Abstract

For decades, reliable low-cost electricity from Utah coal plants has attracted business investment to Utah while also creating jobs and economic development for the rural Utah communities that have mined this important resource for generations. But coal faces mounting challenges, both nationally and within the state of Utah. Already, the threat of a national carbon tax has caused most utilities—including Rocky Mountain Power in Utah—to abandon plans to build new coal plants. Furthermore, the US Environmental Protection Agency may begin regulating carbon dioxide emissions and is considering a number of other regulations on pollution that could force expensive retrofits at existing Utah coal plants. In Utah, coal is becoming more difficult and expensive to mine, and coal reserves near operating Utah mines are dwindling—with some forecasts showing depletion in little more than a decade. This has been recognized in the draft of the Governor's Utah Energy Initiative: "Given the current situation with coal as a primary fuel for base-load electric generation, Utah needs to develop every viable renewable energy project it can identify." All these factors add up to increasing risks for Utah's coal-based economy; these risks could run into billions of dollars, causing our economic engine to sputter unless we head them off.

The eUtah study shows that careful development of Utah's abundant renewable energy resources can provide a technically sound, economically feasible, and reliable long-term strategy to meet Utah's growing energy needs through the middle of the this century. Using technology that is commercially available today, Utah's wind, solar, and geothermal resources can be paired with utility-scale storage to provide the same level of reliability that electric utilities demand today. And if we are bold enough to pioneer the development of an intelligent and distributed electricity system that would use rooftops and passive buildings as much as large scale renewable resources, Utah has the resources to become the technological leader of the 21st century grid.

The least cost and lowest risk way to face the uncertainties of the present is to couple renewable energy and energy efficiency improvements with natural gas and compressed air energy storage. This strategy would save 20 billion gallons of water per year compared with one that employs nuclear energy and coal with carbon sequestration. Furthermore, using nuclear power to reduce emissions by about the same amount is the most financially risky approach, with nearly double the at-risk peak investment capital, compared to employing renewables plus natural gas.

Beyond consequences for Utah, our study shows that pairing renewable resources with energy storage allows renewable energy to provide 75 - 100% of a state's electricity needs, far beyond the 20 - 30% renewable energy goals already adopted and widely discussed by states and countries today.

Finally, we provide a roadmap for Utah's policy makers, leading research institutions, and entrepreneurs to begin tackling the challenges of such a 21st century grid; doing so will position Utah as a leading national and international energy innovator and a pioneer of arguably the most advanced electricity system in the world.

Designing a reliable renewable energy system

Utah possesses abundant renewable energy resources. These resources, their potential capacity in Megawatts (MW), and their general locations across the state have been identified in two reports compiled by the Utah Renewable Energy Zones (UREZ) Task Force. **Figure 1** is the UREZ II map showing wind, solar, and geothermal zones across the state of Utah, identified with black circles.

The UREZ II study identifies twenty-seven zones of the most economically feasible wind, solar, and geothermal renewable resources in the state. The total resources identified by UREZ include 14,696 MW of wind and 8,875 MW of solar. We selected only a subset of the total generation sites for inclusion in the eUtah study—six solar zones and twelve wind zones for a total generation capacity of 3,045 MW of wind and 8,167 MW of solar as the "unit" amounts to be fitted (with storage) to the demand curve for 2003.

We then associated these UREZ sites with actual solar radiation data and hourly wind speeds from nearby locations to calculate hourly energy production from these sites for every hour of the year. **Tables 1 and 2** show the UREZ sites that we selected, their power production capacity as identified by UREZ, and the location of the hourly meteorological data.

In this way, it is possible to not only say *how much* wind or solar can be generated at different sites across the state, but also *when* this power production actually occurs, on an hourly basis.

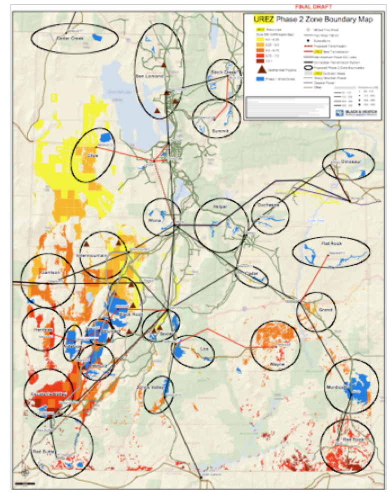


Figure 1. UREZ map showing renewable energy zones (black circles) across Utah

Tables 1 & 2. UREZ solar and wind sites paired with meteorological data for the eUtah study

