Public Interest Energy Research (PIER) Program

INTERIM PROJECT REPORT

HUMBOLDT COUNTY AS A RENEWABLE ENERGY SECURE COMMUNITY

Database of Local Renewable Energy Sources and Current/Projected Energy Demands

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PREFACE

This document describes a deliverable for CEC contract PIR-08-034, "Humboldt County as a Renewable Energy Secure Community". The deliverable, referred to as the "RESCO Database", is a database that includes estimates of the local renewable energy resources in Humboldt County as well as estimates of energy demand. The deliverable is submitted in the form of an excel workbook titled "HumCo RESCO Database Aug2011.xlsx". The purpose of this database is to provide enough data that other researchers may conduct independent analyses of Humboldt County's potential for renewable energy development.

This companion document is only a technical guide describing the format and contents of the database and how one might use it to simulate supply and demand for energy in Humboldt County. Detailed background information about the database (e.g., the original sources of the data and/or what models and analyses were conducted to produce the estimates) is described in Zoellick (2011), which is a separate project deliverable titled "Humboldt County as a Renewable Energy Secure Community: Resource and Technology Assessment Report".

DATABASE DESCRIPTION

The database is saved in an Excel workbook containing eleven sheets with the names listed in Table 1. Each sheet provides data specific to that technology.

Table 1: Sheet names included in database.

Technology Type	Sheet Name
Supply	BIOMASS
	HYDROPOWER
	IMPORT
	NATURAL GAS
	PV
	WIND
	WAVE
Demand	ELECTRICITY DEMAND
	HEAT DEMAND
	TRANSPORTATION DEMAND
	EFFICIENCY

Time Scale

Most of the sheets present data at an hourly time scale. Many columns in the database contain 8760 values, corresponding to the 8760 hours in a year. Every sheet that contains hourly data also contains a column labeled "hour". This label is an index into the year, so it should be interpreted as the hour of the *year*, not the hour of the day.

Supply Technologies

The data for all of the supply technologies are presented in terms of resource availability at the hourly time scale. The value in each cell ranges from 0 to 1 and indicates the fraction of the full capacity that is available from that resource for utilization in the given hour. To estimate the availability of a resource in any hour, multiply the value in the appropriate cell by the total capacity for that resource.

For example, in cell B2 of the "BIOMASS" sheet, the value is ~0.671. This means that if there is 100 MW of installed biomass capacity in Humboldt County, then you should expect only ~67.1 MW (or 100MW * 0.671) to be available for use in the first hour of the simulated year. The actual value of the capacity is left to the user of the database to define. See Zoellick (2011) for an account of current capacities in Humboldt County, as well as the range of values explored in the RESCO Study.

Most of the sheets have multiple columns of data. These typically represent replicate years and can be use to simulate year-to-year variation in resource availability. The variation may be due to variability in weather or random chance. In the case of wind power, the columns correspond to multiple years and multiple wind farm locations. The names of the columns (located in row 1) provide some additional information about the source of the data in the column. The following sub-sections provide a resource-specific account of what the column names mean.

BIOMASS

The biomass availability data were generated using a time series model of power plant availability (see Zoellick 2011 – Appendix D.1.4 for a model description). The 10 columns of data represent ten realizations of that model. In other words, the model was run 10 times to produce 10 synthetic availability estimates.

HYDROPOWER

Similar to biomass, the hydropower availability data are produced by a time series model (see Zoellick 2011 – Appendix D.1.5 for a model description). However, the hydropower time series model uses regional precipitation data as an input. The column names therefore represent the actual precipitation year used to generate the resource availability in that column.

IMPORT

In the RESCO study, it was assumed that import up to the full capacity of the transmission lines into the County is available every hour of the year. Therefore the data in the column titled "import" all have a value of 1.

NATURAL GAS

Like import, it was assumed that the natural gas power plant is available every hour of the year. Therefore the data in the column titled "natural.gas" all have a value of 1.

PV

Replicates were not produced for PV in the RESCO Study. The column titled "pv" is based on TMY3 ("typical meteorological year 3") for Arcata CA and represents production from south facing photovoltaic panels titled to 41 degrees and it includes a 75% derate factor for system inefficiencies. The derate factor accounts for elevated module temperature, inverter ineffienciency, dirt and dust on the modules, and voltage drop in the wires. Therefore, PV capacity should be defined in terms of the PV modules DC rating at standard test conditions (STC), which corresponds to an insolation of 1000 W/m^2 and a module temperature of 25°C.

