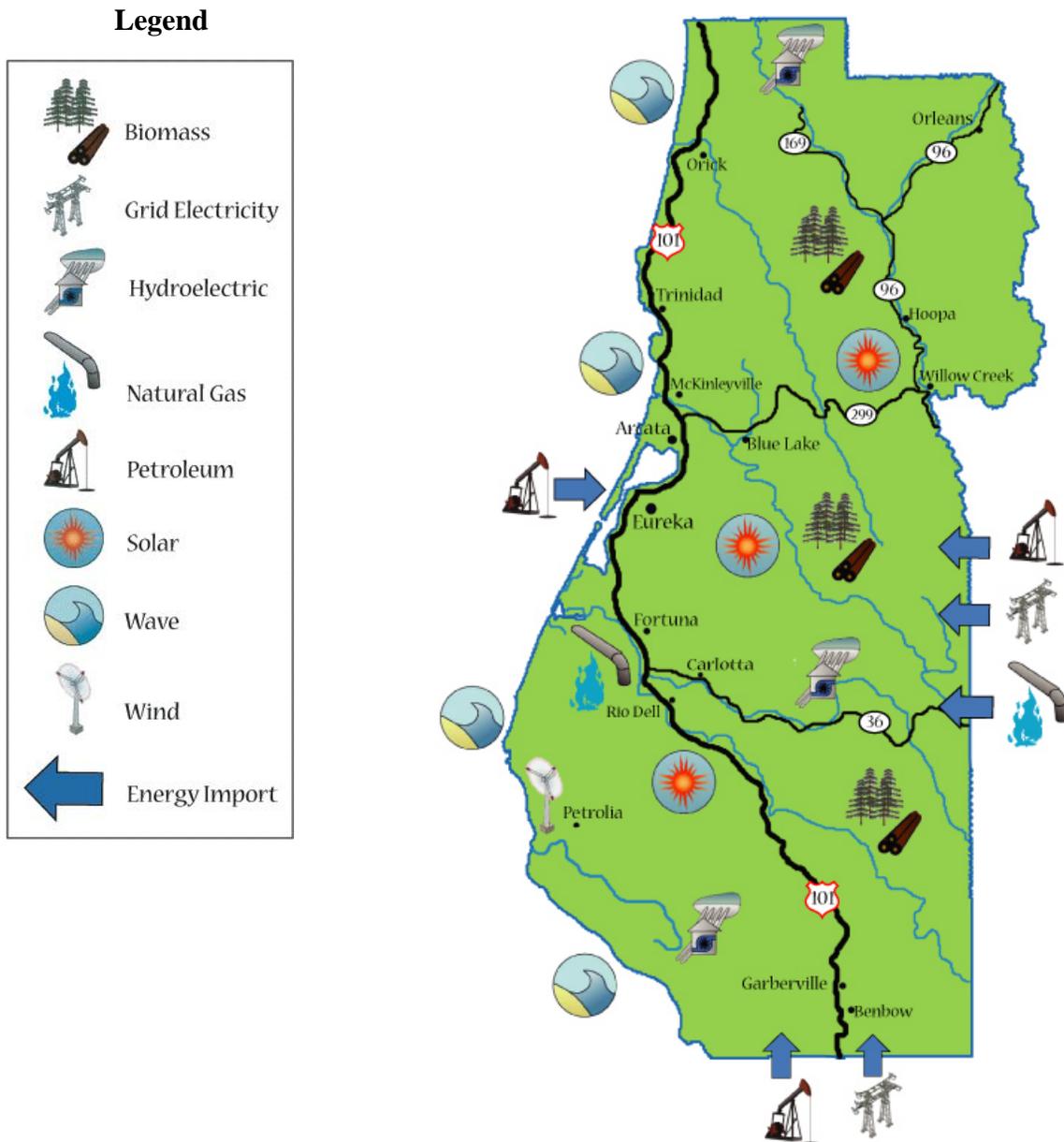


Figure 13. Distribution of Humboldt County Energy Resources

With resources like electricity and natural gas that are transported through wires and pipelines, it is important to remember that not only does the county need to meet its annual energy needs, but it must also meet the peak demands that occur at any given time. The ability to meet peak demands is a function of the local availability of the resource and the capacity of the transmission lines to import additional resources from outside the county.

It is also important to remember that some resources are intermittent, such as solar, wind and wave energy. While these local energy sources may be able to provide a substantial portion of the county's energy needs, they will not be able to provide all of its needs unless some sort of energy storage system is employed. The use of a large energy storage system adds complexity and cost to the system. What is more likely in the shorter term is that the county will use a diverse portfolio of energy resources. When the intermittent resources are available, the county will utilize as much of them as it can. When they are not adequately available, the county will supplement them with other dispatchable resources, such as biomass, natural gas, or imported electricity.

Table 5 shows the list of local energy resources that were examined and summarizes some of their characteristics. It is estimated that total local electricity generation via sustainable means could provide as much as 1500 MW of capacity and over 6000 GWh per year of electrical energy. This supply potential is over six times the county's current consumption rate. Figure 14 shows what portion of this total potential is associated with each resource. A description of how the potential for each resource was estimated is given below. Note that these are rough, "ball park" estimates that are intended to provide a relative sense of magnitude. A more detailed analysis would be required to more accurately estimate the potential of each of these resources. In addition, there are many technological, economic and regulatory uncertainties involved. This is especially true for technologies that are still early in their development, like wave energy systems. The estimate for wave energy potential is the most uncertain and the wave energy resource is the least likely to be significantly developed in the near term. However, even for well proven resources like wind, solar and hydro power there are many potential barriers that could stymie development, including high costs, regulatory hurdles, lack of financing, and lack of public support.

Also note that the 1500 MW of capacity noted above is the total maximum capacity. However, many of these resources are variable and intermittent. The sun does not always shine and the wind does not always blow. The overall capacity factor associated with these various resources would likely be about 40% to 50%, meaning that the effective capacity would be only about 700 MW. Also, because many of these resources are intermittent, there may need to be some sort of local electrical energy storage system that would be capable of smoothing out the peaks and valleys in the electrical generation and load profiles. As discussed below in the wind energy section, variable resources like wind, wave and solar energy are only expected to be able to provide about 10-20% of electricity demands for any given hour without some sort of energy storage system. Only biomass energy offers a local, renewable electricity resource that is dispatchable, meaning it can be supplied on demand.

Table 5. Potential Local Energy Resources for Humboldt County

<i>Resource</i>	<i>Potential</i>	<i>Technology Status</i>	<i>Geographic Location</i>	<i>Comments</i>
<i>Wind Electricity</i>	Large 400 MW, 1000 GWh/yr	Mature	Cape Mendocino, other	Good resource, need transmission access, few viable sites
<i>Wave Electricity</i>	Large 500-1000 MW, 2500- 5000 GWh/yr	Early Development	Coastline	Good resource, technology too early to tell
<i>Biomass Electricity</i>	Medium ≥60 MW, 300-400 GWh/yr	Mature	Variable	Already developed, may be room for growth
<i>Natural Gas</i>	Medium >1 million MCF/yr	Mature	Eel River Basin	Existing, further development underway, non-renewable
<i>Hydroelectricity</i>	Medium 20-40 MW, 80-160 GWh/yr	Mature	Rivers	Existing, more potential but barriers
<i>Solar Electricity</i>	Medium 10-30 MW, 10-30 GWh/yr	Mature	Dispersed	Many small systems
<i>Solar Water Heating</i>	Medium	Mature	Dispersed	Many small systems
<i>Solar Space Heating</i>	Small	Mature	Dispersed	Hard to retrofit
<i>Biogas Fuels</i>	Small	Mature	WW Treatment, Landfill, Dairies	Existing, room for growth
<i>Biodiesel Fuel</i>	Small 40,000 - 80,000 gal/yr	Mature	Variable	Existing, room for growth

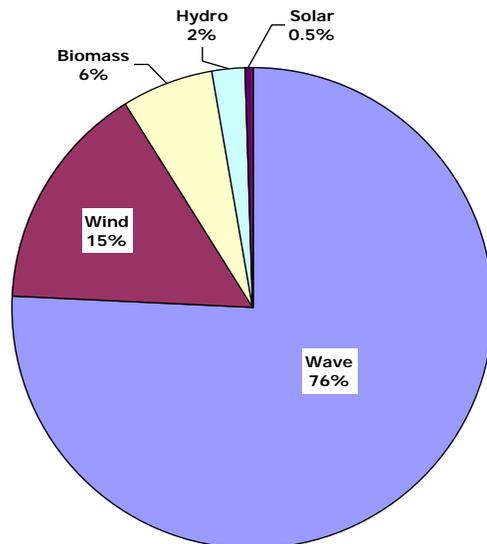


Figure 14. Humboldt County Electricity Generation Potential
(6,950 GWh per year, note that development of wave power is very uncertain)

A. Local Electrical Power Generators

Table 6 lists the major electrical power generators in the county¹⁸. The total portion of Humboldt County's electricity that was generated within the county in 2003 was about 73%. However, note that the capacity factor for the PG&E Humboldt Bay plant is very low – only 19%. This is because the plant is very old, making it relatively inefficient. For this reason PG&E only runs the plant when necessary. If it were a more modern plant it might run at full capacity 80% or more of the time. If this were the case, all of the county's electricity could be generated locally. As discussed in Chapter 5, PG&E is currently looking to replace this aging power plant. Note also that peak generating capacity of plants within the county is more than enough to meet the county's peak demand of 150 to 160 MW.

Table 6. Electrical Power Generators in Humboldt County (2003)

<i>Plant Name</i>	<i>Primary Fuel</i>	<i>Year Online</i>	<i>Capacity (MW)¹⁹</i>	<i>Generation (MWh)²⁰</i>	<i>% Sold</i>	<i>% Used Onsite</i>	<i>Capacity Factor</i>
PG&E Humboldt Bay	natural gas	1956	137	225,065	100	0	19%
Pacific Lumber Co	wood waste/cogen	1931	32.5	204,750	86	14	72%
Fairhaven Power Co	wood waste	1986	15	96,111	100	0	73%
Stockton-Pacific Samoa Pulp Mill	natural gas/cogen	1965	20	138,387	1	99	79%
Ultrapower 3 Blue Lake Mill and Sulphur Creek Project	wood waste	1985	13.8	0			
Baker Creek Project	hydro	1988	1	5,040 ²¹	100	0	58%
Mathews Dam Ruth Lake (HBMWD)	hydro	1987	1.5	7,000 ¹⁸	100	0	53%
Essex Road Pumping Station (HBMWD)	hydro	1983	2	5,927			34%
Kekawaka Creek/Zenia	hydro		2	726			4%
CSU Humboldt	hydro	1989	5	?			
CSU Humboldt	natural gas, cogen	1991	0.35	2,000 ²²	0	100	65%
CSU Humboldt	natural gas, cogen	2005	0.73	N/A ²³	0	100	
Total			231	679,966			

¹⁸ Some power plant databases show a biomass fired generator at the old Simpson pulp mill. According to Bob Marino, the Fairhaven Power Plant Manager, this generator has been removed and is no longer available (Marino, 2005a).

¹⁹ Capacity numbers are primarily from the CEC Power Plant Database (California Energy Commission, 2004b). PG&E's reports show somewhat higher maximum generating capacities for some of these units.

²⁰ Generation numbers are primarily from CEC Form CEC-1304 (Pan, 2005) and are adjusted for power consumed on-site at PALCO and Samoa Pulp mill using CEC data provided by Kurt Kammerer (Kammerer, 2005). HBMWD generation numbers provided by HBMWD.

²¹ Estimated output (Oscar Larson & Associates, 1982).

²² Estimated output (Wright, 2005).

²³ Not yet on-line (Wright, 2005).

B. Fossil Fuel Fired Electrical Generators

One option for meeting local electricity needs is to generate the electricity locally using fossil fuel fired electrical generators. While this is likely to ensure a more secure electricity supply and is considered locally produced electricity, it is important to remember that the fuels being used to run these generators (natural gas, fuel oil, diesel) are predominantly imported.

There are currently two large fossil fuel fired electrical generation facilities in the county, the generating units at PG&E's Humboldt bay Power Plant and the natural gas fired steam electric generator at the recently sold Samoa pulp mill. The Samoa pulp mill unit is rated at an electrical capacity of 20 MW. It is a cogeneration unit that uses the waste heat and steam to help meet process heating and steam requirements at the mill. Essentially all of the electricity produced by this unit is used on site. The mill is currently going through its startup process under new ownership, and it is expected that the natural gas fired cogeneration system will continue to supply a large portion of their electricity requirements.

PG&E Humboldt Bay Power Plant

The Humboldt Bay Power Plant (HBPP) is owned and operated by Pacific Gas and Electric Company (PG&E) and is located on the eastern shore of southern Humboldt Bay at King Salmon. The plant consists of two fossil fuel fired steam electric generators (SEG), two diesel powered gas turbine Mobile Electric Power Plants (MEPP), and one retired nuclear reactor. The SEGs were installed in 1956 and 1958, are rated at approximately 50 MW each, and are capable of running on either natural gas or fuel oil, with natural gas being their primary fuel source. These units are run at rather low capacity factors, averaging 35% between 2001 and 2003.²⁴ Normal base load power plants of this type operate at capacity factors in excess of 80%. These units run less frequently because they are old, relatively inefficient, and relatively dirty for natural gas fired units. In fact, these units were recently identified by the CEC as two of the many aging units in the state that face an uncertain future due to their higher operating costs and lower efficiency. (Hight, 2004). This explains why PG&E is currently in the process of looking to retire these units and replace the electricity they generate.

The two MEPP units, each rated at 15 MW, are relatively new additions to the plant. They offer additional capacity when needed, but are not intended to be run for extended periods. Being diesel fired, they are limited in total number of operating hours per year due to their associated air emissions.

The nuclear reactor is a 65 MW, natural circulation boiling water reactor that operated from 1963 to 1976. It was the seventh licensed nuclear plant in the United States. In 1976, the plant was shut down for a normal refueling. During the shutdown, a number of unresolved seismic issues led PG&E to keep the plant shut down for an extended period of time. In 1984, the fuel was removed from the reactor vessel and the plant was placed in SAFSTOR (with spent nuclear fuel rods stored in water pools on site). More recently, PG&E announced its intent to remove 390 spent (irradiated) fuel rods from the pool at the plant, and place them in on-site, steel containers called dry casks. PG&E plans to begin construction of the dry cask storage in 2006, with loading

²⁴ Note that this is likely a high estimate for their typical capacity factor because the units were run more frequently than normal in 2001 due to the electricity crisis in California. In 2001 these units had an average capacity factor of 56%.

in 2007 (World Nuclear Association, 2003). The decommissioning costs, including plant demolition and construction and operation of dry cask storage through 2015, are estimated to total over \$350 million (World Nuclear Association, 2004). Full decommissioning is targeted for 2015.

C. Wind Power

A wind energy system converts the kinetic energy in the wind into mechanical or electrical energy that can be harnessed for practical use. Mechanical energy is most commonly used for pumping water in rural or remote locations. Wind electric turbines generate electricity for homes and businesses and for sale to utilities. Wind electricity can be generated on a small residential scale with small turbines (typically a few kilowatts or less in capacity, but some as large as 30 kW), or on a utility scale with large wind farms.

The wind power industry has made tremendous progress, and today wind is the fastest growing energy technology in the world. Over the last 20 years, the cost of electricity from utility-scale wind systems has dropped by more than 80%. In the early 1980s, when the first utility-scale turbines were installed, wind-generated electricity cost as much as 30 cents per kWh. Now, state-of-the-art wind power plants can generate electricity for less than 5 cents per kWh in many parts of the U.S., a price that is competitive with new coal- or gas-fired power plants. From 1990-2002, wind has been the fastest-growing power source worldwide on a percentage basis, with an annual average growth rate exceeding 30% (American Wind Energy Association, 2004).

The U.S. is second in worldwide wind energy capacity, behind only Germany, and California is the leading wind energy producer in the U.S. Although wind accounts for less than 1% of the electricity generated in the U.S. today, installed capacity has been expanding at an average annual rate exceeding 20%. The American Wind Energy Association (AWEA) believes that by 2020, with consistent policy support, wind can provide at least 6% of U.S. electricity (American Wind Energy Association, 2004). This projection is consistent with the U.S. DOE's goal of providing 5% of U.S. electricity demands with wind power by 2020.

Wind power offers many advantages (California Energy Commission, 2003b). It does not pollute the air, water, or soil and is a renewable (non-depletable) resource. The price of wind power is not influenced by fuel price increases or supply disruptions. At present, there exist both California and federal tax credits or rebates for wind generation. Wind turbines are modular, which makes adding capacity easy. They can also be installed relatively quickly in comparison to a conventional power plant.

However, the development of a wind energy facility site is a complex endeavor. As developers seek out suitable sites to build turbines, there are several key factors they must consider. These include: 1) the wind resource; 2) land ownership patterns; 3) access to transmission systems; 4) access to the site itself; 5) the degree of construction difficulty; and 6) environmental issues associated with the site.

Wind energy systems pose relatively few environmental impacts. Perhaps the most serious potential impacts are to birds and bats. Serious problems arose at some older wind farm sites, and the wind energy industry has worked to understand the causes of those impacts and to mitigate

them in subsequent developments. Lessons learned have led to a number of improvements in site assessment and design. The use of much larger turbines that are spread farther apart in all directions; tubular towers with few or no perching opportunities; larger, slower-turning rotors; greater spacing between turbines; and site evaluations that include an assessment of avian risk have all become standard practice.

Numerous other permitting issues can potentially limit utility-scale wind power development (California Energy Commission, 2003b). These include the demand for land area²⁵, though the installation of wind turbines can still allow other simultaneous land uses such as agriculture and cattle grazing. Aesthetic issues also pose potential problems, especially along ridgelines. Lessmann (2005) reports that a proposed wind farm near Cooskie Ridge in Humboldt County was recently rejected because residents of Petrolia raised aesthetic objections. Wildlife habitat disturbance and noise are other potential issues, although more recently designed large wind turbines are much quieter than older designs.

Because the power in the wind is a function of the cube of the wind speed, the annual average wind speed is typically used to assess the annual energy output from a wind turbine site. The National Renewable Energy Laboratory (NREL) uses a system of wind speed classes to evaluate the wind energy potential of candidate sites. According to NREL, Class 1 areas (< 5.6 m/s at 50 m) are generally not suitable for development; Class 2 areas (5.6 – 6.4 m/s at 50 m) are marginal for utility scale development; and Class 3 (6.4 – 7.0 m/s at 50 m) or greater are suitable for utility scale development (Elliot and Schwartz, 1993).

It is not possible to supply all of the county's energy needs with intermittent energy resources, such as wind and solar power, unless costly and complicated energy storage systems are employed. This is because the sun doesn't always shine and the wind doesn't always blow. When these resources are available, it is best to capture the energy and use it; however, there must be somebody at the other end of the line ready to use the power. With dispatchable resources, such as a natural gas or biomass fired generator, the same problem does not exist. When power is needed it is generated; when it's not the fuel is stored.

How much wind power (or other intermittent resource) can be used before the storage issue becomes a problem? According to the American Wind Energy Association, up to the point where wind generates about 10% of the total electricity on a system during a given hour of the day, energy storage is not an issue. There is enough flexibility built into the system (reserve backup, varying loads, etc.) that there is effectively little difference between such a system and a system with 0% wind. Variations introduced by wind are much smaller than routine variations in customer demand. When wind power reaches 10% to 20% of the total electricity on a system during a given hour, it is an issue that needs to be addressed, but that can probably be resolved with wind forecasting (which is fairly accurate in the time frame of interest to utility system operators), system software adjustments, and other changes. Once wind is generating more than about 20% of the total electricity on a system during a given hour, things become much more complicated and special features (e.g. energy storage) must be added to the system (American

²⁵ According to the American Wind energy Association (AWEA), wind farms can require as few as 2 acres per MW of peak capacity for hilly terrain and ridgelines to as much as 60 acres per MW of peak capacity for flat areas (American Wind Energy Association, 2004).