UREZ Solar Site	**Hourly Data Site**	**UREZ Capacity (C_z)**
Clive	Wendover	1876 MW
Escalante Valley	Cedar City	2133 MW
Grand	Moab	226 MW
Intermountain	Delta	1564 MW
Red Butte	St. George	1164 MW
Wayne	Moab	1204 MW
Solar Generation Potential Total Capacity:		**8,167 MW**
% of Total UREZ Identified Solar Capacity (14,696 MW): **55%**		

UREZ Wind Site	**Meteorological Data from Site (Tower)**	**UREZ Capacity**
Black Rock	Cricket II	700 MW
Cedar	Elmo	250 MW
Cedar Creek	Snowville	315 MW
Duchesne	Duchesne	320 MW
Garrison	Garrison	120 MW
Helper	Soldier Summit	480 MW
Milford	Milford	860 MW
WGP Total Capacity:		**3,045 MW**
% of UREZ Total Capacity (8,875 MW): **34%**		

Defining Utah's need for electricity: the demand curve

A reliable energy system needs to deliver energy when people need it. The amount of electricity demanded by our homes, offices, and manufacturing plants is always changing, fluctuating as we switch on and off lights, power on and off our computers, and start up or slow down our industrial plants. Accordingly, our analysis starts with hourly electricity demand data for the state of Utah, visualized in **Figure 2** as a demand curve that rises and falls over an example week.

The eUtah study uses hourly demand data over an entire year (2003) as its starting point. The year 2003 was selected because hourly measured meteorological data for wind and solar was available in the same time frame.

The renewable baseload resource—geothermal power

The renewable resource most compatible with the old coal-based generation paradigm is geothermal energy. Unlike solar and wind generation, geothermal energy can be harvested around the clock and does not depend on the weather, making it a very attractive complement to wind and solar, reducing storage requirements. Of the 2,166 MW identified as potentially available by UREZ, we assume that just less than half will actually be developed by 2050. **Figure 3** compares geothermal production, represented in green, to Utah's hourly demand. It is evident that, as attractive as geothermal power is, other sources of renewable energy like solar and wind must play an important role in meeting the remainder of Utah's energy demand.

Figure 2. Utah's demand for electricity visualized over an example week—with base and peak indicated

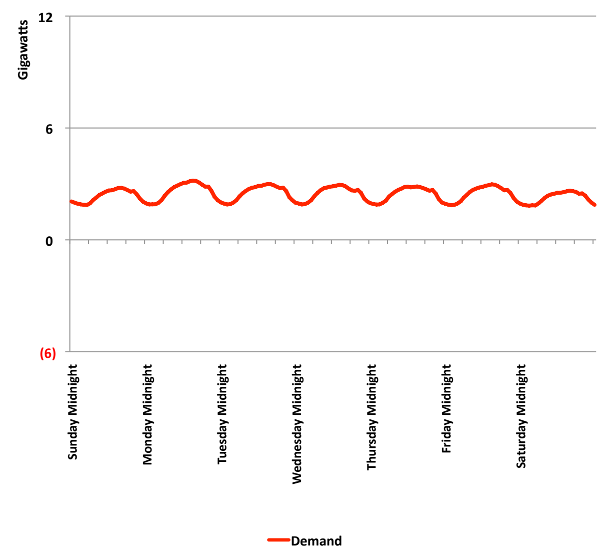
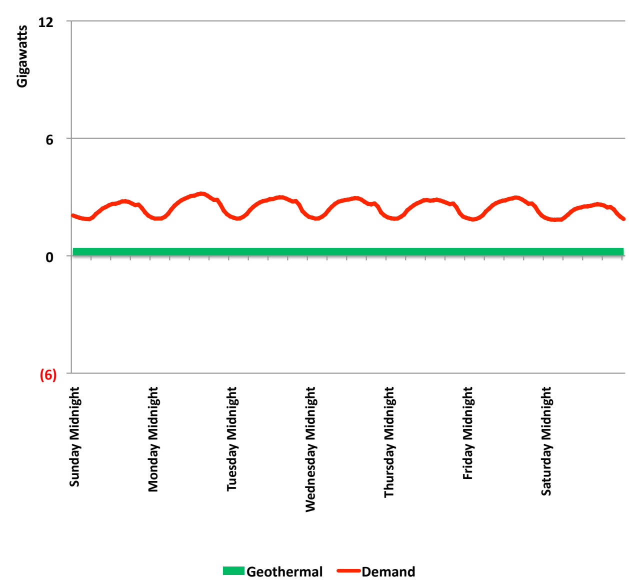


Figure 3. Geothermal energy provides steady, always-on power



Adding solar to the mix

Hourly production from a set of Utah's most promising solar resource sites is added to the graph in yellow in **Figure 4**. As expected, the solar resource comes online gradually in the morning, peaking during mid-day, and trailing off into the evening. Though the deserts of southern Utah are home to Utah's best solar resources, there are quality resources across the state, even as far north as Tooele County. This geographic diversity means that local generation can usefully complement centralized generation. Local resources, such as solar photovoltaic panels on rooftops, can provide as much solar generation for Utah as centralized utility-scale solar power plants over the next several decades. Distributed generation also helps minimize the impact of a passing cloud or local storm system. To accurately represent the hourly variation of solar resources across the state we calculated hourly production levels possible at these sites from measured solar radiation data.