WAVE

Like hydropower, the wave data set is based on environmental monitoring, in this case spectral wave measuresments from NDBC Buoy 46022. The column names therefore refere to the actual years that data were collected by the Buoy. See Zoellick (2011) Appendix D.1.3 for more details.

WIND

The wind data come from the NREL Western Wind Dataset. This dataset provides three years of simulated wind power production from plants at various locations throughout the Western United States. Four relevant locations in Humboldt County were chosen and explored in the RESCO Study. The column names in the WIND sheet specify the location and year from which thoses estimates were derived. Table 2 provides a summary of the locations and their respective properties. See Zoellick (2011) Appendix D.1.2 for more details.

Table 2: Locations from NREL Western Wind Dataset included in RESCO database.

Site Code	Approx. Site Location	Description
BRV	Close to Shell Wind Bear River Ridge project site, on shore	ID 12934, Loc. 40.49N 124.37W capacity factor: 30.2% power density: 532.9 W/m^2 mean speed: 7.3 m/s elevation: 133 m
EEL	Close to Eel River mouth, on shore	ID 12987, Loc. 40.58N 124.34W capacity factor: 22.4% power density: 465.6 W/m^2 mean speed: 6.3 m/s elevation: 81 m
OFF	Offshore of Cape Mendocino, maximum Humboldt offshore resource in Western Wind Dataset	ID 12896, Loc. 40.44N 124.46W capacity factor: 40.6% power density: 668.5 W/m^2 mean speed: 8.3 m/s elevation: 0 m
RDG	Inland ridge south of Bear River Ridge, on shore.	ID 12901, Loc. 40.44N 124.26W capicity factor: 29.9% power density: 764.1 W/m^2 mean speed: 7.7 m/s elevation: 427 m

Demand Technologies

The data in each of the demand-related sheets are described in the following sub-sections. With one exception, all of the demand data are presented as summaries of historical consumption and do not represent projections of future demand. In the RESCO Study, we did project demand into the future, but these projections involved scaling historical demand to a future value based on an estimate of population growth. For a detailed description of the population model used in the study see Zoellick (2011) Appendix D.3.1. To project demand to some future year using the same methodology used in the RESCO Study, use the following formula:

Equation 1:

$$D_{fut} = D_{hist}\left(\frac{P_{fut}}{P_{hist}}\right)$$

Where D_{proj} and D_{hist} are the projected and historical demand respectively and P_{proj} and P_{hist} are the projected and historical population of Humboldt County (be sure the dates of the historical/projected demand are the same as the dates of the historical/projected population estimates). The one exception in the RESCO Database to the above methodology is the TRANSPORTATION DEMAND data. Each of the demand categories are described below.

ELECTRICITY DEMAND

The electricity demand data is based on data provided by PG&E for the years 2004 through 2009. The columns titled “2004” through “2009” represent hourly demand for electricity across the entire County and are in units of MWh. The columns titled “1” through “10” represent normalized replicates of a time series model developed in the RESCO Study to simulate a random year of electricity demand in Humbodlt. Each value in these replicate columns represent the fraction of the *annual* electricity demand that was consumed in that hour. To convert an entire column of data to hourly energy values, simply multiply every row by the total electricity demanded for the entire year.

HEAT DEMAND

The columns in this sheet present the hourly demand for heating fuels in units of MJ (note: electricity demand *in this sheet* is also in units of MJ). All of the data in this sheet are estimates of heating demand in the year 2008. An important component to the RESCO Study was investigating the impact of electric heat pump adoption as an alternative to natural gas furnaces. The column titles that begin with “elec-” and “gas-” also contain a number, which represents the fraction of natural gas furnaces that have been replaced with heat pumps in the respective columns. For example, columns “elec-0.2” and “gas-0.2” correspond to the MJ of electric heat demand and the MJ of natural gas heat demand, respectively, for the scenario where 20% of the natural gas furnaces have been replaced with electric heat pumps. As the fraction of heat pumps increases, the relative consumption of electricity increases and the consumption of natural gas decreases. The range of penetration values allows the user of the database to explore various levels of heat pump use and its impact on the demand for electricity and fuel.

Finally, it’s important to note that the 2008 estimate of demand for electric heat is *already* included in the aggregate electricity demand data presented in the ELECTRICITY

DEMAND sheet. Therefore, to determine total demand for electricity it would not be appropriate to add the demand for electricity from the HEAT DEMAND sheet to the data from the ELECTRICITY DEMAND sheet. Instead, you should first *subtract* the electric heat demand from the 0.0 penetration column ("elec-0") and then add back the electric heat demand for whichever heat pump penetration level you are investigating.