Wind Energy Association, 2004).

Local Wind Energy Resources

Numerous data sources were examined in order to ascertain the local wind energy resource potential. These included the California Wind Atlas (California Department of Water Resources, 1985), the Arcata Wind Study 1980-81 (Oscar Larson and Associates, 1981), and the Results of Wind Monitoring Effort for the Table Bluff Reservation (National Renewable Energy Laboratory, 2004). Figure 15 shows areas in Humboldt County that the California Wind Atlas rated as having “excellent” or “good” wind energy generation potential. All of the areas rated as “excellent” with mean annual wind speeds above 14 mph are near Cape Mendocino. Additional areas rated as “good” with mean annual wind speeds from 10 to 14 mph include more areas near Cape Mendocino, an area northeast of Loleta, Patrick’s Point and Big Lagoon, Schoolhouse Peak, and an area in the Trinity Alps. A wind resource map generated using a computer model (True Wind Solutions, LLC, 2002) also indicates an outstanding and superb (Class 6 and 7) wind resource area off-shore of Cape Mendocino and the southwest coast of Humboldt County.

The wind resource assessment for Northwestern California given in the California Wind Atlas focuses on Bear River Ridge and estimates a potential wind power generation capacity of 425 MW for the 60 miles of ridgeline with 14-16 mph average annual wind speed. However, although adequate wind speed is necessary for cost effective utility scale wind power development, it is not all that is needed to make a site viable for wind energy generation. Power lines are needed to connect the wind generators to the grid, and the further utility scale wind generators are from high voltage transmission lines, the more expensive the installation of a wind farm becomes. For example, wind farm development on Bear River Ridge would require construction of 10 to 14 miles of transmission line to connect with the 60 kV circuit through Garberville to the south at a cost of about \$120,000 per mile (in 1995 dollars) (Energy Information Administration, 2002). A more recent study from Lawrence Berkeley National Laboratory (Bertz et al., 1999) examined the potential profitability of wind sites in California using the California Wind Atlas data and GIS data resources. This study ranked the Bear River Ridge site as one of the top ten most profitable sites out of 36 total sites analyzed. Shell WindEnergy, part of Shell Renewables that is in turn one of the five core businesses of the Shell Group, is currently examining the wind potential on Bear River Ridge.

Based on the information sources reviewed, it is expected that there are at least 400 MW of utility scale wind power available in Humboldt County. A rough guideline is that the capacity value of adding a wind plant to a utility system is about the same as the wind plant's capacity factor multiplied by its capacity. So, assuming a capacity factor of 30% (fairly typical for a wind farm) and 400 MW of capacity, the total effective capacity would be about 120 MW and the annual wind electricity produced would be about 1000 GWh per year. This would be adequate to provide a large portion of Humboldt County’s electricity demand needs (currently about 160 MW) and to effectively provide all of Humboldt County’s electrical energy needs (currently about 1000 GWh per year). However, since there are periods during which the wind does not blow, there would need to be other generation sources available during those periods or some

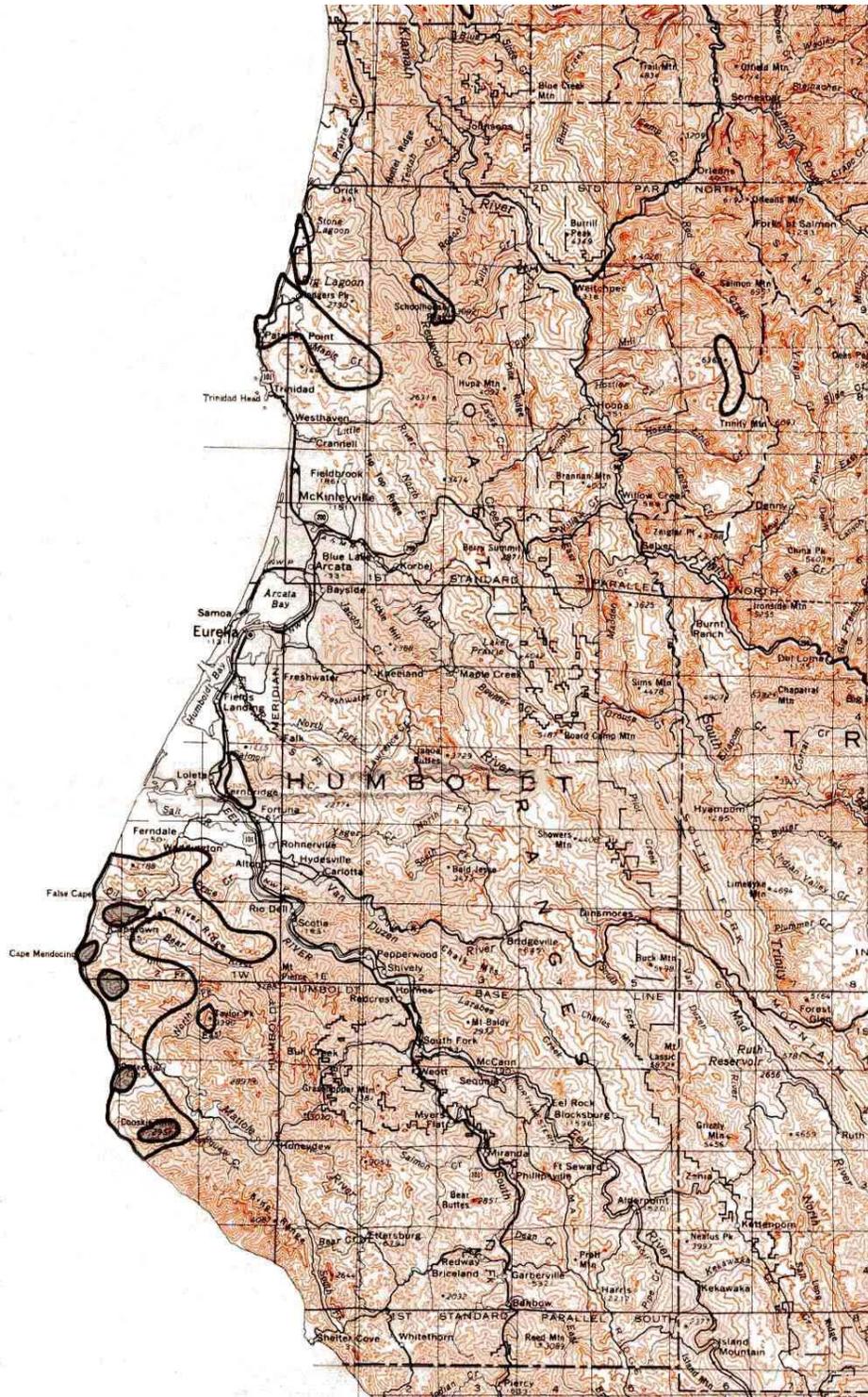


Figure 15. Humboldt County Wind Resource Map (California Department of Water Resources, 1985). Lined and shaded areas have “excellent” energy potential with mean annual wind speeds above 14 mph and lined and unshaded areas have “good” potential with wind speeds from 10 to 14 mph.

type of energy storage system. Also, the electrical transmission capacity into and out of the county would need to be adequate to provide power when there is a deficit and to accept power when there is excess local generation.

Residential Scale Wind Power

Small, residential scale wind power is already popular in Humboldt County. Of the 1400 kW of grid-intertied small wind power systems in California, Humboldt County accounts for about 48 kW (3%) (California Energy Commission, 2005a). Most of Humboldt's capacity is installed along the Eel River near Ferndale and Fortuna (California Energy Commission, 2005a). This total is certainly an underestimate, since no reliable data exist on the number or capacity of the likely many off-grid wind power systems.

Local jurisdictions had limited power to restrict the installation of either grid-intertied or off-grid wind power systems due to State Assembly Bill No. 1207, 2001. Local ordinances cannot set requirements on notice, tower height, setbacks, noise level, turbine approval, tower drawings, and engineering analysis or line drawings that are more restrictive than the State requirements. However, AB1207 is set to expire on July 1, 2005.

Cash rebates are available on small wind turbines (rated at 30 kW or less) from the California Energy Commission through the Emerging Renewables Program. The size of the rebate depends on the system size and installation method. Residential, institutional (such as schools), commercial, agricultural and industrial consumers are eligible. Affordable housing projects may qualify for higher rebates, up to 75% of the system cost. The current (May 2004) incentives are \$2100 per kW for the first 7.5 kW capacity and \$1100 per kW thereafter.

D. Wave Energy

Wave Energy Conversion (WEC) devices capture energy in ocean waves and convert it to electrical power. Because this technology is still in the early stages of development, its potential is still very uncertain. At present, no commercially available units exist and only one operating wave energy plant worldwide delivers power to the grid, a recently launched prototype in the United Kingdom²⁶. However, recent studies indicate that the technology shows promise to be both technically and economically feasible. In addition, there is a significant amount of potential wave energy available in coastal regions. For these reasons, research has been conducted throughout the world for more than 20 years, with activity in the U.S. being minimal. Recently, however, the Electric Power Research Institute (EPRI) and the California Energy Commission (CEC) have both completed wave energy studies in the U.S.

The purpose of the EPRI study (Bedard, et al. 2005) was to examine offshore wave energy feasibility in territorial waters off U.S. It identified and characterized potential sites, identified and assessed wave energy conversion (WEC) devices, assessed technical and economic viability, and identified and assessed environmental and regulatory issues associated with technology implementation. According to the EPRI report there "is a compelling case for investing in wave

²⁶ Ocean Power Delivery, LTD installed a pre-production prototype of their 750 kW Pelamis ocean energy machine in August of 2004 and it successfully sent electricity into the UK grid.

energy related research, development and demonstration including the feasibility demonstration of one or more offshore wave power plant projects.”

There are currently at least twelve worldwide wave energy device manufacturers with technologies in various states of development. However, EPRI felt that only one manufacturer currently has a technology that is ready for a feasibility demonstration (Ocean Power Delivery of the United Kingdom with its Pelamis device), and four others are close (TeamWorks of the Netherlands with its WaveSwing, Energetechs of Australia with its oscillating water column, WaveDragon of Denmark with its overtopping device, and Ocean Power Technology of the U.S. with a floating buoy). The EPRI study looked at five locations in the U.S., and found that Northern California is one area that looks promising. In fact, they predicted that offshore wave energy will first be introduced in Hawaii and Northern California where there is an excellent wave climate and relatively high cost of electricity.

Researchers expect that wave power will be cost competitive with wind power, and see numerous other advantages: 1) with proper siting it may be one of the most environmentally benign ways to generate electricity, 2) most of these devices will likely have a very low profile and will be located far enough from shore that they will generally not be visible (and therefore will likely face less public resistance than technologies which have a greater visual impact), and 3) wave energy is a more steady resource and more predictable than solar or wind, and therefore offers a better possibility of being dispatchable.

Based on the expected initial cost of wave energy, researchers feel it may be cost competitive with other renewable energy sources (like wind) in 5-10 years. The cost of electricity from early commercial plants is expected to be about \$0.10 per kWh (less than for wind power at a comparable production level), and it is expected to drop to about \$0.04 per kWh when installed capacity reaches 40,000 MW worldwide (40,000 MW is the current worldwide installed capacity of the wind energy industry).

Environmental impacts associated with WEC technology are expected to be manageable. Potential environmental effects include: extraction of wave energy and impact on the height of surfing waves, disturbance to seabed and benthos during installation, maintenance and decommissioning, underwater noise, spill of hydraulic fluids, visual appearance, conflicts with other uses of sea space. One environmental assessment has been conducted in the U.S. for the installation and operation of a demonstration wave energy device in Hawaii, and no significant impacts or cumulative effects were determined.

Permitting of a wave power plant presents a significant barrier to the development and commercial use of wave energy technology. This is because there is a wide variety of regulations and agencies (federal, state and local) involved, and jurisdictional responsibilities are not clear. Jurisdictions are complex and often overlapping, and several different types of permits may be required for a single project.

Northern California Wave Power Potential

As stated above, this technology is in the early stages of development, and its potential is therefore very uncertain. However, if the technology does turn out to be viable, it appears that

there is a substantial resource on the north coast of California. The recently completed CEC study (California Energy Commission, 2003c) looked at measured data for the wave energy resource for the entire coast of CA. The coastline north of Point Conception in Southern California looks promising. The CEC study examined the economic feasibility in Northern CA using Eureka as a reference case. It assumed a 41 MW plant (fifty-four 750-kW units) would be installed 4 km from shore at a water depth of 80 m. It also assumed 95% availability (18 days downtime per year) and 42% capacity factor. Under this scenario the plant would produce 148 GWh per year at a projected energy cost of 7¢ per kWh (assuming a 4% discount rate).

Overall, the CEC study assessed a large number of potential wave energy sites along the California coast. Primary sites, those expected to yield optimal economic return, were defined as those with a reasonable permitting process, excellent wave conditions, and deep water (>50m) within 10 miles of the coast. Primary sites for the Humboldt County coastline north of Cape Mendocino (a 72 mile stretch) were estimated to have a total potential capacity of 3910 MW. Primary sites for the southern Humboldt and northern Mendocino coastlines (an 81 mile stretch) were estimated to have a total potential capacity of 3709 MW, approximately half of which falls within Humboldt county's coastline. Assuming 20% of this area is exploitable and a 50% capacity factor (technologies currently deployed or under development have capacity factors in the range of 40-60%), the total estimated capacity and annual energy production for Humboldt County are 1153 MW and 5050 GWh per year, respectively. If only 20% of this potential were realized, it could meet Humboldt County's total electric energy consumption.

It is important to note that a company from Minnesota, Independent Natural Resources, Inc. (INRI), has applied for permits to test their SEADOG™ pump technology off the coast of Table Bluff just the south of Humboldt Bay. The SEADOG™ pump is a point absorbing wave energy converter. It consists of a buoyancy block that sits in the ocean. As the waves push the block up and down, the wave energy is used to pump water onshore to a storage tank atop a bluff. The water in the storage tank is then allowed to flow down hill and power a standard hydroelectric turbine to produce electricity. The testing that INRI is planning to do at Table Bluff will only test the durability of the buoyancy block to withstand actual ocean conditions; it will not pump water to shore or produce electricity. To date the SEADOG™ unit has only been tested in a wave simulation tank.

E. Biomass

Biomass energy generally refers to the combustion of biomass fuels for heat and power generation. Biomass includes all plant and plant derived material. Biomass feedstocks in the U.S. primarily consist of forest, mill and agricultural residues, urban wood wastes, and dedicated energy crops. These feedstocks can be burned outright or processed into various biomass fuels, such as ethanol, biodiesel or biogas. Currently, in the United States, biomass supplies about 3% of the energy used. This percentage is significantly higher in Humboldt County where biomass in the form of wood waste supplies a significant fraction of the energy for generating electricity.

This section considers only biomass feedstocks from forest and mill residues, as these are the sources most relevant to Humboldt County. Biomass fuel from forest and mill residues can be associated with wood waste from mill operations, as well as forest slash left over from timber

harvest operations and other forest residue fuel reduction programs aimed at minimizing forest fire hazards.

Humboldt County is blessed with a tremendous forest resource base, with 1.9 million acres (65% private) of forested land covering more than 80% of the county's land area (Humboldt County, 2005). The timber harvest volume in Humboldt County in 2000 was 388,886 million board feet. This accounted for 20% of the timber harvest volume in the state, ranking Humboldt County as the number one county in the State with almost twice the harvested volume of 2nd ranked Siskiyou County (Laaksonen-Craig, Goldman, and McKillop, 2003).

Burning forest product residues to produce electricity is not a new technology. Many isolated rural areas in northwestern California have used wood wastes to generate electricity. Since 1931, the Pacific Lumber Company in Scotia has produced steam and electricity and provided the town with electricity. In the early 1980's there were three mills (LP Samoa, PALCO, Simpson Paper Co.) generating electrical power from wood waste in Humboldt County. Their total capacity was approximately 75 MW. Much of the power was consumed on site, with the remainder supplied to the town of Scotia or sold to PG&E. At this time there were also numerous additional biomass plants under consideration, with a combined electrical output of about 67 MW (Smyser and Agnello, 1983). One of these plants, the Ultrapower facility in Blue Lake, was brought on-line in 1985.

Today there are two operating wood waste fired plants in Humboldt County, the PALCO plant in Scotia and the Fairhaven plant, with a combined electrical capacity of 48 MW. The Ultrapower plant (13.8 MW) suspended operation in 1999, but is still capable of being brought back on-line. The two operating plants provided approximately 30% of Humboldt County's total electricity needs (including their on-site loads), or about 13% of the rest of the county's needs (excluding their on-site loads) in 2003.

Electricity Generation from Mill Wood Waste

The use of wood waste from the forest products industry to generate electricity and process heat offers many advantages. The waste is already gathered in one place (often at the site where it is utilized) and would need to be disposed of in some fashion. Utilizing this waste stream to generate electrical power and process heat that would otherwise need to be purchased externally undoubtedly makes economic sense. It is estimated that there is currently enough wood waste resource from the local mills to provide fuel to both operating plants (PALCO and Fairhaven), as well as the Ultrapower plant should it be brought back on-line (Marino, 2005b). The growth rate on trees 10" and greater in diameter in the North Coast Resource Area currently exceeds the harvest rate by about a factor of two (Morgan, et al., 2004), and this might indicate that current harvest rates are sustainable. However, this does not necessarily hold true across ownership categories. For example, the net change in standing volume on industrial ownership land showed a large net loss (475 million cubic feet) in the period 1984 to 1994 (Rogers, 2004). In addition, net change in standing volume is only one measure of sustainability. It does not encompass the multifaceted values that forests provide, such as biodiversity and water quality. Ultimately what is required for a sustainable biomass industry is that sustainable forest harvest practices be employed to supply the biomass resource, and that the forest products industry remains economically viable.

Electricity Generation from Forest Residue Fuel Reduction

Another source of biomass wood waste is from forest residue fuel reduction. Although it is difficult to make this biomass source economically viable, the use of this resource does offer many diverse benefits. Fuel reduction programs are being strongly promoted by the U.S. Forest Service and are broadly accepted as good management. Forest residue that has built up over years due to aggressive fire management strategies poses severe fire risks to forest lands. When wildfires occur, the heavy accumulation of biomass makes those fires larger and more severe. This biomass accumulation thereby poses an increasing threat to public health and safety, watersheds, wildlife habitat and timber resources. Efforts to reduce this fire risk involve thinning and clearing of forest residue. However, the disposal method is typically an open burn that can pose severe air quality problems, as well as a fire risk. In addition, for air quality reasons there are frequent “no burn” days and fuel piles are therefore accumulating in the forest (Salazar, 2005).

Transporting these residues to a biomass plant for combustion significantly reduces air quality problems and provides useful energy in the form of electricity and process heat. This appears to be a win-win situation. Unfortunately, it is difficult to get the economics to work out due to excessive transportation and handling costs. The general guideline is that the transport distance should be no more than 50 miles. It seems that the best opportunity is to develop small scale, local biomass operations that utilize forest residue from the immediate area. Heat and power generated could serve schools, community facilities or other institutions. Due to the steepness of the terrain in Humboldt County, it is recommended that forest residue only be gathered near communities and in the proximity of existing roads, including along ridge tops if possible (Salazar, 2005).

