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Managing Water in the West

Klamath Comprehensive Agricultural Power Plan

Initial Scoping Report

U.S. Department of the Interior
Bureau of Reclamation
Klamath Basin

April 2014

Mission Statements

The mission of the Department of the Interior is to protect and provide access to our Nation's natural and cultural heritage and honor our trust responsibilities to Indian Tribes and our commitments to island communities.

The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

Klamath Comprehensive Agricultural Power Plan

Initial Scoping Report

Prepared by

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Abbreviations and Acronyms

APLRP	Agricultural Peak Load Reduction Project
CAPP	Comprehensive Agricultural Power Plan
CEC	California Energy Commission
COPCO	California Oregon Power Company
CSP	Concentrating Solar Power
DOE	Department of Energy
DOI	United States Department of the Interior
EIR	Environmental Impact Report
EIS	Environmental Impact Statement
FERC	Federal Energy Regulatory Commission
FAR	Final Alternatives Report
Hp	horsepower
IAIR	Initial Alternatives Information Report
ITRC	Irrigation Training and Research Center
KBRA	Klamath Basin Restoration Agreement
KHSA	Klamath Hydroelectric Settlement Agreement
KID	Klamath Irrigation District
kW	kilowatt
kWh	kilowatt hours
LOPP	Lease of Power Privilege MW megawatt
MWh	megawatt hours
PV	photovoltaics
Reclamation	Bureau of Reclamation
SCADA	supervisory control and data acquisition
TID	Tulelake Irrigation District
VFD	Variable Frequency Drive
USACE	United States Army Corps of Engineers

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Chapter 1
Introduction

1.1 Background

The U.S. Department of the Interior (DOI) Bureau of Reclamation (Reclamation) Klamath Project is located in south central Oregon and northern California and provides water to approximately 210,000 acres of cropland in the Klamath Basin. It covers lands in Klamath County, Oregon, and Siskiyou and Modoc counties in northern California. The Klamath Project was authorized by the Secretary of the Interior in 1905.

In 1917, the California Oregon Power Company (COPCO), now PacifiCorp, and Reclamation entered into a 50-year contract for the construction and operation of Link River Dam on Upper Klamath Lake. COPCO built the dam and deeded ownership to Reclamation in exchange for the opportunity to use Upper Klamath Lake for hydropower generation. The contract protected irrigation rights and provided the Klamath Project water users with a reduced power rate. The contract was amended in 1956 for an additional 50-year period and became a provision of PacifiCorp's Klamath Hydroelectric Project Federal Energy Regulatory Commission (FERC) operating license.

The expiration of PacifiCorp’s FERC license and the power contract in 2006 ended nearly 90 years of reduced power rates for the Klamath Project and its irrigators. Since then, power rates have increased annually from 0.3¢ -0.6¢ per kWh to tariff rates of 10¢ per kWh in Oregon and 13¢ per kWh in California. With these rate increases, the average water pumping cost on the Klamath Project is now $45 per acre compared to an average power cost of $2.25 per acre prior to the power contracts expiration. These dramatic power rate increases have placed a financial hardship on Klamath Basin irrigators and jeopardize the sustainability of Klamath Basin agriculture.

The Klamath Basin Restoration Agreement (KBRA) and Klamath Hydroelectric Settlement Agreement (KHSA) were developed to address multiple water, power, and environmental issues within the Klamath Basin. Within the KBRA, the “Power for Water Management Program” identified several programs to provide affordable power to agricultural water users affected by the transition to tariff power rates. The Klamath Basin Task Force, created by Oregon’s congressional delegation in 2013 to address water and power issues in the Basin, concluded in its December 2013 draft report that replacing affordable power previously provided by PacifiCorp is critical to the economic sustainability of On-Project and Off-Project irrigators.

The increased power rates also have the potential to impact Klamath Basin wildlife through reduced flows to the Lower Klamath National Wildlife Refuge. Flows to the Refuge are delivered by irrigation canals and farm runoff associated with the Klamath Project; reductions in water use by Klamath Project farmers could result in reduced water deliveries to the refuge.

1.2 Problem Statement and Project Need

Increased power rates in the Klamath Basin as a result of the expiration of the 1956 power contract with PacifiCorp have resulted in an average 18-fold power rate increase per acre for Klamath Basin irrigators in a period of less than 10 years. This dramatic power rate increase has the potential to impair the Klamath Basin's economy and ecosystem through long-term reductions in agricultural output and water to the Lower Klamath National Wildlife Refuge. The KBRA includes multiple programs formulated to address these power cost increases and their potential impact on the Basin. The purpose of the Klamath Comprehensive Agricultural Power Plan (CAPP) is to support the KBRA's Power for Water Management Program (Section 17) that was designed, among other things, to provide affordable electricity to support the "efficient use, distribution, and management of water within the Klamath Reclamation Project and the National Wildlife Refuges, and facilitate the return of water to the Klamath River" as well as "provide power cost security to assist in maintaining sustainable agricultural communities in the Upper Klamath Basin."

1.3 Klamath CAPP Project Approach

Reclamation is undertaking the CAPP to develop and evaluate alternatives to reduce power costs for Klamath Basin irrigators. Through a collaborative and iterative planning process, Reclamation will evaluate the technical, economic, environmental and political feasibility of options that provide low cost power to the Klamath Basin. Options could include supplying Federal power, improving energy efficiency through renovation or reoperation projects, constructing new alternative and affordable energy sources, and establishing distribution and transmission arrangements to supply Basin power.

Reclamation has defined the CAPP process as three main steps:

1. Initial Alternatives Information Report (IAIR) – For the IAIR, Reclamation will identify and screen a comprehensive list of options to meet the CAPP purpose and need. The screening will include a preliminary technical and economic evaluation, as well as an analysis of policies governing agricultural power and compatibility of the options against each other. Based on the options screening evaluation, complete alternatives will be formulated that meet the irrigators'

power needs. Reclamation will estimate power costs under proposed alternatives and analyze the irrigators' "ability to pay" for power costs under the alternatives. Feasible alternatives will be carried forward into the next step of the CAPP planning process.

2. Final Alternatives Report (FAR) – Reclamation will further define and evaluate CAPP alternatives to carry forward into the environmental compliance process. The FAR will include preliminary design of selected alternatives and further economic and financial evaluations to determine an economically feasible alternative for the Klamath irrigators over a 50 year planning horizon.

3. Environmental Impact Statement and Environmental Impact Report (EIS/EIR) – The CAPP process will include an EIS/EIR that evaluates the potential environmental impacts of the proposed alternatives. Based on the EIS/EIR evaluation, Reclamation will issue a Record of Decision that identifies the preferred alternative for implementation.

Throughout the CAPP process, Reclamation will implement a Stakeholder Engagement Plan to provide stakeholders with the opportunity to provide input and feedback on the CAPP.

1.4 Purpose and Structure of this Report

This Initial Scoping Report is the first step of the IAIR. The purpose of this report is to verify the validity of the proposed CAPP process described above, including justification for the types of options being investigated and their effectiveness in reducing power costs or energy use. To achieve this purpose, the Initial Scoping Report documents case studies where irrigation districts in other locations throughout the west have implemented similar efficiency improvement or new power source development projects to reduce overall power costs and their level of success.

This report is organized in the following sections:

Chapter 2 presents the findings of a literature review of power cost reduction mechanisms available for use in the Klamath Basin including equipment renovation, project reoperation and the construction of new renewable, affordable power sources. Numerous case studies are presented where power efficiency improvement or new power sources were developed to reduce power costs.

Chapter 3 presents an assessment of the potential applicability in the Klamath Basin of the projects identified in Chapter 2. For new energy resources, existing studies were reviewed for solar, geothermal, wind, and small hydropower that assessed their resource availability and power generation potential in the Klamath Basin.

Chapter 4 summarizes key findings of the literature review and assessment of applicability in the Klamath Basin.

Chapter 5 lists references used in development of this report.

Chapter 2
Case Study Literature Review

A literature review was conducted to evaluate whether the proposed approach for the CAPP has been implemented in other areas and its level of success. The literature review focuses on existing projects or programs that include equipment renovation, system reoperation, and affordable energy development to reduce power usage and power costs. For purposes of the CAPP, energy efficiency projects fall into the following three categories.

- ***Equipment Renovation*** - Projects include upgrades or replacement of pump equipment and irrigation system components to improve energy efficiency and reduce peak loads. Equipment upgrades include those that replace old inefficient pumps, reduce the total pressure required from the pump or reduce pump power requirements. Equipment renovation can also include replacement of a group of pumps with a single, large, energy-efficient pump. A primary objective of equipment renovation is to maintain high pump efficiency.