Adding wind

Wind blows both day and night, so adding it to the system fills in a lot of gaps. **Figure 5** adds wind production in blue.

Having combined the output of geothermal, solar, and wind, renewable energy is able to provide the needed power in most hours of our example week.

The system also creates surplus energy at times, which as we will see later is very important. While this level of supply is quite large, it is not yet sufficient to function without support from conventional generation systems.

Figure 4. Adding a large component of solar meets much of peak day-time electricity demand

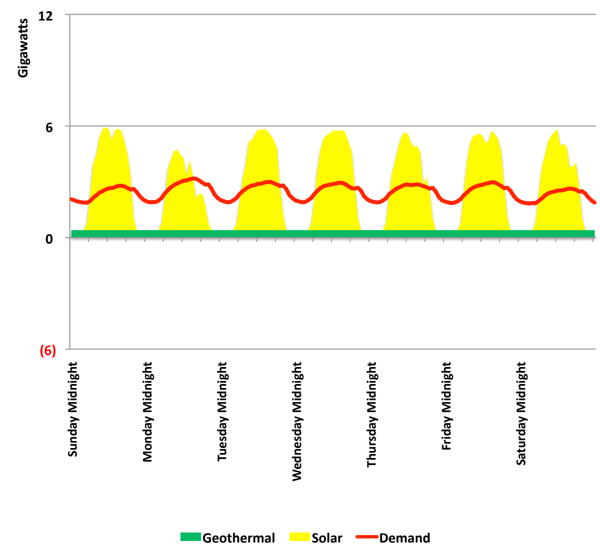
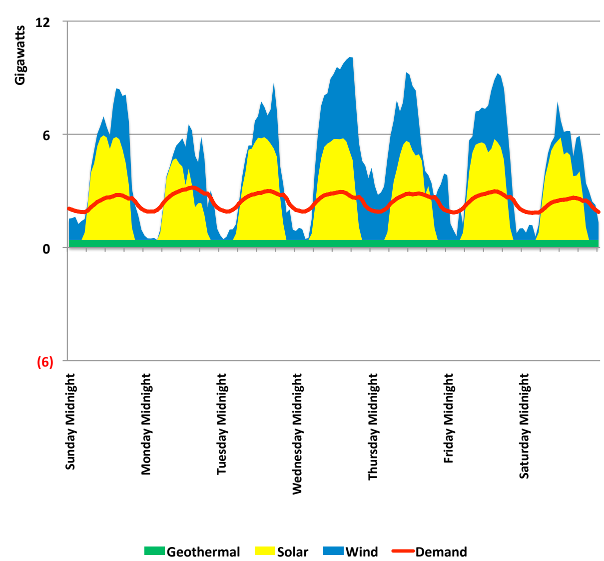


Figure 5. Wind contributes additional energy to the system, sometimes during the day, and sometimes at night



Energy storage—applying energy surpluses to deficits

In **Figure 6**, we highlight the hours where the renewable energy system is falling short of demand in orange.

However, there is a surplus of energy created most days, and that surplus is reflected in the purple outline that falls below the x-axis.

To make the renewable energy system *reliable*, we need to store the surplus energy produced during the day and apply that stored energy to the evening deficits to meet every hour of demand throughout the week.

In **Figure 7** we represent energy that is being supplied from storage in purple. See how the surplus energy made in the daytime is stored at the bottom of the graph and then applied to the energy deficits that occur mainly at night. This combination of storage and generation matched with demand is the basis for our design of a renewable generation system that reliably meets Utah demand.

One other important concept is "spilled energy." Spilled energy in the system results when renewable energy is generated that cannot be effectively used: it can neither be applied directly to supply the demand, nor can it be stored. Spilled energy results when energy surpluses occur at a time when the energy storage capacity is full and cannot accommodate any additional storage.

Generators must either be turned off, or the surplus must be sold outside the system or sold for applications such as pre-heating hot water, pre-cooling buildings in the summer, and pre-cooling refrigerators and freezers. The latter sales are the kinds of elements needed to reduce costs and begin creating an intelligent grid.