The use of efficient, small to medium scale (15 kW to 1 MW) biomass energy technologies that can be connected to the electrical grid will be critical to a strategy employing small scale local biomass operations. A collaborative effort that provides the proper incentives will also be necessary. Furthermore, it is likely the biomass transportation and handling costs will need to be subsidized to some degree, and given all of the additional societal benefits (air quality, fire safety), this would seem justifiable. There is currently a multi-year U.S. Forest Service (USFS) study underway that aims to quantify the cost and benefits of biomass energy using a life cycle assessment approach. According to researcher Gregory Morris, the value of environmental benefits associated with biomass energy production in the United States is 11.4 ¢ per kWh over and above the retail value of the energy generated (Morris, 1999). Finally, there will likely need to be a reduction in regulatory costs to make the use of forest residue economically viable as a biomass fuel.

There are currently a lot of opportunities and work being done in this area. This includes the USFS study mentioned above and serious educational, research and promotional efforts being made by the Forest Products Laboratory of the USFS. Locally, a 2003 study was completed for the Yurok Tribe to examine the feasibility of a biomass utilization project on the Reservation (TSS Consultants, 2003). This study found that a small scale system (15-50 kW) was not currently viable, but that a larger scale system (100-200 kW) might be viable if sufficient power purchasers could be engaged. On the Hoopa Reservation a technology demonstration study was

conducted using a small scale (15 kW) biomass gasifier and generator . Numerous local workshops have also been conducted, including a Firewise Community Workshop in Fortuna (November 2003) and a Woody Biomass Utilization Forum in Redway (September 2003). Forest residue fuel reduction efforts also support the goals of the Humboldt Fire Safe Council and the Humboldt County Master Fire Protection Plan (Planwest Partners and RNB Spatial Data Inc., 2004).

A recent study conducted by researchers from the Pacific Northwest Research Station, USDA Forest Service (Fried, et al., 2002) used computer models and GIS to evaluate the feasibility of landscape scale fuel treatments for biomass based energy generation in the Klamath bioregion of southwestern Oregon. The study developed estimates of biomass availability, financial returns, and fuel treatment efficacy associated with various landscape treatments for reducing the fuel load. In general, treatments involved removing all trees 0 to 5 inches diameter at breast height (DBH) and thinning trees 5 to 21 inches DBH. Trees 7 to 21 inches DBH were valued as merchantable timber, and no trees greater than 21 inches DBH were removed. Of the 4.6 million acres in the Klamath bioregion, 3.8 million acres were considered (after subtracting out wilderness and roadless areas). Of the 3.8 million acres, 1.6 million acres met the criteria for treatment (minimal basal area of 80 square feet per acre). If revenues from merchantable timber and biomass fuel were reinvested, 2.7 million green tons could be generated while treating 636,000 acres at no net cost. This would be enough biomass to fuel a 20 MW plant for about 12 years. If the entire 1.6 million acres were treated, 9 million green tons of biomass would be generated at a net cost of \$1.7 billion dollars. One reason for the high cost of landscape treatments in this study is the existence of steep slopes; approximately half the inventoried plots had slopes greater than 40%.

The conclusions of the Klamath bioregion study found that the utilization of biomass as an energy source can help pay for forest fuel reduction, but only a small fraction of the landscape can likely be treated without considerable subsidies. For the Klamath bioregion only 17% of the land area that was technically feasible could be treated at no net cost. With a subsidy of \$100 per acre there was almost no increase in treated area, and with a subsidy of \$1000 per acre the treated area increased to about 33% of the total feasible land area. Given the high cost of treatment, prioritization of treatment areas will be crucial. A related study underway at the Missoula Fire Lab indicates that if the treated area is strategically chosen (in a herringbone pattern), it may possible to realize nearly all of the fire reduction benefits while treating only 20 to 30% of the landscape at a reduced total cost. The Klamath study also found that it is the utilization of merchantable-sized trees, not of biomass-sized material for energy production, which generated net revenue. Every ton of biomass-sized trees (< 7" DBH) on every acre had negative net revenue in the Klamath bioregion study.

System Scale, Type and Use

Biomass energy systems come in a range of sizes, from system capacities as small as a few kilowatts of electrical power all the way up to large, industrial and utility scale systems of 25 to 75 MW. Biomass systems can provide thermal energy for heating, electrical energy, or both. Systems that provide both thermal and electrical power needs are called cogeneration systems, and allow a much more efficient use of the biomass energy source than a system that provides electricity only. Large scale systems (utility or industrial plants) are typically used to generate

electricity for sale to the electric utility grid and for use on-site, and thermal energy may be used on site to meet process heating needs. Small scale systems (school campus, commercial or institutional buildings) will typically utilize biomass energy to meet space and water heating needs, and possibly to supply a portion of the electrical requirements.

Numerous technologies can be employed to convert biomass energy into heat and/or electrical power. The simplest approach is to combust the wood and then use the resulting heat to generate steam or hot water. The steam can be used for industrial processes or to produce electrical power. A more efficient and cleaner approach is to gasify the wood, and then use the gases to heat a boiler or run an internal combustion engine or gas microturbine to generate electricity. The most efficient plants are integrated gasification combined cycle plants. These plants gasify the fuel, run a gas turbine to produce electricity, and use the hot exhaust gases from the turbine to run a steam electrical generator (a bottoming-cycle) to produce additional electrical power. Small scale gasifier systems are also emerging as a promising technology to supply electricity and heat to rural areas. One advantage is that small modular systems lend themselves to such combined heat and power operations much better than large central facilities.

Environmental Issues

There are numerous potential environmental impacts associated with biomass energy plants, though generally they are seen as offering net environmental benefits. Any biomass energy operation should be supported by sustainable forest management practices. It is important to note that perverse incentives can be created if a biomass energy plant is established and then fuel supplies become short. If care is not taken, the need to acquire biomass fuel in this situation could lead toward non-sustainable forest management practices. Emissions from biomass plants (air, waste ash) are typically manageable; however, it is important to ensure that the biomass fuel stream is kept free of contaminants, such as painted or treated wood or other refuse that could create toxic emissions. Cooling water requirements must also be considered when assessing the environmental impacts associated with large biomass plants.²⁷

Biomass Crops

Growing crops specifically for use as biomass fuel poses substantially more challenges. The amount of land required could be sizable, thereby leading to conflicts with other uses for the land. For example, according to a recent report (National Research Council and National Academy of Engineering, 2004), the amount of land area needed to grow energy crops to produce hydrogen fuel for supplying U.S. transportation energy needs is approximately equal to the total amount of land currently being used for growing food. Over the long term, it is unlikely that a significant amount of land that can be used for growing food will instead be used for growing energy crops. Only marginal land is likely to be a candidate for growing energy crops.

²⁷ It is estimated that thermoelectric power plants in the US account for 39% of total fresh water withdrawals and 3% of total fresh water consumption (Torcellini, Long and Judkoff, Dec. 2003). The average thermoelectric power plant in the US consumes 0.47 gallons of water per kWh of electrical energy generated (Torcellini, Long and Judkoff, Dec. 2003). Like with any thermoelectric steam power plant, large biomass fired steam power plants will require substantial amounts of water for cooling. Older designs with open loop cooling systems do not consume a lot of water, but instead draw large amounts and then return heated water to the source. Because of problems with thermal pollution in aquatic ecosystems, newer designs employ closed loop cooling systems that use cooling towers and evaporate water to achieve adequate cooling. In this case there is less thermal pollution, but more fresh water is consumed.

Therefore, crops grown specifically for energy are likely to only meet a small percentage of current energy use.

As with any form of agriculture, soil degradation is also an issue. Soil degradation can be minimized if biomass crops are perennials rather than annuals so that the soil does not need to be tilled. Also, energy crops are likely to have much lower Energy Return on Energy Invested (EROEI)²⁸ than traditional fossil fuel sources and lower EROEI than from waste biomass. To achieve net energy production (EROEI > 1), the energy crop would need to have a very low level of fossil fuel based inputs.

F. Natural Gas

Natural gas is a hydrocarbon fuel that is found in reservoirs beneath the earth's surface. Natural gas is composed primarily (70-90%) of methane (CH₄). The Chinese began using natural gas as early as 500 BC. Today it is used for space and water heating, process heating, electricity generation, and as a transportation fuel. The use of natural gas is expected to rise substantially in the coming years because it is a relatively clean alternative to other fossil fuels like oil and coal. This is true in California and throughout the western United States where many new natural gas fired electrical generation plants are being brought on-line. In addition, the U.S. accounts for the largest portion of the world's natural gas consumption (currently about 45%), but holds only about 3% of the world's reserves. This explains why there is so much interest in importing liquefied natural gas (LNG) from other parts of the world. However, at best this would be a stopgap measure because world supplies of natural gas are only expected to last about another 50 years.

There are natural gas deposits in Humboldt County, mainly in the Eel River basin. There are currently 38 producing wells and 15 shut-in wells in the county. Shut-in wells cannot produce gas at their existing depths and are sealed off in order to maintain the pressure on remaining deposits. Total net gas production in the county in 2003 was 1,038,365 MCF. The active gas wells are concentrated in the Tompkins Hill gas field, where there are 31 producing wells. Net gas production from these wells in 2003 was 1,010,605 MCF. This was enough gas to supply approximately 11% of Humboldt County's total natural gas needs. The peak production for the Tompkins Hill field has passed. Current production rates are barely one half what they were in 1992 when net production was 1,927,787 MCF (California Department of Conservation, 2003).

There were 10 new exploratory wells drilled in the last couple of years in the Alton area, and there are currently two producing wells (Wheeler, 2005). The companies involved are Forexco and Inex. Forexco, Inc. of Greensboro, NC, secured a 20 year lease (through 2022) to explore for natural gas on the east and west side of the Eel River near Alton. Forexco has proposed to construct a natural gas collection and transportation system that would cross the Eel River and interconnect with the existing gas sales delivery point at PG&E's natural gas meter station in Alton. The design of the system will allow excess capacity for possible future development of natural gas reserves west of the Eel River (Kammerer, 2004). The size of the natural gas reservoir in the Alton area is unknown at this time, and data being collected is currently proprietary.

²⁸ A key indicator for assessing whether alternative energy sources are worthwhile is the Energy Returned on Energy Invested (EROEI). The EROEI measures how many units of energy output an energy source can produce for each unit of energy input.

All of the active gas wells in Humboldt County are dry gas wells and are not associated with oil deposits. The gas from dry wells is much simpler to process because it doesn't have to be separated from associated petroleum. For this reason there are also fewer environmental impacts associated with dry gas wells. The only oil associated gas wells in the county are two shut-in wells in Petrolia. These wells were the source of the first oil produced in California in 1861. The wells were drilled manually and the oil produced (only 350 barrels worth) was transported in goat skin sacks (Hofweber, 2005).

G. Small Hydroelectric

Hydroelectric power systems convert the energy in flowing water into electrical energy by spinning a turbine. Hydroelectric system sizes can vary from the Grand Coulee Dam (largest in the U.S.) at a total installed capacity of 6480 MW to small home power systems (micro-hydroelectric systems) that put out a few hundred watts. Federal law and the State of California define "small hydroelectric" as having a capacity of 30 MW or less. The State of California goes on to define these small hydroelectric facilities as a renewable energy source. Small hydroelectric systems typically use small dams or employ run-of-the river techniques where only a portion of the river flow is diverted so as to not block the passage of fish. In 2003, small hydroelectric power provided about 2% of California's total electricity needs.

There are currently six small hydroelectric facilities that serve Humboldt County (Table 7). These facilities have a combined rated capacity of 11.5 MW. All but one of these systems are run-of-the-river type. The Mathews Dam facility at Ruth Lake is not. Note that the Mathews Dam facility is actually located in Trinity County; however, it is operated by the Humboldt Bay Municipal Water District (HBMWD), a Humboldt County agency. Similarly, the Kekawaka Creek project is just over the county line in Trinity County; however, PG&E lists the Kekawaka unit as serving the Humboldt area. There are also many, probably greater than 100 (Smyser and Agnello, 1983), micro-hydroelectric systems in Humboldt County that serve off-grid homes. The total capacity of these systems is unknown, but it is likely rather small (i.e. less than a few hundred kW cumulative capacity).

In 1982, a local engineering firm made an assessment of the potential for small hydroelectric power in Humboldt County (Oscar Larson & Associates, 1982). At that time PURPA had just recently been enacted and there was tremendous activity occurring in the independent power producer's market. The Oscar Larson study cited that 27 permits had been filed with the Federal Energy Regulatory Commission (FERC) for new hydroelectric installations with an estimated 60 MW of cumulative generating capacity. The study went on to say that there were as many as 100 more sites that were being considered.

Interestingly, it appears that only three of the 27 installations were ever installed (Baker Creek, Mill/Sulphur Creek, Maple Creek). The Baker and Mill Creek operations are still running; the Maple Creek unit is shut down. Another unit that was being investigated at the time and is now operational is the unit at Matthews Dam/Ruth Lake. According to Mr. Ed Schillinger (2005), a local surveyor who has had a lot of experience with the local hydropower scene, all of the hydro systems that are currently installed began preliminary work in the early and middle 1980's. At

Table 7. Small Hydroelectric Facilities Serving Humboldt County

<i>Name/Location</i>	<i>Start-up Date</i>	<i>Rated Output (kW)</i>	<i>Estimated Annual Output (MWh)</i>	<i>Design</i>
T.Benninghoven/ Garberville	11/22/82	25	1.27	Run of River
Mathews Dam/ Ruth Lake HBMWD	4/10/83	2,000	5,927 (actual)	Reservoir
Essex Road Pumping Station HBMWD ²⁹		2,000	726 (actual)	Run of River
Baker Creek/ Bridgeville	12/10/87	1,500	7,000	Run of River
Mill & Sulphur Creeks/Dinsmore	2/23/88	995	5,040	Run of River
Kekawaka Creek/Zenia	12/27/89	4950	?	Run of River

that time PG&E was issuing 10 year contracts based on avoided costs with a purchase price of \$0.06 - \$0.07 per kWh. In addition, environmental and social issues were much less of a concern in general. The Sulphur and Mill Creeks unit is on government land, which further lowered the bar as the Feds were actively encouraging the development of alternative power at that time.

Since that time, the avoided cost rate for electrical power dropped to the \$0.02 - \$0.04 per kWh range through midyear 2000, so there was much less financial incentive as well as a much larger number of environmental and regulatory hurdles to clear. Studies on the impact of proposed projects to areas such as fisheries, forestry, local communities, historic and archeological sites, to name a few, must all be funded by the prospective investors with no guarantee of a return. As a case in point, recent studies associated with the development of a hydropower project in Willow Creek (Big Rock Partners) cost the developer about \$75,000, only to find out that regulators wanted another round of studies totaling \$200,000 before the project could proceed (Shannon, 2005).

The 1982 Oscar Larson study developed recommendations for the County’s General Plan update, including specific policy language, code amendments, and development of a County permitting process for small hydroelectric projects. In general, the report recommended that the County address and encourage the development of small hydroelectric projects. However, these efforts apparently were not sufficient to overcome the barriers to the widespread development of small hydropower in Humboldt County.

Mr. Schillinger cited studies for a hydroelectric installation in Willow Creek as an example. In this case, the minimum required bypass flow (flow not going through the power plant) to satisfy fisheries requirements was in excess of the total flow of the river during the summer months. With regard to the Oscar Larson report, he thought that the estimate of 60 MW of potential for hydropower in the county is unreasonable, as many of the sites are geologically unstable and therefore unbuildable. Furthermore, most, if not all the sites are of an intermittent or seasonal nature, further reducing any economic payback (Schillinger, 2005).

²⁹ The Essex Lane unit only runs from May through October during which time they sell to PG&E during peak demand times.

According to Mr. Schillinger, the only way that there will ever be further small hydroelectric development in Humboldt County is if PG&E substantially increases the rate that it pays, and if environmental and social barriers are dramatically reduced (Schillinger, 2005). Since midyear 2000 PG&E's avoided cost rates climbed to between \$0.04 - \$0.06 per kWh, and as of early 2005 they were at about \$0.07 per kWh. There is certainly opportunity for further development of micro-hydroelectric resources, but these resources will not likely make a tremendous contribution to Humboldt County's overall electricity needs. If half of the potential identified in the Oscar Larson report were developed, this would provide a total small hydro capacity of about 35 MW, with the ability to provide an estimated 150 GWh per year of electrical energy.

H. Solar Electric

Solar electric, or photovoltaic (PV), systems convert sunlight directly into electricity. Solar electric system technology is well proven and in widespread use throughout the world, both in grid-connected and in remote, off-grid applications. The solar electric industry is one of the fastest growing energy industries. Over the last few years worldwide PV production has grown at a rate of over 30% per year. The majority of this growth has occurred in Japan, Europe and the U.S., though growth rates in the U.S. have started to falter.

Although PV power can be generated at centralized solar power plants, the majority of growth in the PV market is for smaller distributed systems. Most of the distributed systems installed in the developed countries are grid-connected systems. Grid-connected systems are comprised of PV modules, often roof mounted, and an inverter that converts DC electricity to AC electricity. No batteries are required. Instead, these systems effectively use the electrical grid for energy storage. When excess power is produced, it is fed out to the larger electrical grid and consumed by a neighboring customer. When the PV power production is less than what is required onsite, like at night, electrical power is drawn from the grid to meet the onsite loads.

California is one of the leading states in the U.S. in PV installations. Since 1998, the California Energy Commission has offered installers of small (< 30kW) PV systems a substantial rebate that has covered as much as half of the installed system cost³⁰. In addition, electric utilities in California must offer their customers net metering. With net metering, a customer is able to spin the meter backwards and earn credit when the PV system is producing excess power. The customer's bill is settled on an annual basis, so excess solar power generated in the summer can be banked as a credit and then used up in the wintertime. In some cases, customers may choose time-of-use (TOU) rates that assign a greater value to electrical power that is produced during peak periods (summer time, noon to 6 PM). This can increase the value of the PV generated electricity by a factor of 3 to 4. Over the last few years California has also offered tax credits to people who install PV systems³¹. For businesses, the tax credits are even more lucrative, with very favorable federal and state depreciation benefits, the CA tax credit, and a 10% federal tax credit.

³⁰ As of June 2005, rebates are \$2.80/watt. They are set to decrease by \$0.20/watt every six months on July 1 and January 1.

³¹ The CA tax credit is equal to 7.5% of the installed system cost after deducting any rebates. The CA tax credit expires January 1, 2006.

Although the incentives being offered for solar electric systems may change, they are not likely to disappear – there is simply too much interest and support for solar energy. In California there is currently legislation (SB1) that has passed the State Senate and will soon come before the State Assembly. This piece of legislation also has the Governor’s support. SB1 would provide ten years of incentives for rooftop solar electric systems with the goal of installing 1 million systems (or 3,000 MW) on new and existing residential and commercial customer sites by the end of 2018. In addition, the federal energy bill that was recently passed by the Senate (but still needs the House of Representatives’ and the President’s approval) will offer a new residential and an expanded commercial federal tax credit of 30% for solar energy systems. Finally, the California Energy Commission has initiated a pilot program that offers performance-based incentives for solar electric systems. The current performance-based incentive level is set at \$0.50 per kWh of generated solar electricity for a three year period. This performance-based approach is similar to an approach that has been very successfully implemented in Germany.