- ***Water System Reoperation*** - Water system reoperation is similar to equipment renovation in that the focus is on improving efficiency of irrigation distribution systems, including pumping plants. Water system reoperation projects are distinct in that they affect the timing and movement of water and volume of water pumped through improved scheduling and operations. This can include Variable Frequency Drives (VFD), supervisory control and data acquisition (SCADA), reregulating reservoirs, or recirculation.

- ***Affordable Energy Development*** – At this time, affordable energy development is focused on low cost renewable energy, including low-head hydropower, wind, solar, geothermal and biomass.

It is important to note that many projects in the literature review, particularly those in California, emphasized peak load reduction together with a general reduction in energy usage. Developing power reduction strategies or new power development projects that are mindful of the peak load will be important in the CAPP. Off-peak power is the least expensive power and irrigators generally have a high level of flexibility for power use during a 24-hour period. Reducing peak usage will also reduce the size of any new energy projects that might be developed for the CAPP.

2.1 Reoperation and Renovation

The literature review found many examples of water districts implementing power and water management projects that include renovation and reoperation. Generally, where water districts or agencies were seeking large reductions in power or water usage, they used a combination of reoperation and renovation strategies. The case studies provided in this section therefore include a discussion of both reoperation and renovation projects. This is consistent with the proposed approach for the CAPP in which options will be evaluated individually, but will likely be combined into initial alternatives that include renovation, reoperation, and energy development. A separate section discusses the value of system automation through the use of SCADA and VFDs.

2.1.1 Case Studies

Agricultural Peak Load Reduction Program (APLRP)

The California Energy Commission (CEC) developed the APLRP in June 2001, under the authority of California Senate Bill 5x. The primary goal of Senate Bill 5x was to reduce peak period electric demand throughout California. The California Polytechnic State University Irrigation Training and Research Center (ITRC) administered the program from 2001 to 2004, which included various projects to implement agricultural energy efficiency measures in California irrigation districts. The APLRP is a good example of how renovation and reoperation project can reduce power usage. It was considered an extremely successful program by CEC and the participating districts (ITRC 2005a).

The APLRP incorporated over 50 megawatts (MW) of peak load reduction into Categories 1 and 3, and an estimated 16 million kWh of energy saved per year through Category 2, from a $6.5 million investment from the State of California (ITRC 2005a). Table 2-1 summarizes APLRP categories and example projects. Below the table are two water districts case studies that participated in the APLRP.

Table 2-1. APLRP Categories and Example Projects

Category	Description	Examples of Projects
1	High Efficiency Electrical Equipment/ Other Overall Electricity Conservation Efforts	• Expanding buffer reservoirs to supply water users during the peak period (12 p.m.-6 p.m. M-F) • Installing variable frequency drives • Replacing groundwater well casings • Other innovative solutions
2	Pump Efficiency Testing and Retrofit/Repair	• Rebates for pump testing and retrofitting/repairs • Five ITRC-developed pump test training courses
3	Advanced Metering and Telemetry	• Installation of advanced metering and/or telemetry • Grants for participating in California Independent System Operator Demand Relief Program

Source: ITRC 2005a

North Kern Water Storage District

The North Kern Water Storage District encompasses 60,000 acres in the San Joaquin Valley in California. The district relies largely on groundwater for irrigation and uses nearly 10 MW of load during the peak water use season. The district implemented three projects to reduce peak load by nearly 9.9 MW. The first project included new storage reservoirs to supply water to users during the peak period. Groundwater wells were used during the off-peak period to refill the reservoirs. This project curtailed 5.1 MW of peak load. The second project involved rehabilitating wells with new lining, casing, and column pipes and equipping them with clock timers. The timers automatically shut the well off during peak periods. The district also made modifications to a siphon, pumping bays, and weirs to increase capacity of the regulating reservoirs to reduce peak period electrical demand. Seventeen telemetry sites were installed to monitor water levels in canals and reservoirs. This project curtailed an additional 3.3 MW of peak load. The third project was an expansion of the previous two and curtailed a final 1.5 MW of peak load. The district has estimated that the installation of regulating reservoirs and telemetry have saved water users $20-$30 per acre foot of received water from reduced power costs and also improved overall irrigation distribution system operation by providing additional flexibility. The total project, completed in 2004, cost approximately $2.65 million. The APLRP grant was approximately $1.5 million (ITRC 2005b).

Orange Cove Water District

The Orange Cove Water District supplies surface water from the Friant-Kern Canal to 28,000 acres of farmland in Fresno and Tulare counties in California. The district implemented two projects to reduce peak loads over 763 kW. The first project included the addition of remote system monitoring, measurement, and control components for sections of the water distribution system without monitoring. The equipment allowed real time monitoring of load, flow, and pump efficiency. The district reprogrammed the pump activation process so that the most efficient pumps would run the majority of operational hours. This project curtailed 637 kW of peak load. The second project equipped farmer-owned pumps with clock timers, flow control values, and time of use meters, constructed a regulating reservoir, and installed telemetry on the final portion of the distribution system. This project curtailed an additional 126 kW of peak load. The project resulted in reduced power costs associated with load shifting to off-peak hours. The total project, completed in 2003, cost $383,334. The APLRP grant supplied $211,575 (ITRC 2005b).

Additional Case Studies

Due to both energy and water price and supply constraints, many water districts and agencies throughout the west have undertaken energy and water efficiency projects to reduce costs to water users. Table 2-2 lists additional examples to further show the extent to which renovation and reoperation projects have been

implemented for water savings and load reduction purposes. The projects identified here are just a sample of the total projects found during the literature review.

Table 2-2. District Examples where Renovation and Reoperations Resulted in Reduced Power Use

District	Project Description
East Columbia Basin Irrigation District	The district implemented a Pumping Plant Modernization Plan to replace aging equipment to improve conveyance system efficiency and energy conservation. Efficiency improvements were made by matching the amount of water pumped to the amount needed in the receiving lateral. As pumps were replaced, the equipment was sized to match the known demands and VFDs were included at most plants. The new units were fitted with high efficiency motors that add to the energy savings. These improvements resulted in less lateral spill and pumped water, and the pump units were more often operating within their higher efficiency flow ranges (East Columbia Basin Irrigation District 2005).
Lower Stemilt Irrigation District	The district constructed the Three Amigos Reservoir, a 100 acre-foot reregulating reservoir, to balance water storage between the reservoirs and allow the stored water to be moved between parts of the system. This reregulating reservoir helps the district avoid pumping water out of Stemilt Creek later in the year to meet irrigation demands. The quantity of water and power savings varies from year-to-year depending upon total water supplies and runoff conditions (RH2 Engineering 2010).
Roza Irrigation District	Over 47,000 acres have been converted from an open channel gravity delivery system with weir boxes to an enclosed pipeline gravity pressure system with in-line flow meters. Gravity pressure allows some irrigators to eliminate on-farm pumps while others receive enough pressure to reduce their pump and electrical costs by using smaller on-farm booster pumps (Sonnichsen 2014).
Lower Colorado River Authority	Under a Reclamation WaterSMART grant, the Authority implemented an improvement project that automated 11 new canal gate structures and installed a radio-based communication system to remotely operate the gates. The project also included a new SCADA system that automatically controls water levels and collects and displays real time canal data for system operation. The Authority estimated annual water savings of 2,560 acre feet and annual energy savings of 132,000 kWh, primarily through pumping reductions (DOI 2013).
Whitestone Reclamation District	Under a Reclamation WaterSMART grant, the district is installing a new high-efficiency booster pump station at its pumping plant. Installation is expected to save 12,343 kWh per year (DOI 2013).
Berrenda Mesa Water Storage District	Under the APLRP, the district increased the height of the existing 100-foot wide spillway on Berrenda Mesa Reservoir by 15 inches to accommodate an additional 15 acre-feet of storage capacity. Additional water is stored during the off-peak period for delivery during the peak period, saving 770 kW of peak load. Sediment removal in the reservoir also increased capacity and curtailed an additional 3,900 kW of peak load (ITRC 2005d).

2.1.2 SCADA and VFDs

The literature review found many examples of districts (agricultural and municipal) optimizing power use and reducing water use through SCADA (which incorporates telemetry, remote control/monitoring, and automation) and VFDs. Typical benefits of such projects include an increased level of service to

water users, reduced pump wear and increased pump efficiency, reduced labor costs, and energy savings.

The ITRC surveyed 30 agricultural water districts in the Central Valley of California to determine the present status, and current and future energy needs for irrigation water pumping. The survey was sponsored by CEC Public Interest Energy Research Program and results were summarized in ITRC's *Irrigation District Energy Survey Final Report, 2008.* The survey results show that many districts have already installed SCADA and VFDs to operate irrigation systems more consistently and with more flexibility. These were mostly applied to surface water pumps. The survey also found that real-time power monitoring and other SCADA system components represent a significant portion of planned future investments of the districts interviewed. Districts noted the importance of operating at the highest possible efficiencies and the capability to remotely monitor and control pump operations to ensure that the most efficient pumps are used (ITRC 2008).