Figure 6. Energy deficits are identified in orange; surpluses are outlined in purple (below the x-axis)

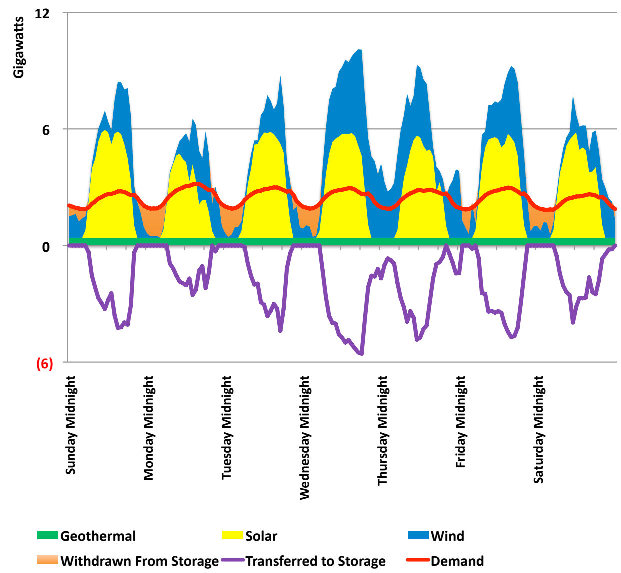
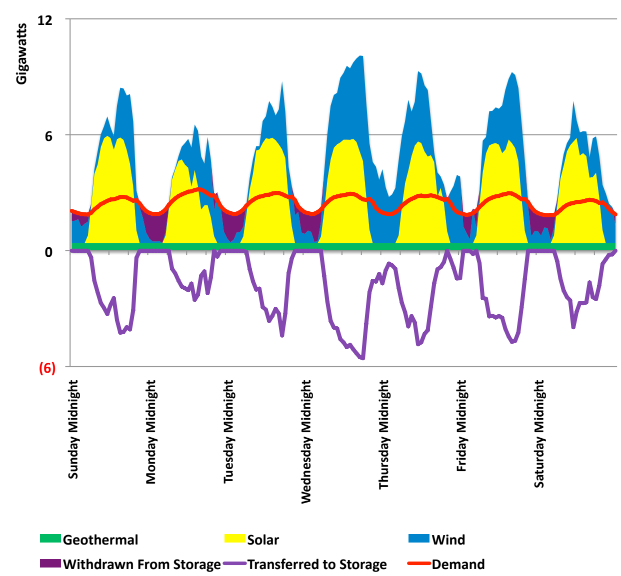


Figure 7. Energy surpluses are stored and then applied to energy deficits—turning the deficits from orange to purple



Compressed air energy storage—a utility-scale energy storage solution

Compressed air storage is familiar in a number of everyday contexts, for instance, in the use of air under pressure storage in cylinders to power tools in road repair and automobile garages. However, compressed air has also been stored in large underground caverns for the purpose of reducing the use of natural gas fuel in peaking gas turbines in electricity systems. Two large scale commercial Compressed Air Energy Storage (CAES) systems exist. The Huntorf plant in Germany has a capacity of 290 MW and has been in operation since 1978. The McIntosh plant in Alabama is 110 MW; it has been in operation since 1991.

The eUtah study uses CAES as the reference storage technology for the following reasons: it provides a large, utility scale storage option in the range of hundreds of megawatts of capacity; it is in commercial use in the United States and Germany; it can deliver needed energy quickly, with a startup time on the order of 10 minutes; it increases electricity costs only modestly, on the order of 3 cents per kilowatt hour (kWh) as estimated in this study; it is the focus of several national pilot and Research and Development projects; and a Utah company, Magnum Gas Storage, is looking at developing a CAES plant in salt formations near Delta, Utah. Utah has many potential locations for siting CAES storage caverns. Appliance and building efficiency standards, combined with an intelligent grid with local storage, can reduce the number of caverns needed, and also potentially reduce costs.

In the case of a renewable energy system, the air compressor would be operated when the total available supply (solar, wind, geothermal) is greater than the demand in any particular hour. The compressed air is stored in an underground cavern. The caverns at Huntorf and McIntosh are in salt formations which were solution-mined to create the storage volume needed. This is a well-understood technology, since compressed natural gas is often stored in solution-mined caverns. Additionally, compressed air can also be stored in aquifers—as a large bubble of pressurized air.

Since most of the natural gas use in a single-stage gas turbine is for compression of air, the amount of energy needed to reheat the compressed air is much smaller than the total needed to generate electricity directly using a peaking single-stage gas turbine. About 4,500 Btu per kWh of natural gas is needed to reheat the compressed air, compared to 11,000 Btu or so for a peaking natural gas turbine. Because re-generating the stored energy requires the input of natural gas, and entails some energy losses, the CAES system has an efficiency of about 75%.