With the above mentioned incentives and with continuing decreases in the costs of PV equipment, the economics for rooftop solar electric systems is better than it has ever been. Typical system payback periods in coastal Humboldt County can range from 10 to 20 years or more, and are shorter in areas that receive more sun. Obviously this is not a get rich quick scheme, but with all of the other “green” benefits associated with solar power, customers in California have demonstrated great interest. Since the start of the CA rebate program more than 11,000 PV systems have been installed, with a total installed capacity of about 46 MW (equivalent to a medium sized power plant) (California Energy Commission, 2005a).

The interest in PV in Humboldt County has been even greater than for the state as a whole. Since 1998 there have been about 150 grid-connected solar electric systems installed in Humboldt County with a total installed capacity of 380 kW (California Energy Commission, 2005a). On a per capita basis Humboldt County has installed grid-connected PV systems 3.5 times faster than the state as a whole, and this is for an area that receives less sun than the majority of the state³² and has less economic wealth than much of the state. What does this say about solar in Humboldt County? It shows that solar works here, and that people are interested in installing it. Humboldt County also features a strong solar installer/supplier network, one that has been built up over the last 25 years or more.

Humboldt County also has a tremendous number of off-grid solar electric systems, many of them in the southern part of the county. In the mid-1980’s one of the largest distributors of off-grid PV systems was Alternative Energy Engineering in Redway, and most of the systems they sold were installed right here in Humboldt County. It is estimated that well over 1000 off-grid PV systems are installed in the county, representing perhaps 1 MW or more of capacity (Katz, 2005). Although it is not anticipated that there will be tremendous growth in this local off-grid market, off-grid PV certainly represents an important electricity supply option for the remote areas of the county.

In terms of the grid-connected market, continued vigorous growth is expected. Although the ongoing status of the current State rebate program is somewhat uncertain, the Governor has

³² For example, Arcata receives approximately two-thirds the amount of solar energy that Sacramento receives.

announced ambitious plans to promote PV in the state over the next 10 years with a new incentive plan modeled after Japan's. The goal of the program is to install almost 3000 MW of new solar electric power. However, these efforts may focus on the more heavily populated areas in the warmer parts of California where summer cooling loads drive electricity use. Nonetheless, strong activity here on the North Coast will likely continue.

One effort to ensure that the solar energy market remains strong here in Humboldt County is participation in the U.S. Department of Energy's Million Solar Roofs (MSR) program. The Redwood Coast Energy Authority (RCEA) is sponsoring this local effort and is developing a strategic plan to ensure the installation of 1000 new solar energy systems (either solar electric or solar hot water) in Humboldt County by 2010. To provide guidance in this effort, RCEA assembled a strategic plan advisory committee comprised of local stakeholders. The objectives of this program are to:

- Improve outreach efforts to residents, businesses, financial institutions and schools;
- Create solar training opportunities for those in the building trades;
- Develop and facilitate solar financing options for local residents and businesses;
- Develop a regional public facilities solar installation plan;
- Generate recommendations for government and land use codes to ease installation barriers for solar energy systems.

Based on the current rate of solar installations in the county, the future planned promotional efforts on a local and statewide level, the phenomenal PV growth rates experienced in Japan, the physical limitations of the electric grid, and the existing limits on net metering, estimates for the total potential generating capacity for local rooftop solar electric systems have been developed. Current state regulation requires that investor owned electric utilities, like PG&E, must allow net metering on their system until the total installed net metered capacity reaches 0.5% of the peak electric demand for their entire service territory. Given the current installed capacity and the current rate of PV installations, it is likely that this limit will be reached in the not-too-distant future³³. Proposals have been put forth to increase this percentage to something like 5%. It remains to be seen how this will play out. Typically the utilities are not in favor of expanding net metering. From a strictly technical standpoint it is estimated that approximately 10% of the local peak demand could be supplied by an intermittent resource like solar electricity without causing problems on the electric grid. Amounts above 10% would likely require special control schemes and amounts greater than 20% would require a means to store electrical energy at times of excess generation for use in times of need (American Wind Energy Association, 2004).

A realistic limit on PV installation capacity in the near term therefore is likely about 5% of total peak demand. For Humboldt County this amounts to about 8 MW currently, or as much as 17 MW in 2025. At 10% of total capacity there would be 35 MW installed in 2025. Assuming an average installed system size of 2.75 kW³⁴, this would require PV installations on about 20% of all households in Humboldt County by 2025. This level could be reached if the number of installed grid-connected PV systems doubled every two years for the next 10 to 15 years.³⁵ An

³³ There is currently about 28 MW of net metered (PV and small-scale wind) capacity installed on PG&E's system, which is equivalent to about 0.13% of the peak electric demand on their system.

³⁴ Average installed system capacity in Humboldt County to date is 2.75 kW per installation.

³⁵ The growth rate of installed PV systems in Japan has averaged a doubling every two years for about the last eight years.

installed capacity of 35 MW in 2025 would produce approximately 38 GWh per year and would supply approximately 9% of the residential electricity demand in the county. Note that this is a very optimistic scenario that would require a tremendous amount of effort and may not be realistic. One of the biggest hurdles with installing large amounts of distributed generation, like rooftop solar, is that it takes a lot of sustained, distributed effort over a long period of time in order to realize a goal. With central station electricity generation there must also be intense effort, but it is all focused on one specific project, and therefore is typically easier.

I. Solar Hot Water

Solar hot water systems collect the sun's radiant energy and transfer it to a hot water tank. There are numerous types of systems available, but all have a collector that captures the solar energy and a tank that stores it. A heat transfer fluid is usually circulated between the collector and the tank in order to transfer the solar heat. The solar water heater is normally used as a preheater. After water passes through the solar storage tank it is sent on to a backup water heater. The backup heater is often a standard electric or gas tank water heater, or sometimes an electric or gas on-demand water heater³⁶. If the solar energy has sufficiently raised the water temperature, then the backup heater will not even turn on. If needed, the backup heater will supply additional heat. Often in the summer season people will bypass their backup water heater and turn it off completely. Typical solar hot water systems in Humboldt County can be expected to provide about 50 to 70% of your total hot water needs.

Solar hot water systems have been in use for thousands of years. Beginning in the 1860's, in California and Florida, solar hot water systems became very popular. Then along came natural gas and people decided solar wasn't really worth the effort. In the late 1970's and early 1980's, following the first "energy crisis" in California, interest in solar hot water re-emerged. At that time there were lucrative tax incentives and many companies sprang up overnight to take advantage of them. Unfortunately, not all of them were reputable. In addition, when people felt the energy crisis was over, their interest waned and the tax credits abruptly disappeared. At that point the solar hot water industry collapsed. However, many reputable companies are still around today and offer reliable, quality products and experienced service.

In the early 1980's, many solar hot water systems were installed in Humboldt County. The City of Arcata even developed a solar utility that provided financing for individuals who wanted to install a solar hot water system, and the residents paid off the loan through a fee on their monthly water bill. Once the loan was paid off they could buy the system from the City for a dollar. Many of the systems that were installed back in the 1980's are still in place, some working and some defunct. In addition, there is renewed local interest in solar hot water. Two recent City of Arcata housing projects, one in the Windsong development and one at the Courtyards at Giuntoli Lane, have featured the installation of solar hot water systems. It is estimated that there are currently hundreds of solar hot water systems in Humboldt County. Some of these systems are in remote, off-grid locations just like the PV systems mentioned above.

Although there are not currently any incentive programs being offered for the installation of solar hot water systems in California, these systems can still pay for themselves. However, the

³⁶ The on-demand water heater is more efficient because there are no standby losses.

payback period is greatly affected by the type of existing water heater that you are using. If you are displacing electric resistance heat, the payback is much shorter than if you are displacing natural gas fired heat. This is because electricity is typically about four times more expensive than natural gas on a per unit energy basis. Typical payback periods for residential solar hot water systems in Humboldt County, without incentives, are about 10 years when displacing electric resistance water heating, and 30 years or more when displacing natural gas water heating (Schatz Energy Research Center, 2001). Payback periods for systems displacing propane fuel fall somewhere in between these extremes. A survey administered by the CEC found that 62% of PG&E's customers on the north coast of California use natural gas as a primary water heating fuel, 21% use propane, and 16% use electricity (KEMA-XENERGY, Itron, RoperASW, 2004).

With new promotional efforts and/or incentives, it would be possible to further revive the local solar hot water market. The Million Solar Roofs program mentioned above is aiming to promote rooftop solar hot water systems in addition to PV systems. As an upper limit, with aggressive promotion, it is assumed that the market penetration for solar hot water systems could be similar to that for solar electric systems. If solar hot water systems were installed on 25% of all households in Humboldt County by 2025, it is estimated that about 360,000 gallons per year of propane fuel, 1.0 million therms per year of natural gas, and 3 GWh per year of electricity could be saved³⁷. This amounts to approximately 9% of total estimated propane use, 4% of total residential natural gas use, and 1% of total residential electricity use.

J. Cogeneration and Distributed Generation

Distributed generation (DG) systems are electric generation units located within the electric distribution system at or near the end use customer. DG systems can be placed on the customer's side of the meter and can thereby reduce the customer's demand for electricity. With net metering a customer may be able to sell power back to the utility. Larger distributed generation systems can serve multiple customers, such as in an industrial park, a subdivision, or a commercial zone. DG can be beneficial to both electricity consumers and the electric utility. DG systems can provide voltage support in localized areas and in some cases can reduce or eliminate the cost of transmission and distribution system upgrades. For the consumer there is a potential for lower cost, more reliable service, higher power quality, and increased energy efficiency and energy independence. In addition, the ability to use renewable generation such as wind, photovoltaic, biomass or hydroelectric power can provide a significant environmental benefit. Efforts to deregulate the electricity market and to allow customers access to the transmission system are creating a marketplace where DG can thrive.

According to the CEC, commercially available DG devices include internal combustion reciprocating engines, combustion turbines, micro-turbines, low temperature fuel cells, photovoltaic systems, wind generators, small energy storage systems, and waste heat recovery devices. Technologies still under development but poised to enter the market include advanced natural gas internal combustion reciprocating engines, high temperature fuel cells, external combustion reciprocating engines (e.g. Stirling engines), fuel cell hybrid systems, large energy storage systems, and thermally driven HVAC, process, and bottoming cycle generators.

³⁷ Assumes that solar hot water systems are installed on 25% of all homes and that they meet 50% of the water heating energy demands in these homes.

One advantage of many DG systems is their ability to provide combined heat and power (CHP), also commonly known as cogeneration. CHP is common practice in large industry; however, there remains a large untapped potential in small industrial and commercial applications. CHP systems use energy resources more efficiently by using fuels to produce electricity for on-site needs and also using the waste heat for heating needs. This added efficiency can lower a customer's total energy costs while also offering the many other advantages of DG systems. Facilities that may be good candidates for cogeneration systems will have large electrical demands as well as demands for hot water and/or space or process heating. These include but are not limited to: hotels, hospitals, schools, mills, and other industrial plants, large office buildings, city, county, and state buildings, jails/prisons, business parks, and shopping centers. Barriers to the implementation of DG include difficulties in retrofitting older buildings, high capital cost, and lack of financing.

The 1983 Project Independence report (Smyser and Agnello, 1983) identified about 2.3 MW of cogeneration capacity that they claimed was economically viable at the time (≤ 6 year payback). These facilities included the County Courthouse, Humboldt State University, and St. Joseph's Hospital. Only HSU proceeded to install cogeneration systems. Both of their units are natural gas fired reciprocating internal combustion engines. One unit was installed in 1991 and is rated at 350 kW. The heat from this unit serves the Jolly Giant housing complex (space heat and hot water). The second unit was just installed this year. It is rated at 730 kW electric and has a combined heat and power efficiency of 73%.

A common characteristic of DG technologies is that they are small scale and locally sited. Planning and approval for these systems will therefore mainly fall within the jurisdiction of the County and local cities. Combustion type units will also need approval from the local air district. In December 2000, the CEC released a report titled "Distributed Generation: CEQA Review and Permit Streamlining (California Energy Commission, 2000). This report describes the permitting processes conducted by city and county governments and air districts for small-scale electric generating facilities.

K. Biogas from Cummings Road Landfill

"Landfilling" is the main method for disposal of municipal solid wastes (MSW) in the United States. Landfill gas (LFG) is generated by the natural degradation of MSW by anaerobic microorganisms (in the absence of oxygen). Gas composition is typically about 40-50% methane, 40-50% carbon dioxide, and a remainder of nitrogen, oxygen, and other trace gases. If the landfill gas is not managed properly it can pose odor, fire hazard and greenhouse gas problems. Therefore, landfill sites are typically capped and gases are collected using a series of wells drilled into the landfill and connected by a plastic piping system. This gas is often flared (burned in open air), but it can also be used as an energy resource.

The gas entering the gas collection system is saturated with water. In order to utilize the gas the water must be removed. After dewatering, the LFG can be used directly in reciprocating engines. It can also be further processed into a higher-energy gas (suitable for use in boilers for manufacturing processes, as well as for electricity generation via gas turbines.) The most important part of the scrubbing process is the removal of sulfur dioxide from the gas since it results in corrosion within the combustion equipment. Further processing to produce pipeline

quality methane requires the removal of carbon dioxide as well as all remaining trace components. The resulting pipeline-quality gas is of high enough quality to be blended with existing natural gas systems. However, the passage of legislation in California in 1988, making a seller of LFG to a gas utility liable for impacts of toxics in the gas, is a serious impediment to this alternative (California Energy Commission, 2005b).

The processed gas is also suitable for electricity generation applications such as gas turbines and fuel cells. In one demonstration project, Southern California Edison and Los Angeles Department of Water and Power operated a 40 kilowatt phosphoric acid fuel cell using processed landfill gas at a hotel/convention center complex in the City of Industry. Currently, California has 42 landfill gas to electricity plants totaling over 200 MW of capacity (California Energy Commission, 2005c)

In Humboldt County, MSW is now being shipped out of the county for disposal. However, the county does have a landfill site on Cummings Road currently undergoing closure operations. The Cummings Road Landfill, located two miles southeast of the City of Eureka, began accepting municipal waste in 1978. The Cummings Road Landfill stopped accepting waste in 2001 and is scheduled for formal closure in 2005. Gas collection at the landfill is mandated by law. Currently, all gas collected is flared onsite. The LFG produced at the Cummings Road Landfill could be converted to electric power, heat energy, or both. Alternatively, it could be sold into the natural gas grid.

Utilization of LFG at Cummings Road Landfill Site

In 2004, SCS Energy developed a report entitled “Power and Heat Generation Feasibility Study for Cummings Road Landfill” (SCS Energy, 2004) for the Humboldt Waste Management Authority (HWMA). SCS Energy specializes in landfill gas, digester gas, flare gas, and natural gas fired microturbine, fuel cell and reciprocating engine plants. The information presented in this summary is based on the SCS Energy report, which was provided by Gerald Kindsfather of the HWMA.

The current LFG recovery system at the Cummings Road Landfill consists of:

- 21 vertical LFG extraction wells
- Five vertical LFG / leachate extraction wells
- An 800 standard cubic feet per minute (scfm) landfill gas flare

The HWMA plans on installing an additional eighteen vertical extraction wells upon the formal closure of the facility in 2005. This is predicted to enhance LFG collection and usage potential. Actual recovery rates of LFG for 2002, 2003, and 2004 were well below SCS Energy model predictions. This discrepancy is explained by the current well configuration’s partial coverage of the landfill area.

SCS Energy has determined that, if a given installation is to operate at 100% capacity for a ten year design horizon, the preferred design capacity for an energy project at the Cummings Road Landfill is 6.07 MMBtu per hour (200 scfm x 60 min/hr x 50% methane x 1012 Btu/ft³ methane). The expected methane production from this project would amount to about 53 MCF per year.

The SCS Energy report evaluated five alternatives for utilizing the LFG at the Cummings Road Landfill (Table 8). Table 8 indicates that the feasibility of utilizing the LFG resource at the Cummings Road Landfill is highly dependent on the use of heat recovery, and therefore on the availability of nearby energy consumers. Note that one additional factor in this assessment is current PG&E regulations regarding small independent power producers. Currently only one option exists for such producers: PG&E is obligated to buy power from Qualifying Facilities at the short run avoided cost rates. The Cummings Road Landfill would be considered a Qualifying Facility under PURPA. The avoided cost rates over the last few years have averaged about \$0.04 to 0.06 per kWh. These values are considered by SCS Energy to be relatively high given historic avoided cost rates over the last 10 to 15 years. Nonetheless, the SCS Energy report is optimistic about future changes in the PG&E regulations, citing the political climate in California as being “very supportive of renewable energy and small power.”

Table 8. Summary of Alternatives Analyzed in the SCS Energy Report

<i>Alternative</i>	<i>Engine type</i>	<i>Engine size</i>	<i>Heat recovery?</i>	<i>Location</i>	<i>Feasibility</i>
1	Microturbine	30 kW	No	Flare Station	Marginally
2	Microturbine	90 kW	No	Flare Station	Not feasible
3	Reciprocating	500 kW	Yes	Offsite	Feasible
4	Microturbine	500 kW	Yes	Offsite	Feasible
5	None	N/A	Yes	Offsite	Feasible

Export of Cummings Road LFG to PG&E Gas Grid

LFG must be treated to remove impurities (scrubbed) and have an odorant added, and then it can be injected into the natural gas grid. Under this scenario, the landfill would become an independent gas producer and make its scrubbed LFG available on the gas commodities market. Gas brokerage firms exist to help end users locate independent gas suppliers. The LFG qualifies as a renewable energy source, and some businesses will pay a premium for a fuel source that is classified as renewable. An end user who contracts with the landfill for gas supply would pay the landfill directly for the commodity and pay PG&E for transmission and distribution charges.

A team of Humboldt State University engineering students conducted an economic analysis of this scenario in the Fall of 2004 (Carter et al., 2005) using the SCS Energy study for predicted LFG recovery rates for years 2010 through 2019 and projected natural gas prices. Prometheus Energy Company was contacted and provided economic and technical data on a unit capable of cleaning the LFG to pipeline specifications. Ivan Marruffo, Senior Major Accounts Manager for PG&E confirmed the presence of a three inch diameter natural gas pipeline at the site (Marruffo, 2004). The study found that by selling scrubbed LFG as an independent gas supplier at \$0.36 per therm (80% of what is believed to be the long term cost of natural gas in California), the landfill could realize a simple payback of approximately 6 years and a gross profit of approximately \$95,000 over a 10 year design life.

Unfortunately, PG&E is not currently accepting scrubbed LFG into its natural gas distribution grid, though Ivan Marruffo indicated that the utility recognizes that suitable scrubbing

technology exists and is researching the logistics of accepting cleaned LFG into the natural gas distribution grid.

L. Biogas from Wastewater Treatment Facilities

Wastewater treatment plants (WWTP) often utilize an anaerobic digestion process to treat municipal sewage sludge. During this process, biogas composed of approximately 60% methane is produced. This anaerobic digester gas (ADG) is commonly used at the treatment plant to supply heat for the digester units and/or electricity for plant operations. The use of ADG in this way is a mature technology. Currently, California has 10 wastewater treatment biogas plants that produce electricity (totaling about 36 MW of capacity) and 12 wastewater treatment biogas plants that produce useful heat (California Energy Commission, 2005d).

Biogas plants that generate electricity typically have used standard internal combustion engine (ICE) generators. Today, however, emerging electrical generation technologies are beginning to find a place in the biogas industry. High temperature fuel cells and micro turbines are examples of emerging technologies that are currently being used on a demonstration basis to generate electricity and heat using ADG. The City of Portland has run both micro turbines and fuel cells on their ADG. Fuel Cell Energy of Danbury Connecticut currently has four 250 kW molten carbonate fuel cells installed and running on ADG at WWTPs in California. Both Ingersoll Rand Energy Systems and Capstone MicroTurbine Corporation produce micro turbines capable of converting ADG to electricity and heat. Capstone MicroTurbine has been filling orders in the WWTP market since 2000, and Ingersoll Rand Energy Systems since 2002. Whenever biogas from wastewater is used to produce electricity a lot of gas cleanup is required, and this can add substantial equipment and maintenance costs to the system.