Table 2-3 summarizes selected examples of agricultural and municipal district projects to improve distribution system efficiency though use of SCADA and VFDs.

Table 2-3. Example Projects where SCADA and VFDs Reduced Power Use

District	Project Description
Delano-Earlimart Irrigation District	The district has 14 VFDs and a SCADA system in place that allows remote and automatic monitoring and control of all district pump stations and reservoirs. With these technologies, the pumps automatically match a set point in the standpipe upstream of the pumps. A computer at the district monitors and collects data from the pump station and allows control from the district. With SCADA, the district analyzes the number of times the pumps are turned on and off, the number of hours pumps are running, and the flow rates delivered to determine pump sequencing, problems in pump, motor, or controls, and actual diversions relative to scheduled diversions (ITRC 2002).
Sutter Mutual Water Company	The Company pumps water from the Sacramento River in California. They installed one VFD and a SCADA system to remotely monitor and control canal water levels at one site. The VFD was installed to automatically match supply and demand without excess energy loss from bypassing the extra water from the pump station and to better manage fluctuations in Sacramento River water levels. A simple control algorithm was used to automatically control the water level in the downstream open channel (ITRC 2002).

Table 2-3. Example Projects where SCADA and VFDs Reduced Power Use

District	Project Description
Covington Water District	The District has a potable water system with 10 pressure zones, 11 wells, 6 interties, and 4 booster pump stations. The water system pumping equipment was analyzed and energy signatures (kWh per million gallons pumped) developed for each unit. Software code was then developed for the District's SCADA system to evaluate the real-time energy signatures of each pump available to a pressure zone, and automatically select the most efficient pump or pump sequence. The energy savings was 1,158 kW or 37.3 percent of power demand. The second energy efficiency measure evaluated the system for optimization of pressures and reservoir operating levels. Reducing the hydraulic grade of zones to match demand and required delivery pressures added additional energy savings. The cumulative savings of using the most efficient pump sequence and lower hydraulic grades was 1,458 kW or 47.9 percent of power demand (RH2 Engineering 2012).
Public Service Company of New Mexico	The Public Service Company of New Mexico operates the Buckman Direct Diversion system which includes a raw water intake structure and pumping station, several booster pump stations along a 13 mile long pipeline, and a membrane water treatment facility. An energy evaluation of lighting, HVAC equipment, motors, and VFDs was conducted to determine energy savings as a result of incorporating high efficiency equipment. The bulk of the energy savings were identified in association with the equipment used to drive the pumps, which consume the vast majority of the energy in the system. The evaluation demonstrated that variable speed pumping reduces the pumping equipment energy consumption by approximately 25 percent as compared to constant speed pumping. For the six largest pumping systems included in the evaluation, an annual energy savings of approximately $55,000 is realized with variable speed operation. Use of premium efficiency motors throughout the project results in an energy savings of approximately $30,000 annually. The overall annual energy savings demonstrated for the project was $93,000 through use of energy efficient equipment (CDM Smith 2012).

2.2 Affordable Energy Development

The literature review found many case studies where agencies or districts are focused on renewable energy development as a low cost, clean power source. Renewable energy development is also consistent with federal and state objectives for clean energy. Affordable energy development case studies were focused on low head hydropower and other renewables, including wind, solar, geothermal and biomass.

2.2.1 Low-Head Hydropower

There has been significant research on the value of low-head hydropower at existing water conveyance facilities as a clean energy source. Reclamation completed the *Hydropower Resource Assessment at Existing Reclamation Facilities* report in March 2011 that evaluated 531 sites for hydropower potential and identified 70 sites (potentially comprising 225 MW of capacity and over 1 million MWh of generation) with a benefit cost ratio greater than 0.75 (Reclamation 2011). Within two years of the study's completion, there have been 10 Lease of Power Privilege (LOPP) projects and 18 Federal Energy

Regulatory Commission applications filed (USACE et al. 2012). A LOPP is a contractual right of up to 40 years given to a non-federal entity to use a Reclamation facility for electric power generation. It is an alternative to federal power development where Reclamation has the authority to develop power on a federal project. As a supplement to the resource assessment, Reclamation completed a *Site Inventory and Hydropower Energy Assessment of Reclamation Owned Conduits* in 2012. The results showed that more than 100 MW of potential capacity and more than 365,000 MWh of potential generation are available at 373 sites on Reclamation's existing canals (Reclamation 2012).

Low-head hydropower development has been a recent focus in the Deschutes Basin in central Oregon. Irrigation districts have evaluated existing water conveyance for hydropower potential and added 15.7 MW capacity of low-head hydropower generation. Some example projects within individual irrigation districts include:

- Central Oregon Irrigation District –The district replaced an open section of irrigation canal that experienced large conveyance losses with 2.5 miles of penstock pipe. The penstock pipe provides 110 feet of head to a new 5 MW vertical turbine unit. The project cost was $24 million and the facility is earning about $100,000 in yearly revenue, with proceeds expected to increase to $1 million annually after the project is debt free in about 16 years.

- Three Sisters Irrigation District – The district has piped over 40 of the 60 miles of open canal within the service area. Some pipelines provide pressurized water to farms, which eliminates the need for pumping stations. The district is also installing a small hydropower plant with a 0.7 MW capacity.

- Swalley Irrigation District – The District piped 5.1 miles of its main canal and several small laterals and constructed an in-conduit small hydropower plant with a capacity of 750 kW (Deschutes Basin 2014).

2.2.2 Non-Hydropower Renewable Energy

In addition to low head hydropower projects other renewable energy projects, particularly wind and solar, have been implemented and proven successful. Table 2.4 summarizes non-hydropower renewable energy projects implemented by irrigation districts found during the literature review.

Table 2.4. Non-Hydropower Renewable Energy Projects Implemented by Irrigation Districts

District	Project Description
South San Joaquin Irrigation District	In 2009, the district installed Phase 2 of a single-axis solar tracking system featuring thin-film photovoltaic cells. The 419-kilowatt system is the second phase of a 1.4 MW solar project that is saving the irrigation district nearly $400,000 a year in utility costs for its Nick C. DeGroot Water Treatment Plant located just east of the solar farm. The project's main goal is to stabilize electrical costs, which can spike substantially in summer months given local time of use metering. In addition to the project's annual electric bill savings, the solar energy systems provide the district with a hedge against rising electricity costs. The projects are connected to the state's electrical grid, which means the district is able to sell its surplus, peak-time energy back to the local utility (South San Joaquin Irrigation District 2012).
Truckee Carson Irrigation District	The district is installing solar panels on the roof of each check structure's concrete building. The solar panel will be connected to the grid through an inverter. The district estimates that the solar panel will provide approximately 1 kW to the grid. The electrical demand of the automation will be approximately 18 kW per month per check during the irrigation season. The solar panels will provide enough power to offset the power usage of canal automation. In 2011, the district installed a solar net metering facility at the district office and shop facilities. The solar project provides power to the grid year round, not just during the irrigation season (Truckee Carson Irrigation District 2011).
Modesto Irrigation District	The district invested in the 25 MW McHenry Solar Project, which includes a motorized array of solar panels mounted on short poles to track the sun's daily path. The district is in a 25-year purchase power agreement with the facility owner. The project generates power to meet about 2 percent of the district's energy needs. The district also has wind power contracts in Solano County, California and in Oregon and Washington (Modesto Irrigation District 2013).
Turlock Irrigation District	The district, located in the San Joaquin Valley of California, purchased a 62-turbine, 136.6 MW wind farm in Klickitat County, Washington along the Columbia River. The wind farm began operation in 2009. The district also has an interest in a geothermal power plant in Lake County, California that has a capacity of producing up to 6.8 MW. The district also installed a 70.7 kW array of solar panels atop a newly renovated parking structure. The district has 28 percent renewable energy (Turlock Irrigation District 2010).
Energy Trust of Oregon	Energy Trust of Oregon worked with a local farmer to install a 10 kW wind turbine mounted on a 120 foot tower on a 100-acre farm. The project is estimated to generate 15,600 kWh per year based on an average wind speed of 10.13 miles per hour. The expected electricity cost savings are $1,248 per year. An Energy Trust incentive, plus state and federal tax credits, can offset up to 50 percent of the costs of installing a wind turbine (Energy Trust of Oregon 2010).
City of Klamath Falls	The City is in a Known Geothermal Resource Area and uses geothermal water supplied from wells producing 200-220 degree water. The City operates a geothermal utility system which provides heating services to commercial and government buildings as well as geothermal sidewalk and bridge snow melt systems. The project reduces energy costs compared to alternate heating sources (City of Klamath Falls Undated).
Oregon Department of Energy	Oregon is implementing grants to support the Wood Energy Cluster Pilot Project, which is six clusters of energy projects that provide biomass heat and power to schools, hospitals, commercial and industrial facilities. The Oregon Wood Energy Cluster Pilot Project is a cooperative effort between the U.S. Forest Service, Bureau of Land Management, Oregon Department of Energy, Oregon Department of Forestry and Sustainable Northwest (Oregon Department of Energy Undated_a).