TRANSPORTATION DEMAND

The transportation demand sheet contains estimates of annual gasoline and electric fuel consumption, as well as the shape of the hourly demand for electricity introduced by electric vehicle charging. The column titled "elec.load.shape" represents the fraction of the annual demand for electric fuel (that is, electricity for charging vehicles) in that hour. Just like columns "1" through "10" in the ELECTRICITY DEMAND sheet, to get an energy value from this column, multiply every row in the column by the total annual demand for electric fuel.

The table in the rest of the sheet presents the annual demand for fuel in the year 2008 assuming various levels of electric vehicle penetration *and* various fuel efficiency projections. The column "ev.frac" indicates the fraction of gasoline vehicles in the Humboldt fleet that have been replaced by plug-in electric vehicles (PEVs, which is a mixture of battery-electric vehicles and plug-in hybrid electric vehicles). The total number of vehicles in Humboldt County in 2008 was ~130,000. Asssuming the various PEV penetration levels in the "ev.frac" column, the rest of the table respresents the resulting number of PEVs ("num.ev"), conventional vehicles ("num.conv"), and fuel consumption. Note that when PEV penetration is 100%, there is still gasoline consumption due to the presence of plug-in hybrid electric vehicles, which are assumed to consume gasoline.

The columns titled "total.gas.####" and "total.elec.####" represent the amount of gasoline (in gallons) and electricity (in units of MWh) demanded assuming a fleet efficiency corresponding to the year in the latter part of the title. The fleet efficiency changes for conventional vehicles only. It's important to note that the gasoline demand is still presented for 2008, but with a fuel-efficiency based on a future year Therefore, to project demand for fuel into the future, first you need to pick the appropriate column. If the future year you are seeking is not provided in the table, then interpolate. The resulting value should then be scaled to future demand using Equation 1.

For example, if you are projecting to the year 2022 with a 50% penetration of PEVs, then you would look in the row where "ev.frac" is 0.5, and you'd interpolate between the values in the columns "total.gas.2020" and "total.gas.2030", or 38,897,002.27 and 38,578,968.64. The interpolation calculation would be the following:

$$38{,}897{,}002.27 + \left[(38{,}578{,}968.64 - 38{,}897{,}002.27) * \left(\frac{2022-2020}{2030-2020}\right)\right] = 38{,}960{,}608.99$$

Finally, the interpolated value would be scaled for population.

EFFICIENCY

See Zoellick (2011) Appendix C for a detailed description of the analysis conducted to make the estimates of efficiency presented in this sheet. The data in the EFFICIENCY sheet represent the average annual savings between 2010 and 2030 for a set of energy efficiency measures that are subsidized to a certain program level. The column titled "program.level" represents how much of the incremental cost of the efficiency measure is subsidized by a utility or government agency; this value ranges from 0 to 1. The columns “elec.savings” and “gas.savings” represent the amount of annual energy energy (in units of MWh for both columns) that would *not* be consumed throughout the County if the given program level were achieved.

It’s important to note that even with a program level of 0, there is still a substantial amount of efficiency savings. This is because we assume that even in the absence of a subsidy the efficiency programs would still be in existence (they are funded by the State of California and PG&E); and even without a subsidy, energy efficiency investments are usually cost negative investments (meaning they save more money than they cost over the lifetime of the investment). Therefore, some residents would adopt these measures without a subsidy, but as the subsidy increases, so the does the adoption rate and the energy savings.

To use the efficiency estimates, select the annual savings value corresponding to the program level you are investigating, then scale the value to the electricity demand shape for the year and then subtract each scaled value from the corresponding electricity demand in that hour. To scale the efficiency savings to the electricity shape, use the following formula:

$$Eff_i = Eff_{tot}\left(\frac{Elec_i}{Elec_{tot}}\right)$$

Where Eff_i is the efficiency savings in hour *i*, Eff_{tot} is the annual efficiency savings, $Elec_i$ is the electricity demand in hour *i*, and $Elec_{tot}$ is the total annual electricity demanded. The same scaling process can be used to substract natural gas savings from the hourly natural gas consumption data. Note that this approach assumes that efficiency savings are distributed throughout the hours of the year in direct proportion to the energy demand by hour.

REFERENCES

Zoellick, Jim, Colin Shepard and Peter Alstone. (Schatz Energy Research Center, Humboldt State University). 2011. ***Humboldt County as a Renewable Energy Secure Community: Resource and Technology Assessment Report.*** California Energy Commission. Publication number: CEC-XXX-2011-XXX.