Energy from ADG in Humboldt County

The Eureka WWTP was designed to utilize the ADG produced on site and has been operating reliably since its construction in 1984. Their system utilizes twin internal combustion engines (ICEs) designed to run directly on ADG to produce roughly 95 kW of electric power for “in house” use. The heat generated from running these ICEs is used to maintain the temperature of the twin digester units at 98° Fahrenheit. Approximately 1.1 MCF of ADG are produced per month at the Eureka WWTP. This ADG flow rate is converted to approximately 95 kW of continuous electric power and an unspecified amount of heat (Bailey, 2005). The Eureka WWTP utilizes its ADG to offset a portion of its energy consumption from the electric and natural gas grids.

Operating characteristics for the Eureka plant were used to estimate potential ADG production for other WWTPs in Humboldt County. Inflow data were collected for all WWTPs in Humboldt County, with the exception of Weott. Each facility showed large seasonal variation in flows due to infiltration from leaky sewage lines. Figure 16 shows the variation in Eureka’s wastewater flows over about a two year period.

Since ADG production is a function of the solids content of the waste stream, averages of inflows from May 1 to October 31 were used to estimate ADG production potential at each plant (Table 9). A value of 0.0079 cubic feet ADG per gallon of inflow was calculated from the Eureka WWTP data and used to estimate the ADG production potential for the other

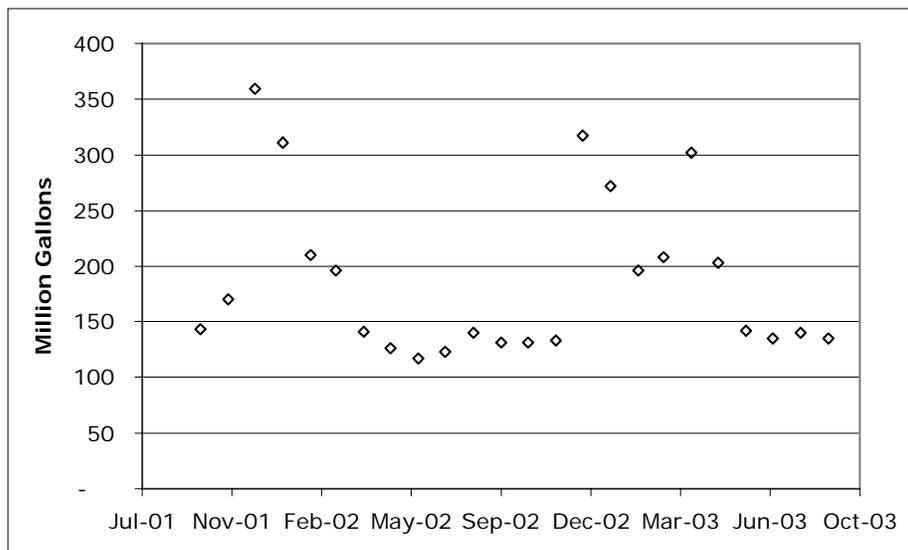


Figure 16. Eureka WWTP Inflows by Month for July 2001 through October 2003

municipalities shown in Table 9. The ratio between the volumetric flow rate of ADG produced and the electric power generated at the Eureka WWTP was used to estimate the potential for electricity generation at the other WWTPs. The cumulative additional electrical capacity for all the new ADG facilities would be 79 kW, with over 86% of this coming from the three larger

Table 9. Average summer monthly inflow, estimated ADG production, and estimated electric power production for WWTPs in Humboldt County

<i>Plant</i>	<i>Average inflow³⁸ (gallons/mo.)</i>	<i>Estimated gas production potential (scf/mo.)³⁹</i>	<i>Estimated electric power potential (kW)</i>
Arcata	44,705,000	354,205	30.6
Blue Lake	2,690,833	21,320	1.8
Eureka ⁴⁰	138,833,333	1,100,000	95.0
Ferndale	6,349,228	50,306	4.3
Fortuna	27,641,667	219,010	18.9
Manila	1,562,681	12,381	1.1
McKinleyville	27,175,000	215,312	18.6
Rio Dell	5,983,333	47,407	4.1

³⁸ These flows are averaged over May 1 to October 31 so as not to include groundwater infiltration through leaky sewage pipes during the winter months (Engel, 2005b).

³⁹ These gas production estimates are a rough, first cut. Each WWTP should be individually assessed to verify its true gas production potential. There may be significant deviations from these estimates due to individual plant characteristics. For example, the Manila WWTP treats septic tank effluent that has had the solids removed by individual interceptor tanks located at or near the residences from which the wastewater originates.

⁴⁰ Data for Eureka WWTP was provided by Darrell Bailey, City of Eureka (Bailey, 2005).

facilities (Arcata, Fortuna, McKinleyville). Assuming a 70% capacity factor, these three plants could generate 418 MWh of electricity annually.

Installation of the necessary equipment (an anaerobic digester if not already present, gas clean-up equipment, and an electrical generator) would likely only be practical for the three larger WWTPs. This is because ADG energy recovery systems such as these are typically only cost-effective for larger facilities. In addition, most smaller facilities use aerobic digesters that do not produce energy rich methane gas.

Aside from the Eureka WWTP, Arcata is the only other WWTP in Humboldt County currently using ADG as an energy source. The Arcata WWTP uses a percentage of its ADG to provide heat for the anaerobic processes occurring in their digester. The remaining ADG is flared.

M. Biogas from Dairies

Anaerobic digestion (AD) is a biological process in which bacteria break down organic matter in an airless environment, with biogas as the end product. Biogas derived from dairy manure is comprised of approximately 60% methane (CH₄), 40% carbon dioxide (CO₂), and trace amounts of other gases, including hydrogen sulfide (H₂S). The biogas can be cleaned up and used to run a generator to produce electricity. Additionally, The AD process converts the chief nutrients in manure, nitrogen, phosphorus, and potassium into a soluble form that is more readily available to plants. It also reduces dairy odors and ground water contamination. The use of AD systems for manure management offers many benefits and can be cost effective for suitable dairies. Suitable local dairies would have the following characteristics (Reis and Engel, 2003):

1. Manure from at least 400 cows can be collected regularly.
2. Cows are housed in freestall barns during the wet season, and spend adequate time around the barn and feeding area during other months to allow at least 40% manure collection.
3. A qualified operator is available to tend to the system (< 30 minutes per day).
4. The dairy land is owned or is secured under a long-term lease.

There are a variety of AD systems used on U.S. farms. A recent study of local dairy biogas potential (Reis and Engel, 2003) concluded that the most appropriate system for Humboldt County is a plug flow technology. However, each dairy has to be independently assessed for its technical and economic suitability for AD technology. Plug flow digesters are designed to handle undiluted dairy manure with 11% to 14% solids content. The standard design consists of a covered rectangular concrete tank that holds approximately 20 days worth of manure. Each time fresh manure is added to the plug flow digester, which is normally done daily, an equal volume of digested manure is forced out at the other end. Biogas is captured in the space between the digesting material and the cover. A daily plug of manure requires about 20 days to pass through the digester.

A digester on a suitable Humboldt County dairy could produce between 4 million and 6.4 million cubic feet of biogas and 124 to 198 MWh of electricity annually, leading to potential annual avoided electrical costs of \$11,100 to \$23,800. Valuable thermal energy for water or space heating could be recovered from the engine-generator set displacing between 3,400 and 5,500 therms of natural gas per year, leading to a potential annual savings of \$2,800 to \$4,500 on

heating costs. The digester would also produce enough fiber each year (used as a soil amendment) for an additional annual income of \$4,800 to \$8,000. Manure pit maintenance costs could be reduced by \$9,000 per year. In summary, anaerobic digester products and avoided operation and maintenance (O&M) on current manure storage systems have a capacity to generate up to \$45,000 for a suitable Humboldt County dairy (Reis and Engel, 2003).

One of the main issues discouraging dairy operators from utilizing AD technology in their manure management plan is the high capital investment necessary for installing the system. A plug flow system for a suitable Humboldt dairy would cost between \$500 and \$1,000 per cow, leading to an installed cost of \$200,000 to \$400,000 for the complete system. Expected operations and maintenance costs of an AD project may be another deterrent. Based on costs reported for existing systems, O&M costs for a typical Humboldt County digester designed to handle the manure from 400 dairy cows are estimated to be \$10,000 to \$20,000 annually (Reis and Engel, 2003).

There are currently Federal and State programs designed to help dairy operators fund and install AD systems on their farms. The Dairy Power Production Program (a CEC program) offers up to 50% of project capital cost or up to \$2,000 per kW capacity. The remaining portion of the project cost could be partially offset with PG&E's Self-Generation Incentive Program (SGIP) that would pay a rate of \$1,500 per kW or up to 40% of the projects' capital cost. The available financial assistance can significantly decrease the simple payback period of an AD system. These results, combined with the project's intangible benefits, could make AD technology a viable option for a local dairy's manure management system. The USDA's Rural Development Program also offers funding for purchase of renewable energy systems, including biogas generators, by agricultural producers. With such external assistance the payback period for installing an AD can be as low as 2 to 3 years (Reis and Engel, 2003).

Unfortunately, the local study concluded that the smaller pasture-based dairies of Humboldt County currently appear to be ill-suited for the implementation of this technology because of the high initial capital cost of these systems and the fact that local pasture-based operations would not allow for adequate manure collection. Therefore, it is not likely that this technology will gain widespread use in the county. Nonetheless, under the right circumstances, a suitable Humboldt County dairy could effectively use a plug flow digester as part of their manure management plan (Reis and Engel, 2003).

N. Biodiesel

Biodiesel is a liquid fuel made from processed biologically produced oils. The oils may either come from animal or vegetable sources. For vegetable sources, the oil may be either new (virgin) or used (recycled). To make biodiesel, the oil is processed using alcohol (methanol or ethanol) and lye (sodium hydroxide or potassium hydroxide). This process is called transesterification and is required in order to use the biodiesel fuel directly in diesel vehicles designed to run on petroleum based diesel fuel. The processing required to make biodiesel is rather simple, and numerous books are available on the subject. Homemade batches of biodiesel are often made in people's garages. However, the chemicals used are dangerous and strong safety precautions must be followed.

There are numerous potential benefits associated with biodiesel as a transportation fuel. It can be produced domestically, it offers reduced air emissions, and it has a low aquatic toxicity and biodegrades rapidly. However, the energy benefits of biodiesel depend largely on its source. Recycled vegetable oil sources offer clear energy benefits, but supplies are limited. Based on an analysis of the nationwide availability of waste vegetable and animal oil for biodiesel production (Engel, 2005), less than 1% of current petroleum diesel production could be replaced by recycled biodiesel.

The energy benefits of biodiesel produced from virgin oils are less clear. Biodiesel produced from virgin oil is likely marginal, at best, in terms of its EROEI. There have been a number of studies of the energetics of producing ethanol (with economics similar to biodiesel), from virgin farm products. One study by David Pimentel showed a net energy loss (EROEI = 0.3) in producing ethanol from virgin farm products (Cornell, 2001). In contrast, studies by the U.S. Department of Agriculture estimated a net energy gain when producing ethanol or biodiesel from virgin agricultural products (EROEI = 3.2 for biodiesel, 1.3 for ethanol) (Environmental and Energy Study Institute, 2003). While the USDA results show a net energy gain, they are still much lower than the historical values for EROEI for petroleum production.⁴¹

In Humboldt County both virgin and recycled biodiesel are available. Renner Petroleum markets virgin biodiesel. Footprint Recycling of Arcata, a small, local company, manufactures and markets recycled biodiesel. Footprint Recycling collects waste oil from approximately 80 sites throughout the county (Cooper, 2005), including restaurants, hospitals, schools, hotels, and casinos. They are currently producing about 40,000 gallons of biodiesel per year. The product is sold to local businesses and residents. The current price for biodiesel from Footprint Recycling is \$3.25 per gallon. Given their current capacity for collecting, storing and processing biodiesel fuel, Mr. Cooper expects that they could double their production to 80,000 gal per year, or possibly more. One gallon of biodiesel fuel will essentially replace one gallon of petroleum derived diesel fuel.

O. Waste-to-Energy Plants

Municipal solid waste (MSW) can be converted to energy via three major pathways: mass burn, refuse-derived fuel, or gasification. In a mass burn the waste is directly combusted with minimal processing. For refuse-derived fuel the MSW undergoes moderate to extensive processing before being directly combusted as refuse-derived fuel. MSW can also be gasified using pyrolysis or thermal gasification techniques, though these technologies are still in the development stage. Each of these technologies presents the opportunity for both electricity production as well as an alternative to landfilling or composting the MSW. In contrast with many other energy technologies that require fuel to be purchased, MSW facilities are paid by the fuel suppliers to take the fuel (known as a "tipping fee"). The tipping fee is comparable to the fee charged to dispose of garbage at a landfill.

Although at first glance this may seem like a win-win situation, there are numerous downsides associated with waste-to-energy plants. Experience in other areas of the country has shown that the existence of incinerators becomes a disincentive for waste reduction and recycling. A waste-

⁴¹ Historical EROEI values for petroleum production were as high as 50 to 100. However, EROEI values for petroleum are decreasing as oil becomes scarcer and harder to recover. Current EROEI values for petroleum range from about 3 to 10.

to-energy plant has large fixed costs relative to its operating costs. Burning more waste produces more revenue and improves the economics of the plant. In a number of municipalities this has led plant operators to discourage recycling to increase the amount of waste being transported to a plant. In 1990, AB939 became law in California and set a goal of reducing solid waste going to landfills by 50%. This bill did not accept incineration as a way to reduce the amount of solid waste going to landfills. AB939 created a new state agency, the Integrated Waste Management Board, for overseeing solid waste and implementing the intent of AB939.

There are also some serious environmental concerns regarding the toxic pollution issues associated with heavy metals and other constituents of the MSW stream. Also, because the constituents of waste being burned in a plant are highly variable, it is difficult for plant operators to optimize plant operation. This has energy efficiency and pollution control ramifications, and can also lead to hazardous operating conditions. Illegal disposal of highly flammable materials has resulted in explosions, equipment damage and danger to operators in a number of plants.

Locally, Winzler and Kelly conducted a study in 1978 that explored the economic feasibility of building a facility to burn a combination of municipal solid waste (refuse-derived fuel) and wood waste (hog fuel) (Winzler & Kelly and CH2M Hill, 1978). The study concluded that such a plant was economically marginal and that customers for the energy produced were limited. Since the study was done in 1978 there has been increased emphasis on source reduction and recycling over incineration.

The overall conclusion is that waste-to-energy plants operating on single, consistent waste streams (such as wood waste) can be successful. Plants operating on the highly variable and generally unpredictable streams of municipal solid waste have generally not been successful and are not recommended. A waste-to-energy plant does not appear to be a viable option for Humboldt County for the foreseeable future.

P. Hydrogen and Fuel Cells

There has been a lot of interest in hydrogen and fuel cells over the last few years. However, hydrogen and fuel cells are not the answer to our energy problems. Hydrogen is not an energy source; it is an energy carrier (like electricity). It takes energy to make hydrogen. Although hydrogen is the most abundant element in the universe, hydrogen gas does not naturally occur in significant quantities on earth. Instead, hydrogen is bound up in compounds such as water and hydrocarbon fuels. To be usable as a fuel, hydrogen must first be separated from these compounds. Separation methods include the electrolysis of water and the reformation of hydrocarbon fuels.

The long-term role that hydrogen could play in our energy future is to provide a means to store intermittent renewable energy sources such as wind and solar energy. In this way it could be a key to long-term energy sustainability. In the nearer term hydrogen, generated from natural gas, may become one of the many fuels that is used for transportation and distributed generation applications. Although there may be some benefits to this diversification, the use of hydrogen in this way does not really solve long-term energy sustainability problems.

Today the majority of hydrogen is produced by reformation of natural gas, which is the cheapest way to produce hydrogen. When hydrogen is produced from natural gas, or from any hydrocarbon fuel for that matter, the energy returned on energy invested (EROEI) is less than one, meaning that there is a net loss of energy. If the hydrogen is then used in a fuel cell to power an electric vehicle, some improvement in efficiency will be gained compared to a natural gas powered internal combustion engine vehicle. When all is said and done and the vehicles travel the same distance, the total amount of natural gas used in each case is likely to be about the same. So why produce hydrogen from natural gas and run a fuel cell? One reason is the opportunity to reduce greenhouse gas emissions. When hydrogen fuel is produced from natural gas, the carbon dioxide is produced at a central location. This affords the opportunity to capture and then potentially sequester the carbon dioxide. However, the prospect of sequestering large quantities of carbon dioxide is highly uncertain at this time. Another reason to produce hydrogen from natural gas for use as a transportation fuel is to help develop the technology and infrastructure that will one day be needed to convert to a renewable hydrogen economy.

High temperature fuel cells (phosphoric acid, molten carbonate or solid oxide types) running on fuels such as natural gas or biogas do offer some real near term benefits. These technologies can offer advances in efficiency and are just one of many technologies suitable for distributed generation applications. High temperature fuel cells are mainly still in the development stages, though many successful demonstration projects have been conducted and commercial viability in niche applications may not be that far off.

Q. Alternative Fuel Vehicles

Alternative fuel vehicles (AFVs) are not an energy source, but rather a form of fuel switching. However, some AFVs can be run on locally available energy sources, such as natural gas, biodiesel, and renewable electricity.

Compressed Natural Gas Vehicles

Until recently, natural gas seemed like a positive alternative to petroleum diesel. The natural gas resource base seemed abundant. Natural gas produces less CO₂ per unit of energy than any other fossil fuel. Natural gas is the cleanest burning of all fossil fuels. Natural gas was the lowest priced vehicle fuel. Until recently, the Humboldt County Transit Authority was considering switching to buses powered by natural gas. However, the price advantage that natural gas enjoyed has greatly diminished, and there are potentially serious supply problems. It now appears that North American natural gas production has peaked and is going into permanent, long-term decline. At the same time, the use of natural gas continues to increase in the U.S. Consequently, natural gas imports continue to rise. However, world supplies of natural gas are only expected to last about another 50 years. As mentioned earlier, there are some natural gas deposits in Humboldt County, but the county supplies only a small fraction (about 10%) of its own total needs. In summary, the use of natural gas as a transportation fuel does not appear likely to make energy in Humboldt County more secure or sustainable over the long term.

Propane Vehicles

Propane is widely available in Humboldt County. The bulk of it is used for stationary applications like space heating and water heating. Only a limited amount is used for vehicles. Propane has lower volumetric energy density than gasoline, but significantly higher volumetric

energy density than compressed natural gas. As with natural gas, emissions are very low. The price per unit of energy for propane is typically comparable to that for gasoline. Propane traditionally occurred as a component of natural gas. In this case the supply of propane was dependent on the production of natural gas. More recently propane has been produced as part of petroleum refining. This production method significantly increases the supply of propane. However, there are long-term supply problems with both natural gas and petroleum, so the use of propane as a transportation fuel does not appear likely to make energy in Humboldt County more secure or sustainable over the long term.