Chapter 3
Applicability to the Klamath Basin

Chapter 2 summarized many energy efficiency and renewable energy projects undertaken by water and irrigation districts throughout the western states. This chapter discusses these types of projects' applicability to the Klamath Basin. Reclamation will begin to identify energy projects, or options, available to the Klamath Basin as part of IAIR. Options to be considered include equipment renovation, water system reoperation, and affordable energy projects. This chapter considers, at a very conceptual level, the availability and effectiveness of implementing these options in the Klamath Basin based on existing information. Basin irrigators use in excess of 100 million kW hours annually with peak usage occurring during summer months. Replacing this large amount of power would likely rely on a mix of different power reduction or low cost generation strategies to meet the overall power needs of the Basin irrigators. The IAIR will further define and evaluate options and develop alternatives to meet the Basin's power needs.

3.1 Equipment Renovation

There are approximately 70 reserved and transferred pumping works in the Klamath Project with horsepower ranging from 2 horsepower (hp) to the largest at the D Pumping Plant at 3,650 hp. Many of the reserved and transferred works are old and there are no records of renovation. There are also approximately 2,648 on-Project and off-Project private pumps that move surface water (irrigate and drain water) and pump groundwater.

In 2012, Tulelake Irrigation District (TID) evaluated the D Pumping Plant for power use efficiency as part of a power and salinity management investigation. ITRC conducted the study to assess the power usage at TID and to develop options to manage salt accumulation in the Lower Tule Lake Sump 1A and 1B. The TID study concluded that between 2006 and 2011, the D Pumping Plant pumped an annual average of 39,000 acre feet (17 percent of TID's total pumping), and used an annual average of 3.7 million kWh (40 percent of TID's power usage). The D Pumping Plant's five pumps demonstrated efficiency ratings of between 64 percent and 71 percent (ITRC 2012). A power efficiency of 64 percent is poor and 71 percent is well below large high efficiency pumps available today that operate at levels above 85 percent. Renovating the D Pumping Plant with high efficiency pumps and motors that operate at 86 percent would result in a power use reduction on the order of 16-25 percent.

TID operates ten groundwater wells that pump 4 percent of the total water used for irrigation, but use 22 percent of the TID's total power demand. Groundwater pumping requires on average, ten times the kWh per acre foot of water pumped compared to the other pumps (ITRC 2012). TID's groundwater pumps and wells could be inefficient or could be lifting the water from deeper aquifer depths leading to high lift costs. Either way, efficiency testing is needed to understand the high power usage of groundwater pumps and wells.

Energy efficiency assessment of other reserved and transferred works and private pumps and wells in the Basin are likely to show similar results to those of the TID energy evaluation. If the D Pumping Plant serves as an example, high efficiency pump motors alone could reduce power consumption by up to 25 percent.

3.2 Water System Reoperation

Multiple water system reoperation projects were identified as effective in the literature review, including lining or piping canals, installing VFDs and SCADA, and constructing check structures and re-regulating reservoirs. As indicated in Chapter 2, VFDs alone can account for power saving of 25 percent and system reoperation can account for over 45 percent reduction in power usage.

The Klamath Project operations are not automated at the Project level. TID and Klamath Irrigation District (KID) have installed some automation on district canals and have limited telemetry or SCADA systems. TID and KID also have VFDs installed and operating on some district pumps. The Project and additional district facilities could likely benefit from improved scheduling, automation, and SCADA systems to improve energy efficiency. System automation could also allow operators to use and select pumps and pump sequences based upon the most efficient energy signature of the units, which can yield energy savings.

Re-regulating reservoirs could be used within the Klamath Project to capture spills or for load shifting purposes. For example, the use of reregulating reservoirs at the tail end of the D and G laterals in KID could be used to capture operational spills that are now diverted into drains and then re-pumped by TID. Re-regulating reservoirs were evaluated by KWAPA as part of the On Project Plan to reduce water use but were not evaluated for potential energy savings.

Canal lining and piping has been successful in some areas, such as the Deschutes Basin. Lining reduced water loss and piping eliminated pump stations and in some cases provided for small hydropower development. The Klamath Basin may not have high opportunity for such water and power savings opportunities from canal lining or piping. Canal lining can be very costly and

the irrigated region of the Klamath Basin has little topographic change, reducing the effectiveness of piping.

The power and salinity management investigation undertaken by TID evaluated reoperation of the D Pumping Plant and concluded that actively managing water in Lower Tule Sumps 1A and 1B through an altered delivery schedule to irrigators together with two new smaller VFD controlled pumping stations would "greatly reduce" the reliance on the District's largest energy user, the D Pumping Plant (ITRC 2012). The study also identified a direct correlation between rainfall events and pumping at the D Pumping Plant suggesting that integrating hydrology and water deliveries together with active storage in Sumps 1A and 1B could further reduce the reliance on the D Pumping Plant. Actively managing water in Sumps 1A and 1B could also provide additional water in dry years and largely eliminate the need for the groundwater wells in all but the driest years; between 2006 and 2011 wells were responsible for 22 percent of energy consumed but only provided 4 percent of the water volume delivered (ITRC 2012). Although the ITRC did not attempt to quantify the potential power reductions of TID reoperations involving the D Pumping Plant and Sumps 1A and 1B, eliminating groundwater pumping alone would reduce power use by 22 percent and a 50 percent reduction in the use of the D Pumping Plant would result in an additional 20 percent reduction in total power usage within TID (ITRC 2012).

If the TID study at the D Pumping Plant serves as an example of other Project or district operations, there should be many other reoperation opportunities to reduce power use in the Basin.

3.3 Affordable Energy Development

The case study review in Chapter 2 revealed that agencies have implemented numerous renewable energy projects to provide a new low cost energy source and also help meet state renewable energy objectives. This section describes potential opportunities for renewable energy development in the Klamath Basin based on availability of renewable energy resources. In particular, this section evaluates low-head hydropower, wind, solar, geothermal and biomass power potential. The National Renewable Energy Laboratory (NREL) has conducted significant research on renewable energy resource availability throughout the U.S. and developed maps to show the availability of resources. Appendix A includes the NREL maps for concentrating solar power (CSP), utility-scale solar photovoltaics (PV), onshore wind, geothermal, and biomass resources.

3.3.1 Low-Head Hydropower

There are various opportunities for developing low-head hydropower in the Klamath Basin that could be developed to supply local power needs for the CAPP.

Keno Dam

PacifiCorp's Keno Dam is located on the Link River, approximately 20 miles downstream of Link River Dam. The dam controls Keno Reservoir, the upper end impounded reach of the Klamath River (U.S. Fish and Wildlife Service (USFWS) 2013). The KHSA calls for transferring ownership and operation of Keno Dam from PacifiCorp to the Department of the Interior. Hydropower was never installed at this facility; however, an affirmative Determination by the Secretary of the Interior would allow the installation of low-head hydropower at Keno Dam on the order of 5 to 10 MW.

East Side and West Side Facilities

PacifiCorp's East Side and West Side Powerhouses are located on the Link River, and receive water diverted into canals on each side of the Klamath River at Reclamation's Link River Dam (USFWS 2013). PacifiCorp's East and West Side facilities were proposed for decommissioning in the 2004 relicensing application because the facilities lack fish screens for short-nose and Lost River suckers. These facilities could be refurbished with a diversion off Reclamation's A Canal eliminating the need for fish screens (Reclamation operates a fish screen on the A Canal). These facilities could produce a very dependable 4 MW of power.

Klamath Project Facilities

The Klamath Project has existing dams and diversion dams without existing hydropower facilities. Reclamation evaluated the opportunities for low-head hydropower development at these facilities (Reclamation 2011). Table 3-1 summarizes the Klamath Project dams and diversion dams evaluated for hydropower potential and the results of the reconnaissance level resource assessment. The evaluation indicated little to no hydropower potential at the sites but where it did exist the development benefit/cost ratios were not economically viable.