Hydrogen Vehicles

Vehicles capable of running on hydrogen fuel include internal combustion engine vehicles and fuel cell powered vehicles. Although both of these vehicle types exist today, they are still in the developmental stage and as such are prohibitively expensive. In addition, hydrogen fuel is expensive to produce. As long as liquid and gaseous hydrocarbon fuels continue to be widely available, it is unlikely that hydrogen will be a cost effective transportation fuel. In the future, as hydrocarbon fuels become scarcer and more expensive and hydrogen and fuel cells become cheaper due to high-volume production, hydrogen could become a cost competitive transportation fuel. In this situation, if the hydrogen is produced from local, renewable energy sources, hydrogen could make a significant contribution to energy security and sustainability for the county.

Electric Vehicles

Until the second decade of the twentieth century most automobiles were powered by electricity. Electric cars were clean, quiet, and reliable and didn't have to be cranked to start. After World War I gasoline-powered internal combustion engine cars supplanted electric cars. These cars had the advantage of quick refueling, effectively unlimited range, and greater power. Electric starters and increased reliability largely eliminated the advantages of electric cars. In the mid 1970's and late 1990's electric cars briefly reappeared, but quickly disappeared due to poor performance and lack of commitment by automobile manufacturers. Battery performance is the most significant limiting factor for electric vehicles. Nickel metal hydride batteries, used in more recent vehicles, significantly improve their range and performance.

Electric vehicles can be practical as "around town" cars. Locally, there is a small contingent of electric vehicle enthusiasts⁴² who drive full size electric vehicles for short trips around the area. A number of these enthusiasts even use grid-connected solar electric systems to recharge their vehicle batteries, and thereby drive indirectly solar powered cars. Also, small electric vehicles are widely used as golf carts and as small, limited-range lift trucks and utility vehicles. These types of vehicles serve niche applications. Local examples include the small electric vehicles driven by City of Arcata parking enforcement staff and some of the Humboldt State University campus services staff.

If the electricity for electric powered vehicles is produced from local, renewable energy sources, electric vehicles could make a significant contribution to energy security and sustainability in Humboldt County.

⁴² Humboldt Electric Vehicle Association (HEVA)

Hybrid Electric Vehicles

Hybrid electric vehicles combine batteries and an electric motor with a gasoline internal combustion engine. When effectively implemented, this combination provides much higher fuel efficiency than gasoline-only non-hybrids. Two manufacturers, Toyota and Honda, are now mass producing hybrid vehicles, Toyota and Honda. Ford is doing limited production. Other manufacturers have announced hybrids and are likely to have them in production in the relatively near future. All existing commercially available hybrids are fueled by gasoline and generate electricity internally.

A type of hybrid that is currently in experimental development is the plug-in hybrid. This type of hybrid typically gets most of its energy from the electric grid, but could also get its electricity from a residential solar electric system. This type of hybrid has a much larger battery pack than existing hybrids and is capable of running exclusively on batteries for distances of up to 30 miles. A diligent consumer who plugs in their hybrid every night could do the majority of their driving on batteries and use very little gasoline. No manufacturer has yet announced plans for manufacturing a plug-in hybrid, though there have been some efforts to retrofit the Toyota Prius to operate as a plug-in hybrid vehicle. Plug-in hybrids would combine the nearly unlimited range of gasoline-powered hybrids with the ability to use energy from local renewable sources.

Standard hybrids can improve energy security and sustainability in the county by reducing fuel consumption. Plug-in hybrids could do significantly better if they were primarily powered by locally produced renewable energy. Plug-in hybrids would likely have a higher first cost, but this could be partially offset by using their electricity storage and generation capability to support the grid, provide storage for renewably-generated electricity, and to function as back-up generators when the grid is down.

Vehicle-to-Grid (V2G)

Electric vehicles, including battery-powered vehicles, hybrids, plug-in hybrids, and fuel cell vehicles, could potentially provide large amounts of generation and storage capacity for the electric grid. They could be used to provide various support services to the grid including storage for electricity from renewable sources. The transfer of electricity from electric vehicles to the grid is termed “Vehicle-to-Grid (V2G).” A 2001 study by UC Davis Institute for Transportation Studies analyzed the possibilities for V2G services. They found that electric-drive vehicles could become an important resource for the California electric utility system, with consequent air quality, system reliability, and economic benefits. The economic value of some forms of V2G appear high, more than enough to offset the initially higher costs of electric-drive vehicles (Kempton et al., 2001).

R. Heat Pumps

Often there is a choice between the fuel or energy source that will be used to meet end use heating needs. For example, natural gas can be burned in an on-site furnace to heat air or water. Alternatively, natural gas fuel can be burned at a centralized electrical power plant to produce electricity, and the electricity can be used on-site to power an electric space or water heater. Heat pumps are electrical devices that can be used to meet many end use heating needs. Their

advantages include their high efficiency and their ability to use renewable electricity sources (e.g. solar and wind electricity). Disadvantages include high capital costs and long payback times.

A heat pump is a device that moves heat energy from one place to another, from a lower to a higher temperature. It does this by using electricity to power a compressor motor that drives a vapor-compression refrigeration cycle. In heating applications the device is called a heat pump, and heat is removed from ambient air, water, soil, or rock and delivered to where it is needed. In cooling applications the device is called a refrigerator or air conditioner, and heat is removed from the space that is to be cooled and is discharged to ambient air, water, soil, or rock.

One of the advantages of heat pumps is their high efficiency. For every unit of electricity used, several units of heat are delivered. The number of units of heat that a heat pump delivers for each unit of electricity used is called the Coefficient of Performance (COP). The COP depends on operating conditions and typically varies between 2 and 5.

A comparison of the use of heat pumps to provide space heating versus a high efficiency natural gas furnace can illustrate the efficiency benefits of heat pumps. A typical ground source heat pump⁴³ currently being manufactured has a COP of 3.75. When combined with the efficiency of the existing PG&E power plant⁴⁴ the overall heating system efficiency is approximately 125% ($30\% \times 3.75 = 125\%$), or approximately 33% more efficient than the best natural gas furnace with an efficiency of 93%. With a new, higher efficiency electric power plant⁴⁵ the overall efficiency would improve to 187% ($50\% \times 3.75 = 187\%$), approximately 100% more efficient than the best natural gas furnace.

If a high-efficiency, combined-cycle gas turbine power plant were installed in Humboldt County and high-efficiency heat pumps were widely implemented in place of gas furnaces, then net natural gas consumption in the county could be significantly reduced. This potential reduction in natural gas consumption is much greater than could be achieved by improvements in the end-use efficiency of natural gas combustion heaters.

In addition, using heat pumps in place of natural gas combustion heaters could help make electricity a universal energy carrier for stationary applications. This would allow primary energy sources to change without changing end use equipment. This could hasten a transition to the use of local renewable energy resources, such as wood waste, wind and solar. Once heat pumps are installed, water and space heating could be made fully renewable by switching to renewable sources of electricity. However, it is also important to note that an all-electric energy infrastructure for end use heating might be less secure than the existing system, considering that many homes using natural gas are able to continue cooking and heating during Humboldt County's common and sometimes extended winter power outages.

⁴³ There are two common types of heat pumps: air source heat pumps and ground source heat pumps. An air source heat pump takes heat from the surrounding air, whereas a ground source heat pump takes heat from the ground. Ground source heat pumps are typically capable of attaining higher efficiencies and are much more expensive to install.

⁴⁴ The PG&E Humboldt Bay power plant has an efficiency of 25 to 30%.

⁴⁵ PG&E is discussing installation of high-efficiency combined-cycle gas turbine power plant to replace the existing plant. Such a plant typically has an efficiency of about 50%.

CHAPTER 7 - INVENTORY OF ENERGY CONSERVATION AND EFFICIENCY OPPORTUNITIES

One way to meet a portion of energy needs is by using energy more efficiently. What is really desired is not electricity, natural gas and gasoline, but instead things like well lit, comfortable buildings and mobility. It is often possible to provide light, comfort and other end use services while using less energy. This can be accomplished by using technologies that are more energy efficient.

Energy Efficiency Potential for Electricity and Natural Gas

The potential for energy efficiency savings is substantial, and California has long been a leader in achieving energy efficiency savings. It is estimated that California's cumulative energy efficiency efforts from 1976 to 2000 (including energy efficiency programs, building standards and appliance standards) saved approximately 34,000 GWh per year, or approximately 13% of total state electricity use (Rufo and Coito, 2002). It is therefore no surprise that California is one of the most energy efficient states in the nation. In 2000, CA had the second lowest electricity consumption per capita in the U.S., with a per capita consumption rate nearly half the national average. Humboldt County's per capita electricity consumption rate (7.4 MWh per year) is nearly identical to the state rate.

Although a lot of progress has been made in CA toward achieving energy efficiency savings, there is still room for improvement. Estimates of energy efficiency potential vary depending on the many assumptions that go into such an estimate. For example, one can estimate the technical potential, the economic potential, or the achievable potential. The technical potential is an estimate of the maximum savings that could be gained if the most energy efficient equipment were installed in every application, regardless of cost effectiveness. The economic potential examines the savings that could be realized if only the cost effective efficiency measures were installed. And the achievable potential tries to account for the fact that just because a measure is cost effective doesn't mean that everyone is going to install it. The achievable potential is therefore a more conservative, and likely also a more realistic estimate. Achievable potential estimates can vary based on the expected future cost of energy and the amount of resources spent on promoting energy efficiency programs.

The American Council for an Energy Efficient Economy (ACEEE) has examined the results of numerous energy efficiency studies (Nadel, Shipley, and Elliot, 2004) and found that estimates for achievable savings over periods of 5 to 20 years ranged from about 10% to 30% for electricity and 8% to 10% for natural gas (see Table 10). For comparison the study found that actual electricity savings achieved in leading states (CA, CT, MA, RI, VT) in the years 2001 and 2002 ranged from about 0.5% to 2% per year, indicating that the projected savings estimates are indeed achievable.

Table 10. Nationwide Energy Efficiency Estimates (percent savings)

	<i>Electricity</i>	<i>Natural Gas</i>
Technical Potential (%)	18% - 36%	40% - 47%
Economic Potential (%)	13% - 27%	13% - 35%
Achievable Potential (%)	10% - 33%	8% - 10%

Some recent studies have examined the energy efficiency potential in California. ACEEE estimated near term electricity and natural gas savings for each state in the nation (Elliot, Shipley, Nadel, and Brown, 2003). They estimated that energy efficiency measures in California implemented over a 5 year period could reduce electricity consumption by 4.2% and natural gas consumption by 5.1%.

Another set of very detailed, statewide energy efficiency studies were conducted by Xenergy, Inc. for Pacific Gas and Electric Company, The Energy Foundation and The Hewlett Foundation (Rufo and Coito, 2002; Coito and Rufo, 2003a; Coito and Rufo, 2003b). These studies looked at both electricity and natural gas savings potential in California over the next 10 years⁴⁶. The Xenergy studies were somewhat more conservative than some of the studies mentioned above because they looked only at technologies that are readily available for widespread use today, and they focused on equipment that could easily be replaced in the next 10 years as opposed to measures requiring major renovations or remodels. The Xenergy studies proceeded to develop estimates of technical potential, economic potential, and achievable potential under various scenarios. The various scenarios for achievable potential included cases with differing amounts of investment in energy efficiency programs and cases with different future energy prices. As you would expect, the cases with higher program spending and higher energy prices resulted in greater savings.

The Xenergy studies estimated the maximum achievable energy efficiency savings to be equivalent to 10% of California's total electricity consumption and 5% of total natural gas consumption (excluding natural gas used to generate electricity). These estimates were obtained using a base case for energy costs that start at today's rates and experience a modest rise over the next 10 years. In order to reach these maximum achievable savings, it was estimated that energy efficiency program spending would need to increase by 300% to 600%. The maximum achievable savings estimates captured 45% to 75% of the total estimated economic potential.

The Xenergy statewide estimates of maximum achievable savings were used to estimate the energy efficiency potential for Humboldt County for the year 2013. The year 2013 was chosen because it is 10 years beyond the base year of 2003, which is the most recent year for which actual electricity and natural gas consumption data were readily available. The statewide estimates were scaled down to the county level across three sectors: residential, commercial and industrial. These county level estimates were then adjusted to eliminate measures that were not appropriate for Humboldt County's climate and customer base. These adjustments included eliminating air conditioning and swimming pool related measures. The Xenergy studies did not develop estimates for natural gas savings in the industrial sector, so the ACEEE estimates mentioned above (Elliot, Shipley, Nadel, and Brown, 2003) were used in this case.

The total estimated potential electricity savings in Humboldt County in 2013 is 84.8 GWh per year. This represents 8% of the county's projected total electricity use, and at current retail electricity rates represents a total value of approximately \$11.9 million per year. The net dollar savings is expected to be substantial as well. Figure 17 shows how these electricity savings are split across the residential, commercial and industrial/agricultural sectors, with 44% attributed to

⁴⁶ These studies have been used by the California Public Utilities Commission to adopt energy efficiency goals for the state over the next ten years.

the industrial/agricultural sector and the remainder split almost evenly between the residential and commercial sectors. The proportion of the electricity savings attributable to various end uses is shown in Figure 18. This shows that half of the potential savings are in the lighting end use, followed by process end uses (18%) and motors (15%).

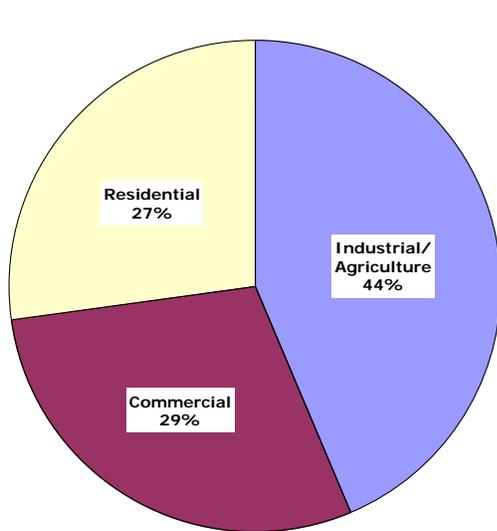


Figure 17.
Humboldt County Electric Efficiency Savings Potential by Sector
 (85 GWh/yr in 10 years)

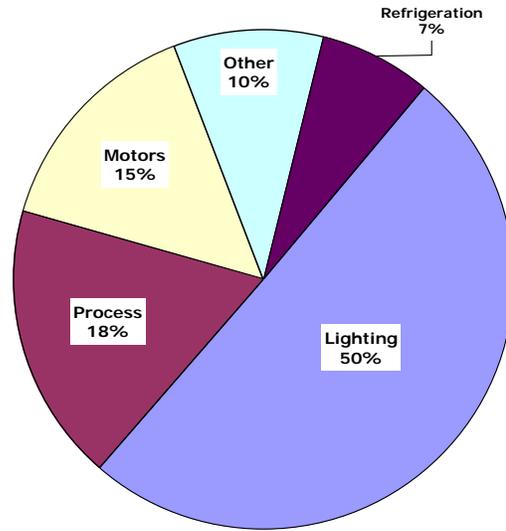


Figure 18.
Humboldt County Electric Efficiency Savings Potential by End Use
 (85 GWh/yr in 10 years)

The total estimated potential natural gas savings in Humboldt County is 2.6 MTh per year. This represents 5.4% of the county’s projected total natural gas use, and at current retail natural gas rates represents a total value of approximately \$1.8 million per year. Figure 19 shows that these natural gas savings are split nearly evenly across the residential, commercial and industrial/agricultural sectors. The proportion of the natural gas savings attributable to various end uses is shown in Figure 20. This indicates that 45% of the savings potential is in the industrial sector, and another 50% can be attributed to the water heating and space heating end uses.

The opportunities for energy efficiency improvements in Humboldt County’s existing housing stock are potentially substantial. The CA energy code (Title 24) was first established in 1978, and continues to be updated and improved every four years. According to the 2000 census, there are over 55,000 housing units in Humboldt County, and 69% of these are single family detached homes. The median year of construction for a housing unit in Humboldt County is 1966. Over 70% of Humboldt County housing units were built before 1980, and 86% before 1990 (U.S. Census Bureau, 2000). Figure 21 shows the distribution of housing by year of construction. These many older homes will clearly offer substantial energy saving opportunities. One prime opportunity for realizing these savings is at the time of sale. Over the last few years approximately 1500 homes per year have been sold in the county. At a rate of 1000 homes per year it would take approximately 50 years to turn over the entire housing stock of Humboldt County.

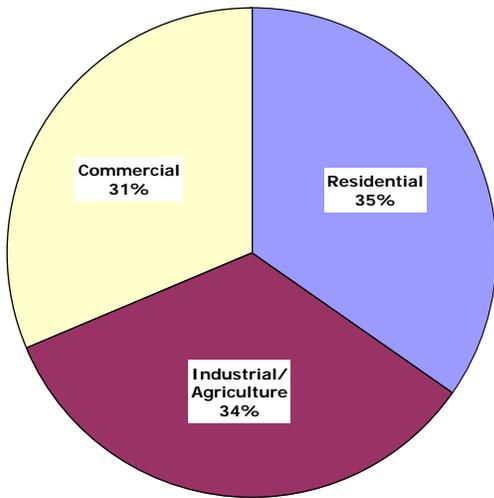


Figure 19.
Humboldt County Natural Gas Efficiency Savings Potential by Sector
 (2.6 million therms/yr in 10 years)

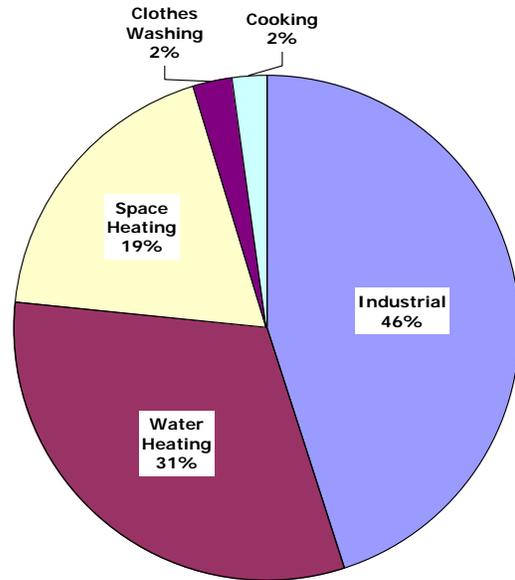


Figure 20.
Humboldt County Natural Gas Efficiency Savings Potential by End Use
 (2.6 million therms/yr in 10 years)

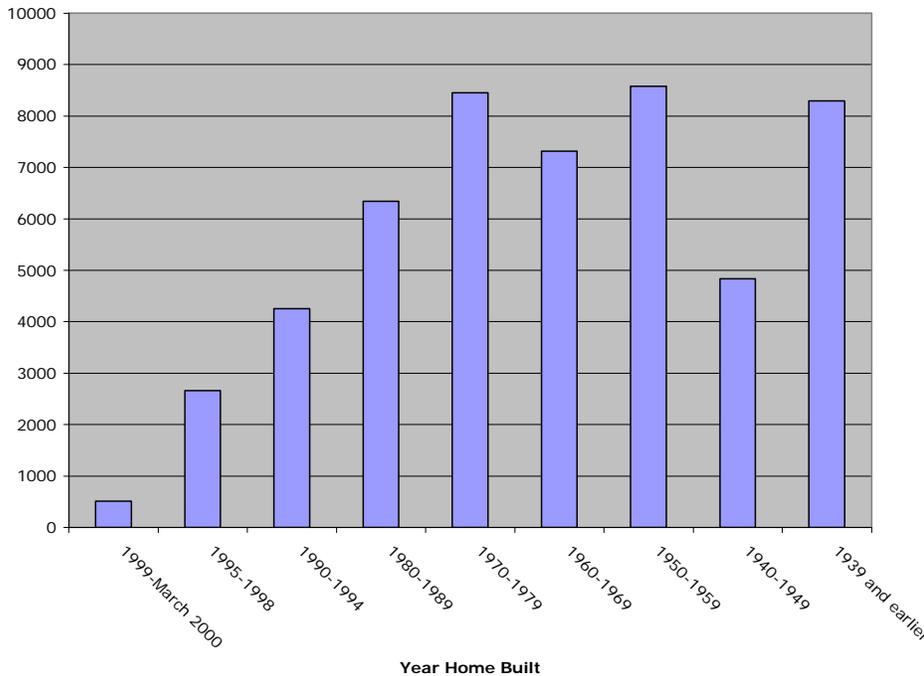


Figure 21. Humboldt County Housing Stock Age Distribution
 (51,238 occupied units, 70% single family, 18% multi-family, 10% mobile home)

According to results from the California Residential Appliance Saturation Survey (KEMA-XENERGY, Itron, RoperASW, 2004), homes on the North Coast offer numerous opportunities for energy efficiency improvements. For example, in the water heating end use 54% do not use water heater insulation blankets, 36% do not use low flow showerheads and 54% do not use faucet aerators. With respect to space heating, 43% have single pane windows and 40% have metal frame windows. Homes lacking attic insulation total 23%, with an additional 32% reporting six inches or less of attic insulation. Twenty five percent of homes have no wall insulation, and only 25% employ programmable thermostats. In the area of lighting, 36% of homes reported no use of compact fluorescent lights, while 30% reported use of two or fewer compact fluorescent lights.

Energy Efficiency and Conservation in Transportation

Many opportunities exist for energy efficiency and conservation in the transportation sector. These opportunities range from equipment improvements to behavior/lifestyle changes to land use planning. A sampling of transportation efficiency measures are listed below:

- Equipment Improvements
 - Alternative fueled vehicles
 - More efficient vehicles
- Behavior Changes
 - Carpooling
 - Walking/bicycling
 - Public transit
 - Reduced trips
 - Telecommuting
- Land Use Planning
 - Mixed-use development
 - High density development
 - Development along transit corridors

CHAPTER 8 - INVENTORY OF EXISTING ENERGY TRANSMISSION SYSTEMS

Humboldt County is remotely located at the end of the electrical and natural gas supply grids, and this limits both energy supply options and system reliability. Pacific Gas and Electric Company owns the natural gas and electricity transmission and distribution systems in Humboldt County. There is one major natural gas supply line that comes from a compressor station in Gerber in the Central Valley and follows a route roughly parallel to Highway 36 (see Figure 22). According to PG&E, this line is capable of transporting enough natural gas to meet current local needs. There are no gas storage fields in the local area, though there are some native gas fields in the Eel River Valley (as discussed in Chapter 6). Based on data from the 2000 Census and the California Residential Appliance Saturation Survey (KEMA-XENERGY, Itron, RoperASW, 2004), it is estimated that approximately 65% to 70% of the households in Humboldt County have access to the natural gas grid.



Figure 22. Northern California Natural Gas Transmission Lines (Pacific Gas and Electric Company, 2005b)

The Humboldt area electrical grid covers about 3000 square miles and is connected to the bulk PG&E transmission system by four transmission circuits, each ranging from 31 to 115 miles in length (see Figures 23 and 24). Electricity imports mainly are through two 115 kV circuits that come from the east at Cottonwood and follow a route roughly parallel to Highway 36 and Highway 299. The lesser capacity circuits include a 60 kV circuit coming from the south at Bridgeville-Garberville (roughly parallel to Highway 101) and a second 60 kV line coming from Trinity in the east via Maple Creek. The total electrical transmission capacity into Humboldt County through the existing lines is approximately 70 MW (Pacific Gas and Electric Company, 1996), less than half of the county's current peak demand. Therefore, local electrical generators (PG&E Humboldt Bay, PALCO, Fairhaven, etc.) are critical to meeting local electricity needs.

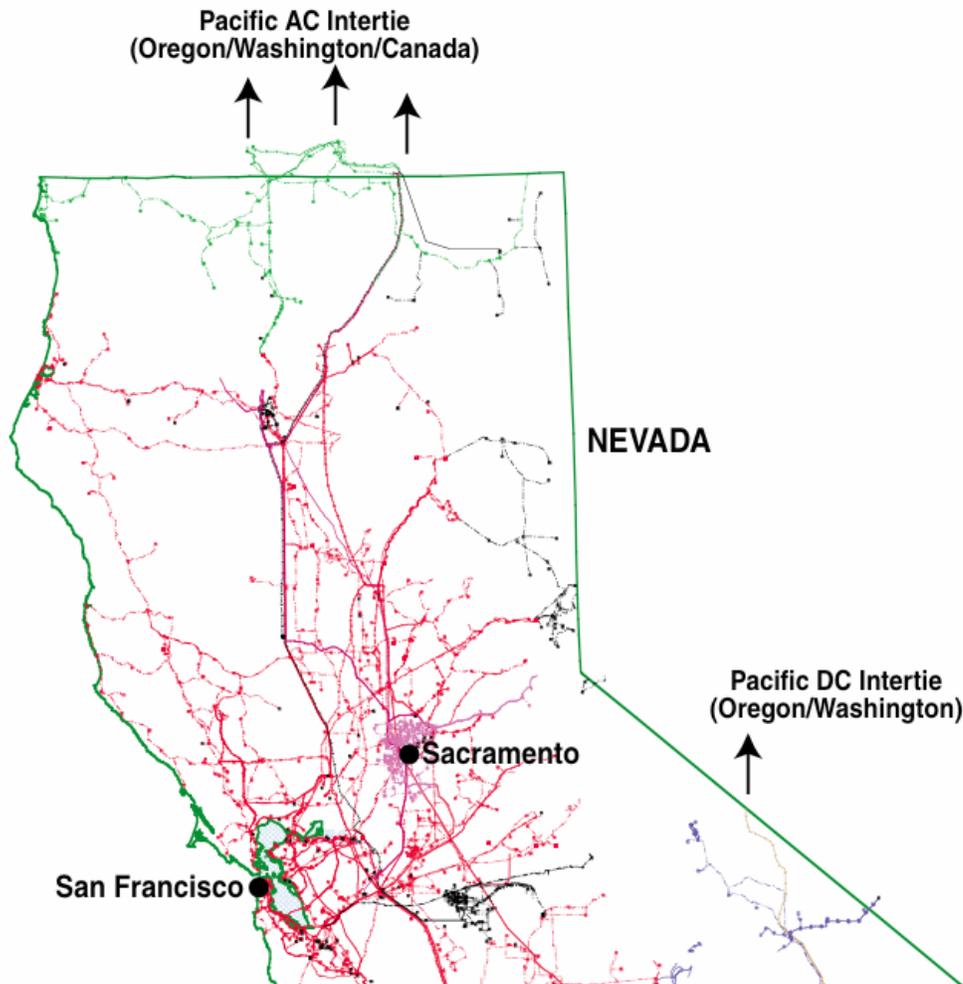


Figure 23. Northern California Electrical Transmission Lines (California Energy Commission, 2005e)

Humboldt County’s connection to PG&E’s larger electrical transmission grid serves many important functions. It supports wholesale market transactions and helps stabilize electricity prices, improves system stability and reliability, and provides additional voltage support. This connection allows electrical power to be imported, as well as exported (as was done substantially during the rolling blackouts in California in 2001).

The power import requirement for the Humboldt transmission system is a function of the load within the Humboldt area and the amount of local generation. The Humboldt area is winter peaking. The peak loads during the period of 2001 through 2004 ranged from about 153 to 158 MW. However, according to PG&E the expected “1-in-10” winter peak load⁴⁷ for 2004 was about 190 MW, including loads served by self-generation facilities (Pacific Gas and Electric Company, 2004b). With 70 MW of transmission capacity and over 200 MW of local generation capacity (PG&E cites 183 MW scheduled and 230 MW maximum available local generation capacity), there is currently enough local generation and import capacity to meet local demand under normal system conditions. However, the system must be robust enough to handle unexpected transmission and generation system outages.

⁴⁷ Demand forecasts are made for a range of scenarios, including various weather conditions. A “1-in-2” forecast has a 50% probability of occurring while a “1-in-10” forecast has only a 10% chance of occurring



Figure 24. Humboldt County Electrical Transmission Lines (Pacific Gas and Electric Company, undated)

Humboldt County has been identified by the CAISO⁴⁸ as a region of concern due to congestion of the transmission system, stability issues, voltage collapse, and thermal overload issues (Kammerer, 2004). These problems are compounded by a reduced level of availability of local generation due to age, generator maintenance outages, and potential shortages or limitations of fuel (i.e. natural gas, oil, wood chips). Pursuant to CAISO regulations, PG&E prepares and submits periodic transmission assessment studies. These include long term transmission assessments and transmission grid expansion plans.

The Humboldt Long-Term Study conducted in 2002 found that with the existing local generation, the transmission system is sufficient to serve the area load reliably for the next 10

⁴⁸ California's restructured electricity industry is complex, with traditional utilities, private generating companies and state agencies each playing a variety of roles and carrying different responsibilities. The California ISO, a not-for-profit public benefit corporation, is one link in this chain. The ISO is the impartial operator of the state's wholesale power grid—maintaining reliability and directing the electron traffic on the transmission superhighway that connects energy suppliers with the utilities that serve 30 million Californians.

years (Pacific Gas and Electric Company, 2004b). However, if 30 MW or more of local generation is retired, the system would not be able to serve the projected 2012 load of 198 MW reliably under the emergency condition of losing one transmission facility. If 100 MW or more generation is retired, the system would not be able to serve the 2012 load under even under normal operating conditions. These are important realizations given that PG&E is looking to retire the Humboldt Bay Power Plant rated at approximately 130 MW.

The most recent transmission assessment report is the 2005 Humboldt Long Term Transmission Assessment (Casuncad, 2005b). This study concluded that the existing Humboldt area electric system (transmission and local generation) meets all CAISO reliability requirements. However, the study concluded that as demand continues to grow, reactive support will likely be needed at the Humboldt and Garberville substations, at an estimated cost of \$9 to \$14 million, to improve system reliability. PG&E will refine these future reactive needs in its 2005 Electric Transmission Grid Expansion Plan. Finally, the study examined transmissions needs in the event there is zero generation from Humboldt Bay Power Plant. Upgrades examined for this scenario included two new transformers for the Humboldt Substation (at a cost of \$16 to \$24 million) and a new 115 kV transmission line from Cottonwood to Humboldt via Bridgeville (at a cost of \$180 to \$270 million). Large capital investments such as these could seriously impact future energy options for the county and therefore should be thoroughly examined in light of what would be best for Humboldt County's long-term energy goals.

While added transmission capacity would increase the ability to import, or export, larger amounts of electrical power, there are potential disadvantages associated with additional transmission capacity. New transmission can be very costly, and siting issues for new transmission lines are often complex due to the large number of parties that are affected by such projects and the many potential impacts (e.g. visual impacts, potential impacts on property values, concerns for the impacts of electric and magnetic fields). Consequently, the CEC recently commissioned a comparative study of transmission alternatives (Lee, 2004) that identified strategic generation and demand management as two options to transmission system upgrades. If new local generation is brought on-line to replace the aging Humboldt Bay Power Plant then it is unlikely that a new 115 kV transmission line between Cottonwood and Humboldt would not be warranted. In addition, the role for local demand response and distributed generation should also be considered.

Although a new, more efficient power plant could potentially produce an excess of power for export from the Humboldt area, PG&E has specified that replacement generation be no more than 150 MW. Even though the existing Humboldt transmission system can support some export of electricity, PG&E claims it is typically undesirable to export electricity out of the Humboldt area because most of the export ends up in the Cottonwood area, and this area is resource rich and already faces congestion problems in exporting its resources. Any additional resources sent to this area will exacerbate the problem (Pacific Gas and Electric Company, 2004b).

With respect to PG&E's proposal to upgrade the two transformers at the Humboldt Substation, the CAISO felt that they did not demonstrate a need for this upgrade. PG&E concurred that this upgrade may not be needed by 2014 and said that they would continue to monitor the situation.

CHAPTER 9 - INVENTORY OF DISTRIBUTED AND BACK-UP GENERATION FOR DISASTER PREPAREDNESS

Very little data were collected on the existence of back-up generator capacity in the county. It is likely that critical facilities, such as hospitals, clinics, emergency facilities, and the like have back-up generation capability.

Effort was made to investigate possible sources of information for identifying back-up generator capacity in the county. These information sources include the following:

- Two back-up generator (BUGS) databases on CEC website
 - 2004 public generators database lists none in Humboldt County
 - 2001 portable generators database lists one 506 kW diesel genset owned by Kern Construction in Blue Lake
- Humboldt County's Office of Emergency Services
- Air Resources Board – Emergency generators (anything at the commercial or industrial scale) are required to be permitted and are listed in a state database. However, this requirement is relatively new and very few generators are registered in Humboldt County. In addition, the ARB relies on people coming to them to get the permits. ARB is not actively seeking them out. This explains, in part, why so few permits have been issued.
- Pacific Gas and Electric Company – PG&E requests that customers who install back-up generators notify them about the installation. They may have a database of connected generators. However, getting access to the information may prove to be difficult.
- Local Building Departments – Any new generator connections should at least require an electrical permit from the local building department. However, it is unlikely that these specific permits could be easily identified and pulled from the overall files. While the information is likely here, it is probably impractical to access it.

CHAPTER 10 - CONSTRAINTS AND OPPORTUNITIES FOR SUSTAINABLE ENERGY INITIATIVES

Overall, the Humboldt County energy picture looks good. There are numerous constraints to be faced, but the constraints appear to be manageable. There are also many opportunities to be pursued, and these opportunities may offer the promise of long-term energy sustainability for Humboldt County.

Constraints

Humboldt County is a relatively sparsely populated rural county that lacks the strong financial resource base often associated with more metropolitan areas. It is located in a remote, rural corner of the State of California. These characteristics pose numerous constraints with respect to the development of sustainable energy resources. These constraints include:

- The county is isolated at the end of the electric and natural gas transmission infrastructure. This isolation can threaten the reliability of the county's electricity and natural gas supplies, and limits the options for both importing and exporting energy resources.
- The county is isolated in terms of ground transportation options. There are only two major highway routes in and out of the county (Highway 101 and Highway 299). Propane fuel is delivered to the county by truck and deliveries can be curtailed when highways become inaccessible due to winter storms and associated mud or rock slides.
- Transportation fuels (gasoline and diesel) are transported into the county by barge through Humboldt Bay. Access to the bay inlet can also be impaired during winter storms.
- The majority of the county's energy resources are currently imported. The majority of the money spent on energy leaves the county.
- The county is not capable of importing all of its electricity due to the limited capacity of the electrical transmission lines serving the county.
- The county is dependent almost entirely on imported fossil fuels for transportation and transportation energy alternatives are limited.
- The rural, sparsely populated nature of the county makes it harder to serve the county's transportation needs with mass transit options.
- The county has limited financial resources for energy capital development projects
- The county has limited buying power in the energy market due to the small population.
- The county has less access to programmatic resources (e.g. energy efficiency programs) than more metropolitan areas.

Opportunities

Humboldt County's remote, rural locale offers many opportunities as well, including a potential wealth of renewable energy resources in the form of wave energy, wind power, solar power, biomass energy, and small hydroelectric power. In addition, there is a strong interest in the local community to develop local, sustainable energy resources, to make wise and efficient use of energy resources, and to be as energy self-reliant as possible. Humboldt County is known for its strong independent spirit, and that spirit extends to the area of energy supply and demand. Opportunities for the development of sustainable energy resources in the county include:

- Increase local energy efficiency and conservation efforts. Substantial gains can be made to reduce energy consumption, save consumers money, and keep energy dollars local. The RCEA is furthering these efforts.
- Further develop local energy resources, including:
 - Wind power – Significant opportunity for wind power development exists, especially in the Cape Mendocino area.
 - Wave power – While this technology is too immature to comprehend its true potential, it seems worth pursuing on a research and demonstration scale, especially given the tremendous resource that is estimated to be available on the Humboldt County coastline.
 - Biomass – A substantial amount of biomass energy is already used in the county, including firewood for space heating and wood waste that is burned to produce electricity. There appear to be opportunities for further development of biomass as a fuel source for generating electricity. One of the most promising opportunities may be to link forest residue fuel reduction efforts to biomass electricity generation.
 - Natural gas – Natural gas fields in the Eel River valley have been utilized for many years, and new fields are being developed.
 - Small hydroelectric – There appears to be a substantial amount of run-of-the-river, small-scale hydroelectric potential in the county, though development of this resource has been hampered by regulatory and economic constraints.
 - Solar energy – There is a strong interest in solar energy in Humboldt County, and substantial opportunity to increase the number of rooftop solar electric, solar water heating, and solar space heating systems. The RCEA’s Million Solar Roofs Partnership is furthering these efforts.
 - Biogas – Biogas fuel from local wastewater treatment plants, dairies, and the Cummings Road landfill is a local energy resource that can be utilized.
 - Biodiesel – Recycled oil is already being used to produce biodiesel fuel in the county, and there is room for some modest expansion of this industry.
- Increase the supply of energy from distributed generation and cogeneration. These technologies can offer significant efficiency gains and energy cost savings, increased energy security, the ability to use local energy resources, and benefits to the electricity transmission and distribution system.
- Exploit local energy resources for local use, thereby keeping energy dollars in the county.
- Exploit local energy resources for export and help to boost local economic development.
- Develop and implement county-wide strategic energy planning, including codes, zoning, regulations, incentives, organizational support, and education.
- Make the link between energy planning and land-use planning by promoting “smart growth” development and wise transportation planning.
- Investigate and pursue opportunities for local management of energy supplies and services. These efforts can be coordinated by the RCEA.
- Investigate and consider the implementation of Community Choice Aggregation, thereby increasing local control over the purchase of electricity.

- Pursue upgrades of energy transmission and distribution infrastructure (natural gas pipelines, electrical transmission and distribution), as appropriate.
- Follow state priorities of 1) increasing energy conservation and efficiency, 2) accelerating renewable energy generation and distributed generation, and 3) meeting remaining demands with conventional resources and improvements to infrastructure.