Table 3-1. Hydropower Potential at Klamath Project Facilities

Facility	Description	Hydropower Potential Results
Anderson Rose Dam	On the Lost River in Klamath County, OR. The dam diverts water to the Tule Lake bed.	Design head: 12 ft Design flow: 40 cfs Installed Capacity: 29 kW Annual Energy: 126 kWh Benefit/Cost Ratio: 0.21
Clear Lake Dam	On the Lost River, in Modoc County, CA. The facilities provide storage for irrigation and reduce flows into the reclaimed portion of Tule Lake. It also functions to reduce flows into the Tule Lake Sumps in the Tule Lake National Wildlife Refuge.	The evaluation determined that there is no head available for hydropower development at this site.
Gerber Dam	On Miller Creek, in Klamath County, OR. The facilities provide storage for irrigation and reduce flows into the reclaimed portion of the Tule Lake and the restricted Tule Lake Sumps in the Tule Lake National Wildlife Refuge.	Design head: 35 ft Design flow: 112 cfs Installed Capacity: 248 kW Annual Energy: 760 kWh Benefit/Cost Ratio: 0.14
Link River	On the Link River, at the head of the	The evaluation determined that

Table 3-1. Hydropower Potential at Klamath Project Facilities

Diversion Dam	Klamath River, west of the Klamath Falls, OR. The dam regulates flow from Upper Klamath Reservoir. Water flows through the canal to the Klamath Project and refuges.	the site has no effective head and water is rarely put down the river. There is no generation potential at the site.
Malone Diversion Dam	On the Lost River, approximately 11 miles downstream from the Clear Lake Dam. The dam functions to divert water to serve lands in the Langell Valley.	Design head: 8 ft Design flow: 95 cfs Installed Capacity: 44 kW Annual Energy: 147 kWh Benefit/Cost Ratio: 0.07
Miller Dam	On Miller Creek, approximately 8 miles below Gerber Dam. The dam diverts water to serve lands in Langell Valley.	Data indicates there is approximately 5 ft of head available at this site, not enough head for hydropower development

Source: Reclamation 2011

As noted in multiple case studies in Chapter 2, districts have taken advantage of existing drops in canals for in-conduit hydropower projects. In the Klamath Basin, KID installed and operates a 900 kW hydropower facility at Klamath C Canal Drop (Reclamation 2014). KID is investigating operational changes to increase water passing through the hydropower unit. As part of the hydropower resource assessment, Reclamation evaluated hydropower potential at vertical drops on existing conduits in the Klamath Project. For each site, flow was available seven months of the year. Table 3-2 summarizes the results of this evaluation. Economics were not evaluated for these facilities. The installed capacity at Klamath A Canal Headworks is comparable to the in-conduit facilities found in the Deschutes Basin case studies described in Chapter 2. There may be some opportunity for hydropower development at this site under the CAPP.

Table 3-2. Low-Head Hydropower Evaluation of Existing Reclamation Conduits in the Klamath Project

Canal Site	Design Head (ft)	Design Flow (cfs)	Installed Capacity (kW)	Annual Energy (kWh)
Klamath Station 48	18	250	329	845,138
Klamath G Canal Drop	12	310	266	911,343
Klamath D Canal Drop	7	255	118	401,799
Klamath A Canal Headworks	12	827	709	2,582,779
Klamath C Canal Spill	40	18	44	153,453

Source: Reclamation 2012

3.3.2 Solar Power

Reclamation has been working with NREL to determine the potential for wind and solar development on Reclamation lands. NREL has completed several recent studies, including *Renewable Energy Assessment of Bureau of Reclamation Land and Facilities using Geographic Information Systems* (May 2013) (NREL 2013a) and *Case Studies of Potential Facility Scale and Utility Scale Non-Hydro Renewable Energy Projects Across Reclamation* (May 2013) (NREL 2013b). The studies conducted utility- and facility-scale screenings. The utility-scale screening examined potential resource intensity for CSP, utility-scale solar PV, and onshore wind on Reclamation lands in the 17 western states. The screening only considered the available resource intensity and available land area. Other factors such as the availability of transmission, regional electricity wholesale prices, and regional demand for renewable electricity were not considered. The facility-scale screening evaluated 748 Reclamation properties for potential use of solar vent preheating, PV, and wind technologies. The facility-scale analysis only considered the renewable energy resource and not local electricity prices or available incentives. The NREL study concluded that no Reclamation areas in the Klamath Basin counties of Oregon and California met the minimum resource requirement for CSP or utility-scale PV (NREL 2013a).

Reclamation has determined that facility-scale solar power is most feasible when energy prices are high, near $0.09-0$0.10/kWh, the amount of sunlight ranges from 275-300 days per year, incentives are available, and sufficient space is available. Utility-scale solar power has similar factors for feasibility, in addition to requiring available transmission capacity to deliver energy to the grid (Reclamation 2013). The Department of Energy (DOE) is currently implementing its SunShot Initiative, a national collaborative to make solar energy technologies cost-competitive for all markets with other forms of energy by reducing the cost of solar energy systems by about 75 percent by the end of this decade. The department's goal is to reduce costs of utility-scale solar electricity to roughly 6 cents per kWh without subsidies, in order to encourage a large scale adoption of solar electricity nationwide (DOE 2011).

NREL has estimated PV solar resource potential throughout the U.S. (Figure 1 in Appendix A). Based on the evaluation, the Klamath Basin area could generate from 5.0 to 6.0 kWh/m^2/day of PV solar power. This is not as high as the southwestern U.S., which NREL identifies as a top location for solar power generation. Figure 2 in Appendix A shows CSP resource potential. The results are similar to the PV map. There are currently on average 230 days of sunshine annually in Siskiyou County, California and 216 in Klamath County, Oregon, which shows some potential for solar development in the Klamath Basin. Further evaluation of solar resources in the Klamath Basin considering factors not considered in the NREL study May 2013 may affect the feasibility of solar power development.

Pacific Power offers an incentive program for its customers in Oregon, California, and Washington. The Oregon Solar Incentive Program (OSIP) began in 2010 and a new enrollment period starts April 1, 2014. The initial enrollment was fully reserved and considered successful. KID and many of its customers installed solar panels under the OSIP. Pacific Power's California Solar Incentive Program began in 2011 and continues to offer solar incentives. For the most part, TID has not participated in the program for cost purposes.

3.3.3 Wind Power

As shown in Chapter 2, several California irrigation districts have been incorporating wind energy into their energy portfolios, primarily to meet renewable energy standards. Districts have purchased wind farms outside of their service areas and supplied the power to the grid. Some small-scale wind development has also been successful in reducing total energy costs.

NREL estimated wind speeds for wind power development across the U.S. (Figure 3 in Appendix A). Northern California currently experiences a range of wind speeds between <4.0 and 6.5 m/s. Southern Oregon currently experiences a range of wind speeds between <4.0 and 7 m/s (AWS Truepower and NREL 2010).

NREL further evaluated wind power development potential based on resource availability alone on Reclamation's lands. The Klamath Basin lands in California and Oregon have a potential of up to 200 MW of wind power, indicating that wind power might be applicable in the Klamath Basin (NREL 2013). Additional feasibility factors include energy prices, transmission costs, and land availability (Reclamation 2013).

3.3.4 Geothermal Power

NREL research has identified the Klamath Basin area as a favorable location for geothermal energy (NREL 2009). Figure 4 in Appendix A shows locations of identified hydrothermal sites and favorability of deep enhanced geothermal systems.

As described in Chapter 2, Oregon has been actively developing geothermal resources state wide. The city of Klamath Falls uses geothermal energy directly to supply heat for a district heating system. Geothermal sources in several other Oregon counties supply heat to buildings, swimming pools, resorts and for industrial uses. Resource uncertainty and high development and exploration costs are barriers to development of geothermal power. The location of potential geothermal sources in environmentally sensitive areas has also been a barrier to siting geothermal power facilities in Oregon (Oregon Department of Energy Undated_b).

3.3.5 Biomass

NREL research has identified the Klamath Basin area as a favorable location for biomass resources (NREL 2009). Figure 4 in Appendix A shows total biomass

resources by county throughout the U.S. The Klamath Basin counties rank at or near the top of the scale for biomass resources.

Potential opportunities to invest in biofuels energy exist within the Klamath Basin either through Reclamation's individual development of a biofuels plant, or through collaboration with the Klamath Tribes. The KBRA specifically calls for the management entity to evaluate the potential for development of a biomass energy project (Section 17.7.2 B) with the Klamath Tribes and KWAPA. The Klamath Tribes are currently in the process of developing a cogeneration biomass facility near Crater Lake in Oregon, at the old Crater Lake Mill site. The Klamath Tribes have already acquired the land for development and are partnering with the local forestry industry and forest managers to acquire a dependable feedstock of biomass from timber harvests. The Tribes indicate that biofuels are a "direct way of restoring the health of our forests (and) should help to stimulate forest land managers to thin overstocked tree stands and thereby reduce their vulnerability to wildfires and insect infestations." The Tribes anticipate a generation of 8 MW of electricity from their facility once it is complete (The Klamath Tribes 2008).

Chapter 4
Summary of Findings

The KBRA includes provisions for the development of a financial and engineering plan to identify specific renewable energy resources and energy efficiency measures to be developed or invested in (Section 17.7). The PacifiCorp tariff rates have resulted in an average 18-fold power rate increase per acre for Klamath Basin irrigators in a period of less than 10 years. The Klamath Basin Task Force concluded that replacing affordable power previously provided by PacifiCorp is critical to the economic sustainability of the Klamath Basin.

As a first step in defining an affordable power strategy, a literature review was conducted to evaluate whether the proposed approach for the CAPP has been implemented in other regions similar to the Klamath Basin and its level of success at reducing power rates. The literature review focuses on programs that include equipment renovation, system reoperation, and affordable energy development to reduce power usage and power costs. The results of the literature search were then reviewed in the context of their applicability within the Klamath Basin.

The literature review identified many programs within western agricultural districts and agencies that were undertaken to reduce power use and cost, and also identified programs that experienced reduced power use as a benefit of reduced water use through system reoperation. The largest example identified is the APLRP conducted by the CEC. This program resulted in over 50 MW of peak load reduction through agricultural system renovation and reoperation with incentives from the CEC. In addition to the APLRP, the literature review found many examples of districts instituting programs to optimize power use and/or reduce water use through SCADA and VFD pump motors to match the pumping to demand.

The literature review found many case studies where agencies are focused on renewable energy development as a low cost, clean power source. Many of the programs were undertaken in recent years to take advantage of renewable energy incentive programs and meet states' renewable energy portfolio standards.

A summary of the applicability of the major findings is summarized below and Figure 4-1 identifies some specific locations where these projects are possible in the Klamath Basin.

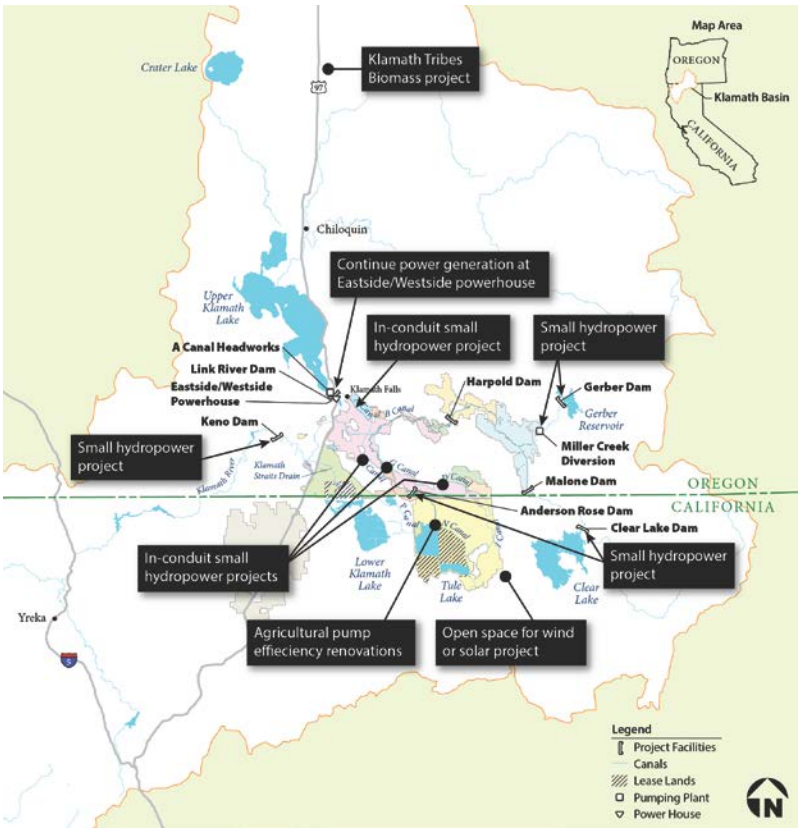

Figure 4-1 Potential Energy Efficiency and Renewable Energy Options in the Klamath Basin

System Renovation and Reoperation. The Klamath Project and the irrigation districts have little system automation and would likely experience power use reductions from the additional application of VFDs, SCADA and other system automation to more efficiently convey the timing and quantity of delivered water. Automation actions can result in power savings exceeding 45 percent as presented in Chapter 2. The Project's reserved and transferred works and the private pumps and wells are old, and have not been evaluated for power efficiency. Upgrades to more efficient equipment including replacement or renovation of inefficient water wells would likely provide substantial power saving to the Klamath Project irrigators. Efficiency studies at TID's D Pumping Plant suggests that upgrading to new high efficiency pumps alone would result in 16-25 percent power savings and eliminating reliance on groundwater wells would reduce total power usage by an additional 20 percent.

Low-head Hydropower. There are several opportunities for developing low-head hydropower in the Klamath Basin that could be developed to supply local power needs. These facilities include Keno Dam, the East and Westside power houses and several locations where in-conduit hydropower is possible.

Wind and Solar. Through NREL, Reclamation has evaluated the wind and solar development potential on Reclamation lands including in the Klamath

Basin. NREL's studies indicated that wind and solar power development in the Basin have moderate potential given average wind speeds, annual days of sunlight and available space. PacifiCorp OSIP was successful in KID and indicates potential for additional solar development.

Geothermal and Biomass. NREL conducted research on the applicability of geothermal and biomass in the Klamath Basin and rated both of these energy sources as favorable to highly favorable. In fact, the City of Klamath Falls is using geothermal as a heat source and the Klamath Tribes are developing Crater Lake Mill site to eventually generate 8 MW of biomass power from forest products.

The findings of this literature review suggest that there are renovation and reoperation improvements in the Klamath Project related to conveyance and pumping facilities that would result in power use savings to irrigators. Many irrigation districts in the west have already undertaken these types of improvement to reduce water and power usage. NREL studies show that there is moderate to highly favorable conditions for renewable energy alternatives including wind, solar, geothermal, and biomass in the Basin. Basin irrigators use in excess of 100 million kW hours annually and this large amount of power is more than any single alternative power project could provide along with renovation and reoperation. The CAPP would likely rely on a mix of different power reduction and generation strategies along with imported power to meet the overall power needs of the Klamath Basin irrigators.

Next Steps

Reclamation is currently developing the IAIR to identify initial alternatives for the CAPP. The IAIR includes various steps including 1) a baseline inventory to evaluate existing pump efficiencies and identify potential upgrades, including renovation and reoperation options; 2) a policy analysis to evaluate potential use of available Federal power in the Basin; 3) identification and technical evaluation of options; 4) economic and financial analysis; and 5) formulation of initial alternatives. The IAIR is expected to be complete at the end of 2014.

Throughout development of the IAIR and future CAPP document, Reclamation will implement a Stakeholder Engagement Plan that consists of technical workgroup, stakeholder, and public meetings to provide opportunities for input into the project tasks and to inform the public of the CAPP progress.

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Chapter 5
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Appendix A

NREL Renewable Energy Resource Maps

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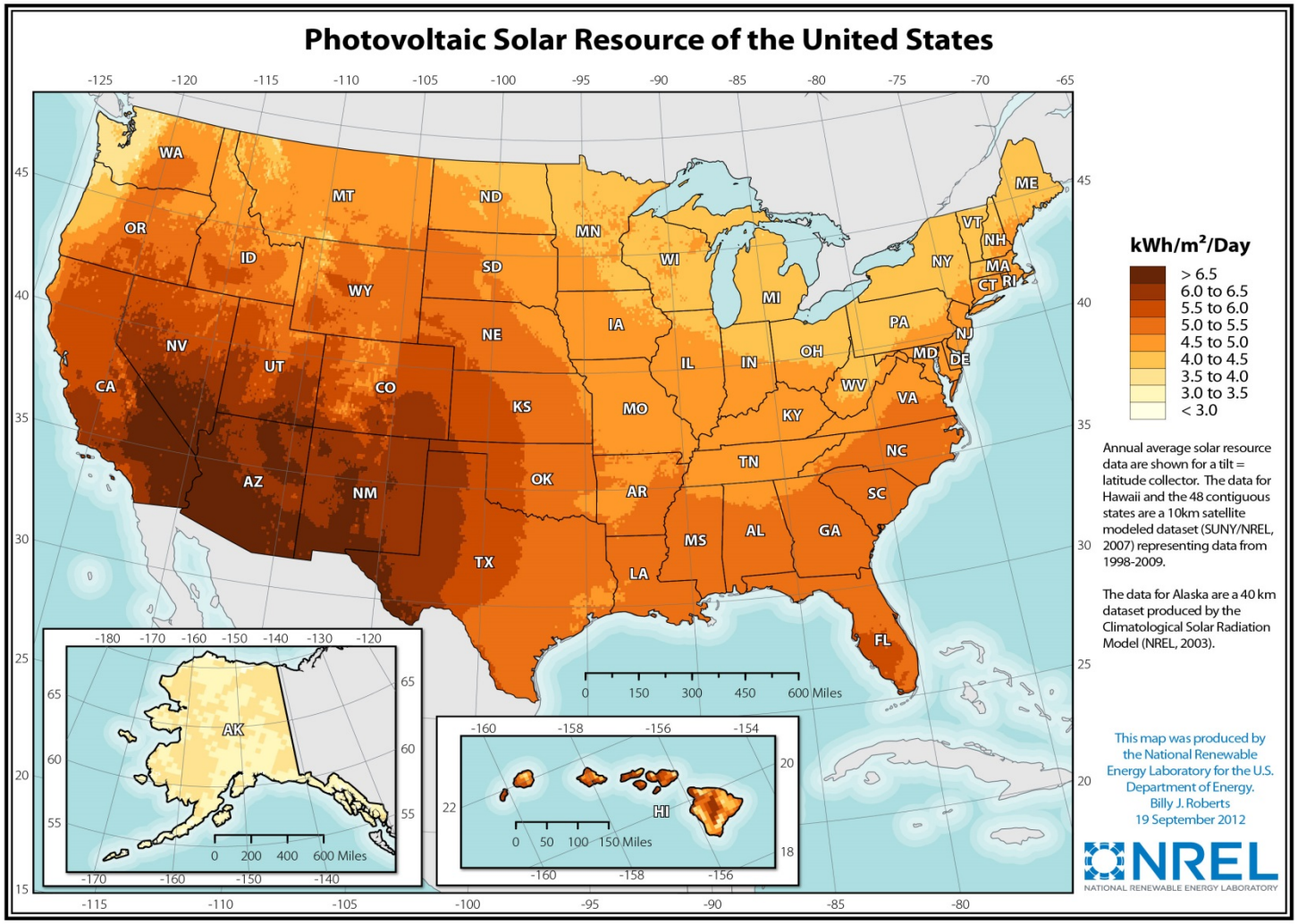