REFERENCES

- American Wind Energy Association (2004), “Wind Web Tutorial,” [Internet]. American Wind Energy Association; c2004, [cited March 2005]. Retrieved from <http://www.awea.org/faq/index.html>.
- Bailey D. (2005), Utility Maintenance Supervisor, City of Eureka Wastewater Treatment Plant, Eureka, CA. Personal communication with: Dave Carter (Schatz Energy Research Center), February, 2005.
- Bedard R., Hagerman G., Previsic M., Omar S., Threshser R., and Ram B. (2005), “Final Summary Report, Project Definition Study, Offshore Wave Power Feasibility Demonstration Project,” Electric Power Research Institute, January 14, 2005. Report No. E2I EPRI global WP 009 – US Rev 1.
- Bertz S., Marnay S., Osborn J. (Lawrence Berkeley National Laboratory), and Osman S. (1999), [Internet], “Using GIS to Analyze the Profitability of Potential Wind Power Sites in the Competitive California Electricity Market,” [cited April 2005]. Retrieved from <http://gis.esri.com/library/userconf/proc99/proceed/papers/pap781/p781.htm>.
- Bihn D. (2005) “Japan Takes the Lead.” *Solar Today*, Jan/Feb 2005, Vol. 19, No. 1, American Solar Energy Society, pp. 20-23.
- California Department of Conservation (2003), “2003 Annual Report, Production and Reserves,” Division of Oil, Gas and Geothermal Resources.
- California Department of Transportation (2004a), “Estimates of Highway Gasoline Use by County,” Office of Transportation Economics, Division of Transportation Planning, revised November, 2004.
- California Department of Transportation (2004b), “California Motor Vehicle Stock, Travel and Fuel Forecast,” Division of Transportation System Information, November, 2004.
- California Department of Water Resources (1985), “California Wind Atlas,” prepared for the California Energy Commission, Contract Number P-500-82-044.
- California Energy Commission (2005a), [Internet], Emerging Renewables Program Account Activities, Microsoft Excel spreadsheet showing completed and approved systems up to January 13, 2005, [retrieved March 2005]. Retrieved from http://www.energy.ca.gov/renewables/emerging_renewables.html.
- California Energy Commission (2005b), “Landfill Gas Power Plants,” [Internet, retrieved March 2005]. Retrieved from http://www.energy.ca.gov/development/biomass/landfill_gas.html.
- California Energy Commission (2005c), “Landfill Gas to Energy,” [Internet, retrieved June 22, 2005]. Retrieved from <http://www.energy.ca.gov/pier/renewable/biomass/landfill/index.html>.
- California Energy Commission (2005d), “Anaerobic Digestion,” [Internet, retrieved June 22, 2005]. Retrieved from http://www.energy.ca.gov/pier/renewable/biomass/anaerobic_digestion/index.html.
- California Energy Commission (2005e), “California Energy Maps, California’s Major Electric Transmission Lines,” [Internet, retrieved June 23, 2005]. Retrieved from http://www.energy.ca.gov/maps/transmission_lines.html.
- California Energy Commission (2004a) “Integrated Energy Policy Report 2004 Update,” November 2004, Report No. 100-04-006CM.

- California Energy Commission (2004b) "California Energy Commission Power Plant Database," Cartography Unit, Systems Assessment and Facilities Siting Division, July 1, 2004.
- California Energy Commission, (2003a) "Natural Gas Market Assessment," Staff Report, August 2003, Report No. 100-03-006.
- California Energy Commission, (2003b) "Wind Energy in California," [Internet, updated January 15, 2003; cited February 2005]. Retrieved from <http://www.energy.ca.gov/wind/overview.html>.
- California Energy Commission, (2003c) "California Ocean Wave Energy Assessment, Volume 1, Draft," August 2003.
- California Energy Commission, (2000) "Distributed Generation: CEQA Review and Permit Streamlining," December 2000, Report No. P700-00-019.
- California Energy Commission, California Power Authority, and California Public Utilities Commission (2003) "State of California Energy Action Plan," adopted April 18 – May 8, 2003.
- California Statistical Abstract (2003), "Estimated Fee-Paid Vehicle Registrations by County, California, As of December 31, 2002," [Internet, cited February 22, 2005]. Retrieved from <http://countingcalifornia.cdlib.org/pdfdata/csa03/J04>.
- Campbell C. and Laherrere J. (1998), "The End of Cheap Oil," *Scientific American*, March 1998, p.78-83.
- Campbell P. (1997) "Current Population Reports, Population Projections: States 1995-2025," U.S. Bureau of the Census, Population Division, P25-1131, May 1997.
- Carter D., Bohn J., Campbell N., Jolley D., Kullmann S., Lora S., Marshall M., Pearlman A., Saucedo D., and Gopal A. (2005), "Design Proposal for a Hydrogen Power Park," Humboldt State University, Environmental Resources Engineering Department.
- Casuncad D. (2005a), "Humboldt Long Term Transmission Assessment, Draft Study Report," Pacific Gas and Electric Company, Electric T&D Engineering, January 13, 2005.
- Casuncad D. (2005b), "Humboldt Long Term Transmission Assessment, Final Study Report," Pacific Gas and Electric Company, Electric T&D Engineering, February 24, 2005.
- Coito F. and Rufo M., (2003a), "California Statewide Residential Sector Energy Efficiency Potential Study, Final Report," KEMA-XENERGY Inc., Oakland, CA, April 2003, Study ID #SW063. Prepared for Pacific Gas and Electric Company, San Francisco, CA.
- Coito F. and Rufo M., (2003b), "California Statewide Commercial Sector Natural Gas Energy Efficiency Potential Study, Final Report," KEMA-XENERGY Inc., Oakland, CA, Revised July 2003, Study ID #SW061. Prepared for Pacific Gas and Electric Company, San Francisco, CA.
- Cooper A. (2005), Footprint Recycling, Arcata, CA. Telephone conversation with: Jim Zoellick (Schatz Energy Research Center), March, 2005.
- Cornell (2001), "Ethanol fuel from corn faulted as 'unsustainable subsidized food burning' in analysis by Cornell scientist," Cornell News, August 6, 2001, [Internet, cited March 2005]. Retrieved from <http://www.news.cornell.edu/releases/Aug01/corn-basedethanol.hrs.html>.

Driscoll J. (2005), "Wanted: 150 megawatts," Eureka Times-Standard, Eureka, CA, February 5, 2005. [Retrieved from the Internet, February 2005].

Dyett and Bhatia Urban and Regional Planners (2002) "Humboldt 2020 General Plan, Building Communities, A Discussion Paper for Regional Workshops," February 2002.

Elliot D.L. and Schwartz M.N. (1993) "Wind Energy Potential in the United States." Pacific Northwest Laboratory, Richland, WA, September 1993. Report No. PNL-SA-23109. NTIS No. DE94001667.

Elliot R., Shipley A., Nadel S., and Brown E. (2003), "ACEEE Estimates of Near-Term Electricity and Gas Savings," American Council for an Energy-Efficient Economy, Washington D.C., August 15, 2003.

Engel R. (2005a), Schatz Energy Research Center, Humboldt State University, Arcata, CA, February 2005, independent analysis.

Engel R. (2005b), Schatz Energy Research Center, Humboldt State University, Arcata, CA, February 2005. Data collected from Humboldt County wastewater treatment plant operators and city and community services district staff during 2003 and 2004.

Easthouse K. (2003), "Destination Humboldt Bay? The Liquefied Natural Gas Debate Heats Up." *North Coast Journal*, Nov. 6, 2003, pgs. 8-11.

Energy Information Administration (2005a), *Natural Gas Monthly*, Energy Information Administration, Office of Oil and Gas, U.S. Department of Energy, Washington, DC, June 2005, DOE/EIA-0130(2005/06).

Energy Information Administration (2005b), [Internet], "Topics for Natural Gas Consumption," [cited June 29, 2005]. Retrieved from http://tonto.eia.doe.gov/dnav/ng/ng_cons_top.asp.

Energy Information Administration (2002), [Internet], Table FE2, Typical Costs and Capacity of New Transmission Lines (1995 Dollars), [cited February, 2005]. Retrieved from http://www.eia.doe.gov/cneaf/pubs_html/feat_trans_capacity/table2.html

Environmental and Energy Study Institute (2003), "Biofuels: Energy Balance," Environmental and Energy Study Institute, Washington, DC, October 2003. [Internet, cited March, 2005]. Retrieved from <http://www.eesi.org/programs/agriculture/Energy%20Balance%20update.htm>

Fried J., Christensen G., Barbour J., Fight R., and Pinjuv G. (2002), Digest of the Study "Development of FIA BioSum to Evaluate Feasibility and Impact of Landscape-scale Fuel Treatments for Biomass Based Energy Generation," USDA Forest Service, PNW Research Station, August 26, 2002.

"Goodbye to a piece of our past," Eureka Times-Standard, June 22, 2005.

Gough A. (2005), California Energy Commission Demand Analysis Office, [electronic mail on the Internet]. Message to: Anand Gopal (Schatz Energy Research Center), February 2, 2005. Humboldt County Electricity Consumption Data by SIC Code.

Hart K.P., (2005), "Energy Conservation & Community Planning," *Planning Commissioners Journal*, No. 57, Winter 2005. [Excerpt retrieved from the Internet, February 2005], <http://www.plannersweb.com/wfiles/w200.html>.

Hight J. (2004), "Reliability Fears Increase in Humboldt County," *California Energy Circuit*, August 13, 2004.

Hirsch R.L., Bezdek, R., and Wendling R. (2005) "Peaking of World Oil Production: Impacts, Mitigation, & Risk Management," prepared for the Department of Energy's National Energy Technology Laboratory (NETL) by Science Applications International Corporation (SAIC).

Hofweber T. (2005), Humboldt County Planning Division, Eureka, CA. [Electronic mail on the Internet]. Message to: Jim Zoellick (Schatz Energy Research Center). March, 2005

Humboldt County, California (2005), [Internet], "Humboldt 21st Century Natural Resources and Hazards Report," [cited March, 2005]. Retrieved from http://www.planupdate.org/meetings/natl_res/nr_report.asp

Humboldt County, California (c2002), [Internet], "About Humboldt County," [cited February, 2005]. Retrieved from <http://www.co.humboldt.ca.us/portal/about.asp>.

Humboldt County (2003), "Technical Background Study for the 2003 Housing Element, Humboldt County General Plan Volume II." Approved December 16, 2003. Amended November 30, 2004. Chapter 2, page 10.

Humboldt County Energy Advisory Committee (1981) "A Report on Energy Use in Humboldt County and the Identification of Major Areas of Policy Recommendations," April 1981.

Kammerer K. (2005), [electronic mail on the Internet]. Message to: Anand Gopal (Schatz Energy Research Center). February, 2005. Humboldt County Electricity Generation Data, 2001-2003, including sale for resale and on-site use information.

Kammerer K. (2004) "Humboldt County Energy Report – Draft," prepared for Redwood Coast Energy Authority, Eureka, CA.

Katz D. (2005), Alternative Energy Engineering, Redway, CA. [Electronic mail on the Internet]. Message to: Jim Zoellick (Schatz Energy Research Center). March 15, 2005.

KEMA-XENERGY, Itron, RoperASW (2004), "California Statewide Residential Appliance Saturation Survey, Final Report," June 2004, Report No. 400-04-009. Prepared for the California Energy Commission.

Kempton, W., Tomic J., Letendre S., Brooks A., and Lipman T. (2001) "Vehicle-to-Grid Power: Battery, Hybrid, and Fuel Cell Vehicles as Resources for Distributed Electric Power in California," Institute of Transportation Studies, University of California, Davis, CA, June 2001. Prepared for California Air Resources Board, California Environmental Protection Agency, and Los Angeles Department of Water and Power, Electric Transportation Program. Report No. UCD-ITS-RR-01-03.

Laaksonen-Craig S., Goldman G., and McKillop W. (2003), "Forestry, Forest Industry, and Forest Products Consumption in California," University of California, Division of Agriculture and Natural Resources, c2003, ANR Publication 8070.

Lee S. (2004), "Comparative Study of Transmission Alternatives, Background Report," Aspen Environmental Group, San Francisco, CA, June 2004. Prepared for the California Energy Commission. Report No. 700-04-006.

- Lessmann C. (2005), "Recommendations for a Zoning Ordinance for the Permitting and Installation of Small Wind Energy Systems in Humboldt County, California," [Masters Thesis, Environmental Systems: International Development Technology], Humboldt State University, Arcata, CA, January 1, 2005.
- Marino B. (2005a), DG Fairhaven Power Co., [Electronic mail on the Internet]. Message to: Jim Zoellick (Schatz Energy Research Center). March, 2005.
- Marino B. (2005b), DG Fairhaven Power Co. Telephone conversation with: Michael Winkler (Schatz Energy Research Center), February 25, 2005.
- Marruffo I. (2005), Pacific Gas and Electric Company. Telephone conversation with: Michael Winkler (Schatz Energy Research Center), February 18, 2005.
- Marruffo I. (2005), Pacific Gas and Electric Company. Telephone conversation with: Dave Carter (Humboldt State University, Environmental Resources Engineering), Fall 2004.
- Morgan T., Keegan III C., Dillon T., Chase A., Fried J., and Weber M. (2004), "California's Forest Products Industry: A Descriptive Analysis," United States Department of Agriculture, Forest Service, Pacific Northwest Research Station, July 2004. General Technical Report PNW-GTR-615.
- Morris G. (1999), "The Value of the Benefits of U.S. Biomass Power," National Renewable Energy Laboratory, Golden, CO, Report No. NREL/SR-510-33111.
- Mueller S. (2005), DG Energy Solutions, [electronic mail on the Internet]. Message to: Jim Zoellick (Schatz Energy Research Center), February 23, 2005.
- Nadel S., Shipley A., and Elliot R. (2004), "The Technical, Economic and Achievable Potential for Energy-Efficiency in the U.S. – A Meta-Analysis of Recent Studies," *Proceedings of the 2004 ACEEE Summer Study on Energy Efficiency in Buildings*, American Council for an Energy-Efficient Economy, Washington D.C.
- National Renewable Energy Laboratory (2004), Results of Wind Monitoring Effort for the Table Bluff Reservation.
- National Research Council and National Academy of Engineering (2004), *The Hydrogen Economy – Opportunities, Costs, Barriers, and R&D Needs*, National Academies Press, Washington, DC, c2004. [Excerpt retrieved from the Internet, June 27, 2005], <http://www.nap.edu/books/0309091632/html/230.html>.
- Oscar Larson & Associates (1982), "An Analysis of Small Hydroelectric Planning Strategies," A report to the Humboldt County Board of Supervisors, May 1982.
- Oscar Larsen & Associates (1981), "Arcata Wind Study 1980-81," addendum to "Step1: Wastewater Management Study for the City of Arcata, California, June 1980"
- Pacific Gas and Electric Company (2005a), "PG&E to Seek Proposals to Improve Electric Reliability in California's North Coast Region," News Release, PG&E News Department, February 3, 2005.
- Pacific Gas and Electric Company (2005b), "Pipe Ranger, California Gas Transmission - Interactive System Map," [Internet, retrieved June 23, 2005]. Retrieved from http://www.pge.com/pipeline/about/system_maps/statemap.shtml.

Pacific Gas and Electric Company (2004a), "Power Content Label." Retrieved from http://www.google.com/url?sa=U&start=1&q=http://www.pge.com/docs/pdfs/customer_service/bill_insets/2004/200404_res.pdf&e=10431.

Pacific Gas and Electric Company (2004b), "Humboldt Area Generation Resource," December 6, 2004.

Pacific Gas and Electric Company (1996), "PG&E Market Power Filing – Appendix B," July 1996.

Pacific Gas and Electric Company (undated), "Northern Area Expansion Plan Assessment," prepared by Lorenzo Thompson and Soussane Sadre, electronic pdf document, filename: 200105311428332746.pdf. Obtained from CAISO. Appears to have been prepared in 2001.

Pan A. (2005), California Energy Commission Electricity Analysis Office, "Net Output in Megawatt-hours of Power Plants in Humboldt County," 2001-2003, from Form CEC-1304. [Electronic mail on the Internet]. Message to: Anand Gopal (Schatz Energy Research Center), January 26, 2005.

Parsons S. (2005), Eureka Chevron Terminal. Telephone conversation with: Michael Winkler (Schatz Energy Research Center), February 15, 2005.

Planwest Partners and RNB Spatial Data Inc. (2004), "Humboldt County Master Fire Protection Plan, Consultant's Draft," July 2004. Prepared for The Humboldt County Fire Safe Council, Humboldt County Community Development Services, Eureka, CA.

Reis A. and Engel R. (2003), "Feasibility Study on Implementing Anaerobic Digestion Technology on Humboldt County Dairy Farms," Schatz Energy Research Center, Humboldt State University, Arcata, CA, June 1, 2003. Prepared for Humboldt County Economic Development Office.

Rogers J. (2004), "ISF State of Sustainability Report," Institute for Sustainable Forestry, Redway, CA, June 2004. Prepared for ISF's Sustainable Forestry Council, funded by USDA Forest Service Economic Recovery Program and Sustainable Northwest Healthy Forests Healthy Communities.

Rufo M. and Coito F. (2002), "California's Secret Energy Surplus: The Potential for Energy Efficiency, Final Report," Xenergy, Inc. Oakland, CA, September 23, 2002. Prepared for The Energy Foundation and The Hewlett Foundation,

Salazar, L. (2005), Six Rivers National Forest, Eureka, CA. Telephone conversation with: Jim Zoellick (Schatz Energy Research Center), February 28, 2005.

Schatz Energy Research Center (2001), "Humboldt Energy Task Force Solar Hot Water Program Recommendations," Schatz Energy Research Center, Humboldt State University, Arcata, CA, August 2001. Prepared for The Humboldt Energy Task Force.

Schillinger, E. (2005), Surveyor, Eureka, CA. Telephone conversation with: Mark Rocheleau (Schatz Energy Research Center), February, 2005.

SCS Energy (2004), "Power and Heat Generation Feasibility Study for Cummings Road Landfill." Prepared for the Humboldt Waste Management Authority, Eureka, CA.

Shannon, P. (2005), Big Rock Partners, Willow Creek, CA. Personal conversation with: Jim Zoellick (Schatz Energy Research Center), February 16, 2005.

Smith M.D. and Steinberg S.J. (2005), "Room to Grow? An Assessment of the Potential for Unincorporated Humboldt County to Accommodate Future Projected Population Growth," Department of Environmental and Natural Resource Sciences, Humboldt State University, January, 2005.

Smyser C. and Agnello P. (1983), "The Humboldt County Plan to Accelerate Economic Development of Local Energy Resources," prepared for The Humboldt County Project Independence Committee, The Humboldt County Board of Supervisors, and The Farmers Home Administration of the U.S. Department of Agriculture, June, 1983.

Thompson P., ed. (2004), "Our Guide to the Growing North American LNG Galaxy," *LNG Focus*, Vol. 1, Issue 1. November 2004, p.16.

Torcellini P., Long N., and Judkoff R. (2003), "Consumptive Water Use for U.S. Power Production," National Renewable Energy Laboratory, Golden, CO, December 2003, Report No. NREL/TP-550-33905.

TrueWind Solutions, LLC (2002), [Internet], Wind Energy Resource Map of California at 50 m, [cited February, 2005]. Retrieved from http://www.awstruewind.com/inner/windmaps/maps/high_re_windmaps/California Wind Power at 50m.jpg

TSS Consultants (2003), "Preliminary Feasibility Study for a Biomass Utilization Project on the Yurok Reservation," TSS Consultants, Rancho Cordova, CA, March 31, 2003. Prepared for the Yurok Tribe, Klamath, CA.

U.S. Census Bureau (2005), [Internet], "California Quick Facts," [updated February 1, 2005, cited February, 2005]. Retrieved from <http://quickfacts.census.gov/qfd/states/06/06023.html>.

U.S. Census Bureau (2000), [Internet], DP-4. Profile of Selected Housing Characteristics, Data Set: Census 2000 Summary File 3, Geographic Area: Humboldt County, California [cited February, 2005]. Retrieved from http://factfinder.census.gov/servlet/QTTable?_bm=y&-geo_id=05000US06023&-qr_name=DEC_2000_SF3_U_DP4&-ds_name=DEC_2000_SF3_U&-lang=en&-redoLog=true&-CONTEXT=qt.

Wheeler, M. (2005), Humboldt County Planning Division, Eureka, CA. Telephone conversation with: Michael Winkler (Schatz Energy Research Center), February, 2005.

Winzler & Kelly and CH2M Hill (1978), "County of Humboldt Solid Waste Resource Recovery Study," April 1978.

World Nuclear Association (2004), [Internet], WNA News Briefing 04.36-10, September 7, 2004, [cited February, 2005].

World Nuclear Association (2003), [Internet], WNA News Briefing 03.50-12, December 16, 2003, [cited February, 2005].

Wright G. (2005), Humboldt State University Plant Operations, [electronic mail on the Internet]. Message to: Anand Gopal (Schatz Energy Research Center), February 2, 2005.