Figure 1 NREL Photovoltaic Map
(Source: http://www.nrel.gov/gis/images/eere_pv/national_photovoltaic_2012-01.jpg)

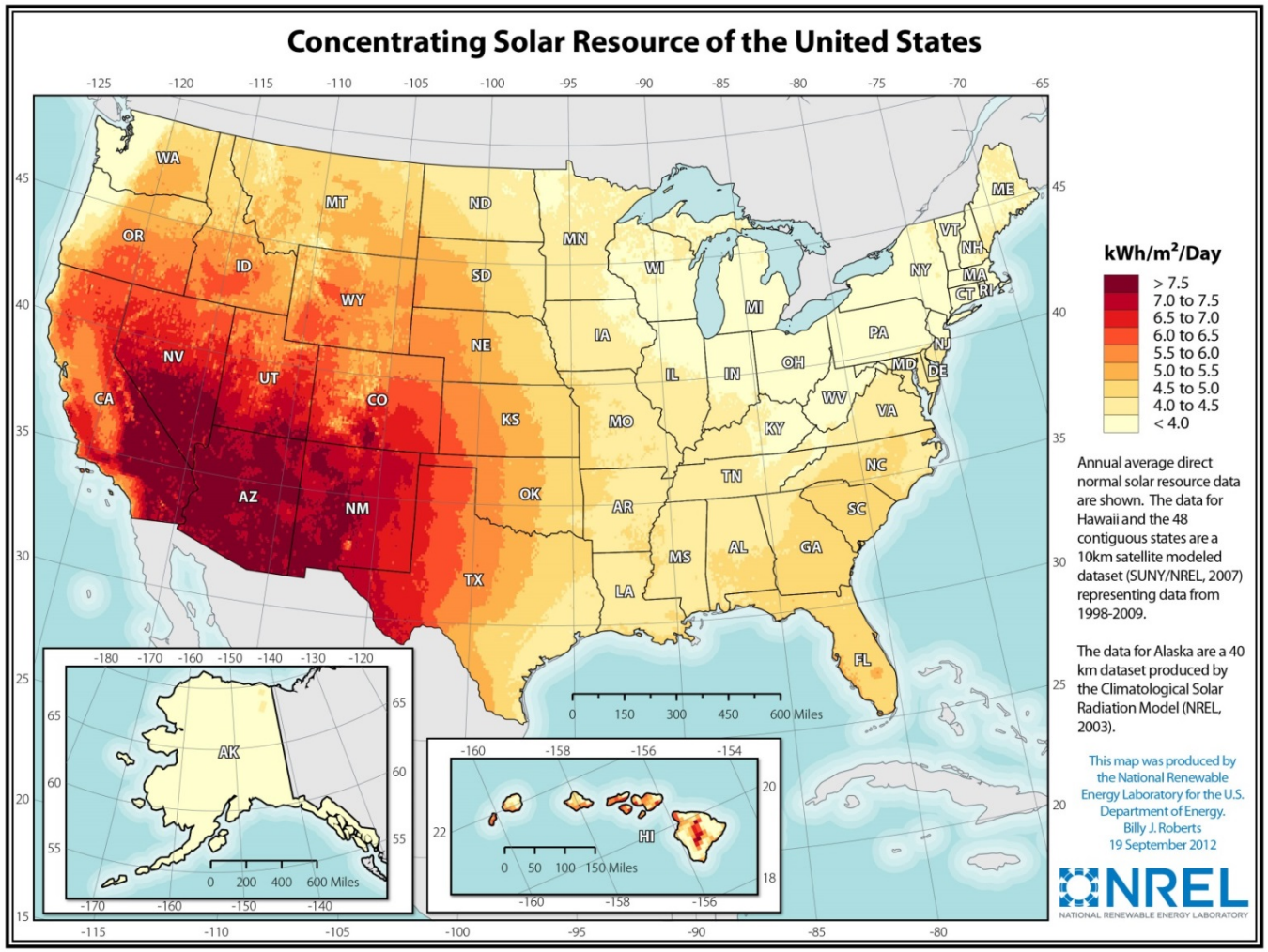

Figure 2 NREL Concentrating Solar Power Map
(Source: http://www.nrel.gov/gis/images/eere_csp/national_concentrating_solar_2012-01.jpg)

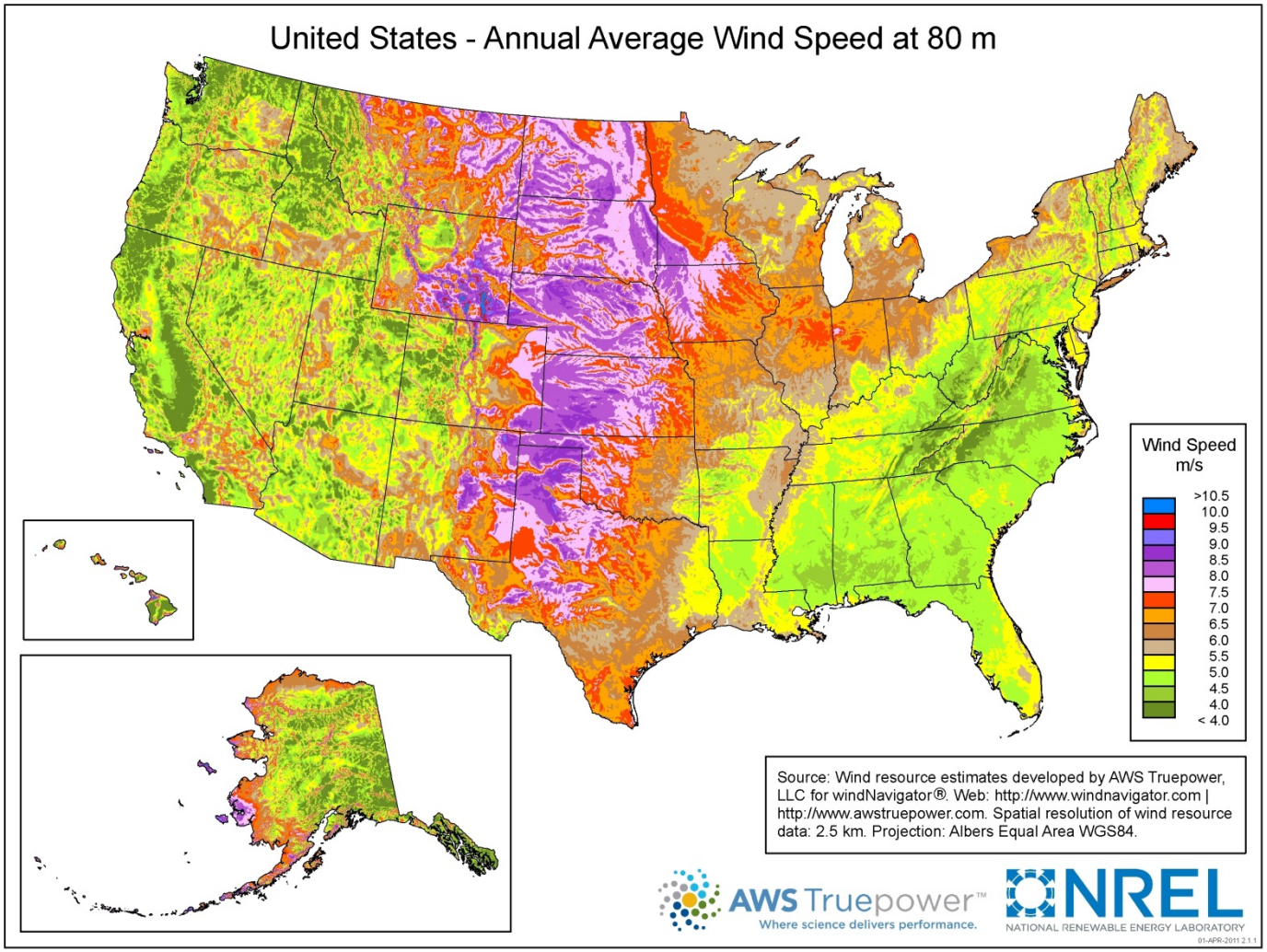

Figure 3 NREL Wind Resources Map
(Source: http://www.nrel.gov/gis/images/80m_wind/USwind300dpe4-11.jpg)

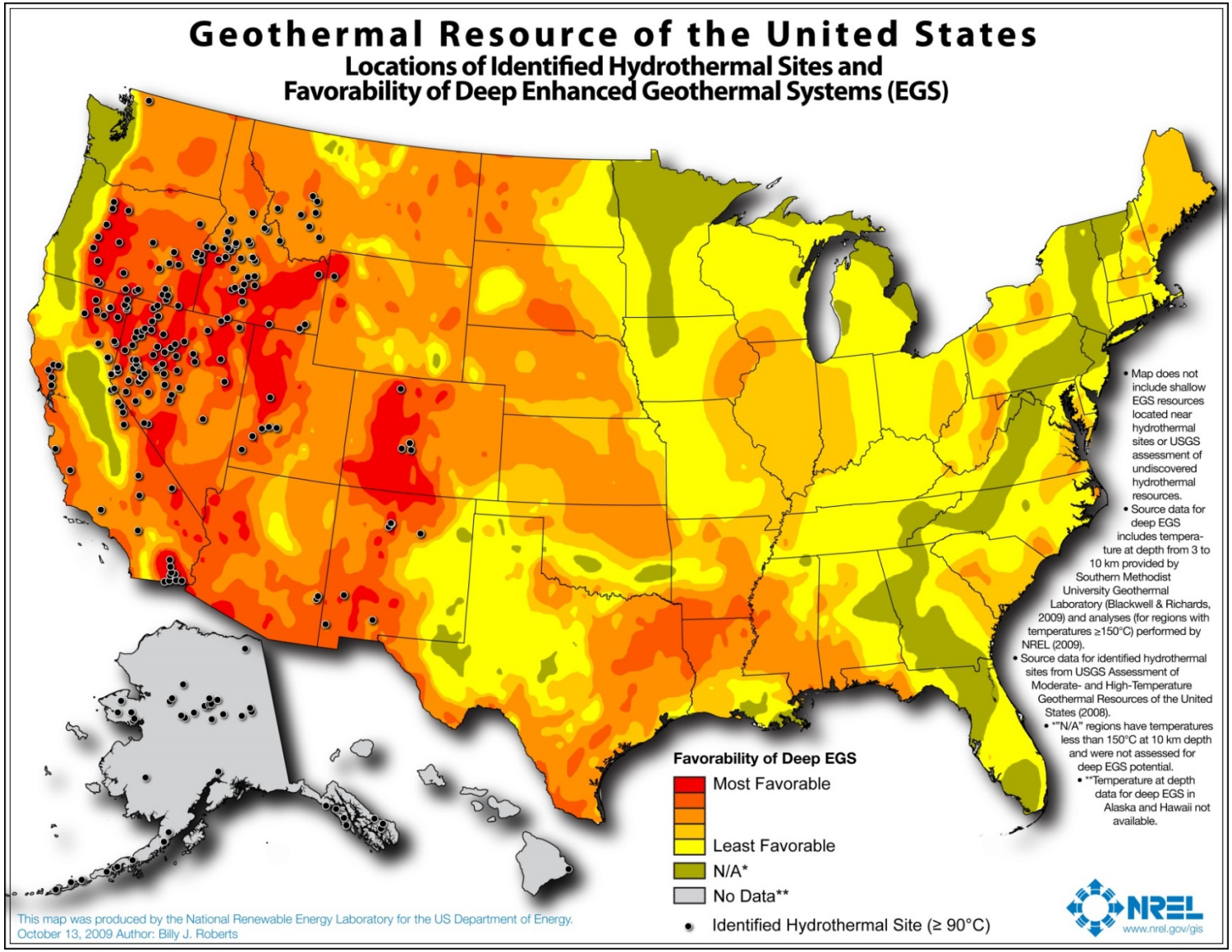

Figure 4 NREL Geothermal Resources Map
(Source: http://www.nrel.gov/gis/images/geothermal_resource2009-final.jpg)

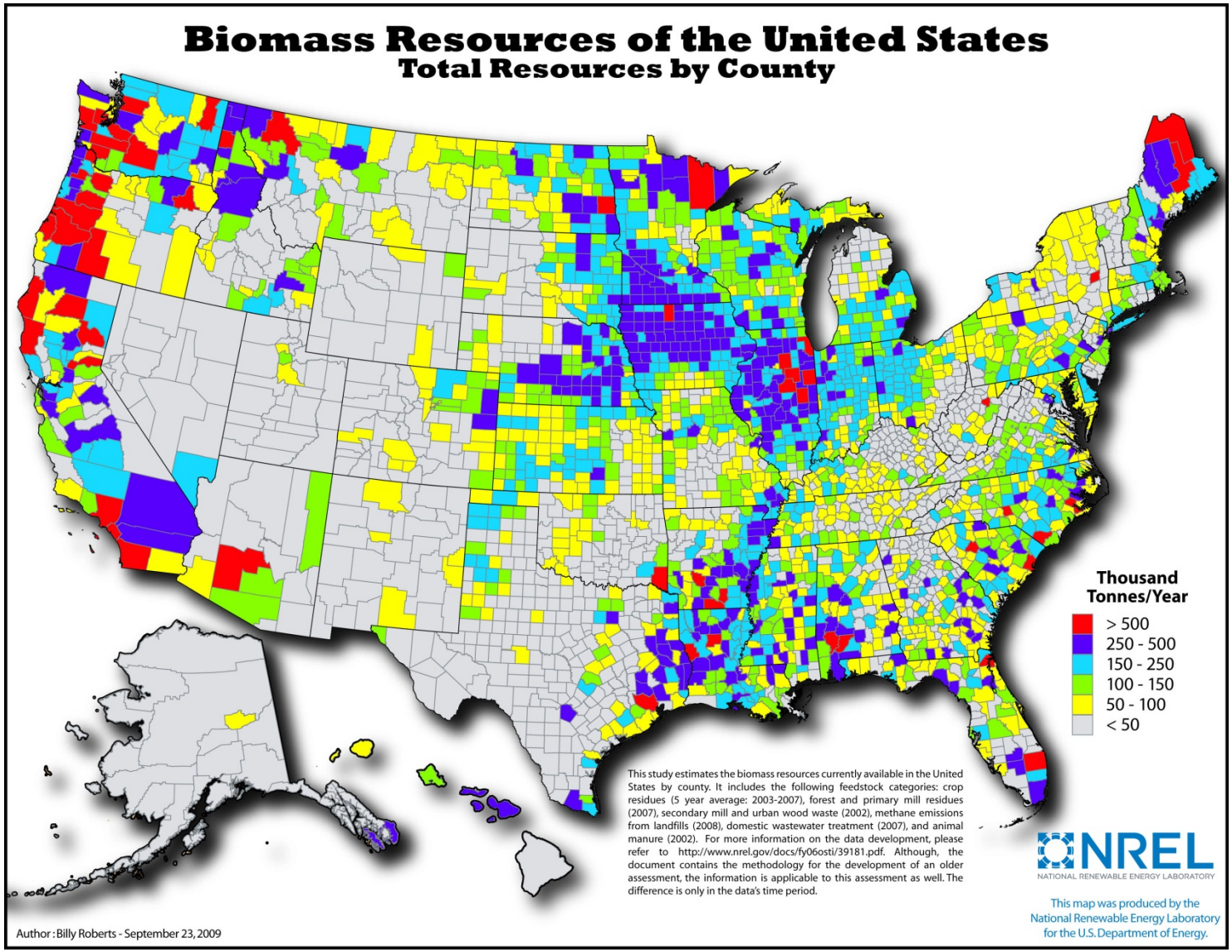

Figure 5 NREL Geothermal Resources Map
(Source: http://www.nrel.gov/gis/images/map_biomass_total_us_new.jpg)