Energy efficiency

Efficiency greatly improves the economics of all new generation, including the renewable energy scenarios considered in the eUtah study. In the context of the eUtah study, "energy efficiency" refers to advancements in appliance, building, and other technologies that allow for the same level of services, comfort, and productivity to be accomplished with a lower input of energy. The eUtah study only assumes energy efficiency using more advanced technologies; it does not assume any reduction in demand from behavioral changes like remembering to turn off the lights.

The high efficiency demand projection assumes that new buildings from 2013 onwards will have a purchased electricity footprint that is 50 per cent of the electricity footprint of the average of existing residential and commercial building stock in 2007. This is broadly comparable to the building code adopted by the University of Utah in 2010, which mandates a 40 percent reduction in energy use in new buildings (except hospitals) compared to the standard new building code.

Additionally, the high efficiency projection assumes that about 30% of residential electricity use can be eliminated through economical efficiency measures by 2030, at an average cost of about 3 cents per kilowatt-hour, based on estimates from the American Physical Society and a modest utility incentive program.

Using these measures, the high efficiency projection achieves reductions in both the total megawatt-hours (MWh) demanded by Utah energy consumers each year, as well as the peak megawatts. In the context of a renewable energy system, energy efficiency improvements that reduce the demand in these ways helps control energy costs by reducing the number of power plants that need to be built.

Five supply scenarios representing different strategies to meet Utah's growing energy needs

Although the eUtah study is unique because it evaluates a nearly-100% renewable energy supply for Utah, there are certainly other approaches to meeting Utah's energy needs over the next century. Consequently, the eUtah study examines five different approaches to meeting Utah's growing electricity needs through the middle of the 21st century; they are:

The eUtah 100% renewable scenario (Figure 8): This scenario relies almost totally on renewable energy sources by 2050, comprised of geothermal, solar, and wind energy, complemented with energy storage in the form of compressed air. Minimal natural gas is used to support generation from compressed air energy storage, resulting in carbon dioxide (CO_2) reductions of 95 percent relative to 2010. The high efficiency demand projection is used here. Demand rises to about 37 million MWh by the year 2050 in this scenario.

Renewables + natural gas (Figure 9): In this scenario, carbon dioxide reductions of around 70% are achieved relative to 2010 using solar, wind, and geothermal generation, supplemented by a significant amount of combined cycle power plants fueled by natural gas. The high efficiency demand projection is used here. Demand rises to about 37 million MWh by the year 2050 in this scenario.

Renewables + natural gas and carbon capture and storage (Figure 9): This is the same as the Renewables + Natural Gas Scenario, except that carbon capture and storage (CCS) has been added to natural gas combined cycle power plants in order to achieve carbon dioxide emission reductions relative to 2010 of 93 percent by the year 2050. The high efficiency demand projection is used here. Demand rises to about 37 million MWh by the year 2050 in this scenario.

Nuclear + coal with carbon capture and storage (Figure 10): This scenario provides an example of a conventional approach to carbon dioxide reduction and assumes that the structure of the present electricity sector, which is dominated by thermal plants, will continue, but with carbon reductions as an added goal. Natural gas plays a supporting role to coal with CCS and nuclear power, both in the form of combined cycle plants and single-stage gas turbines. The scenario results in approximately 70 percent carbon dioxide emission reductions relative to emissions in 2010 and 80 percent relative to the emissions in 2050 in the BAU scenario. A medium level of efficiency improvements, extending present utility planning for demand side management (DSM), is used with this scenario. Demand rises to about 42 million MWh by the year 2050 in this scenario.

Business-as-usual (Figure 11): The Business-as-Usual (BAU) scenario is a reference scenario that assumes the continued dominance of coal in the supply system. Existing plants are assumed to retire at 60 years, and are assumed to be replaced by new coal-fired power plants. A coal-to-coal scenario is useful because it allows us to compare the cost of the other scenarios as low-carbon alternatives. It also allows a calculation of the cost of limiting carbon emissions using different approaches. Finally it allows an estimation of the financial risk of sticking with coal and assuming no carbon constraints, in the event that such constraints are applied at various levels of carbon price or tax. No new efficiency or DSM measures are assumed. In this case, electricity generation grows to about 52 million MWh by 2050.

These scenarios are evaluated against each other for a variety of criteria, including cost, investment risk, and water consumption, through the middle of this century.

Figure 8. Installed Capacity in the eUtah Scenario

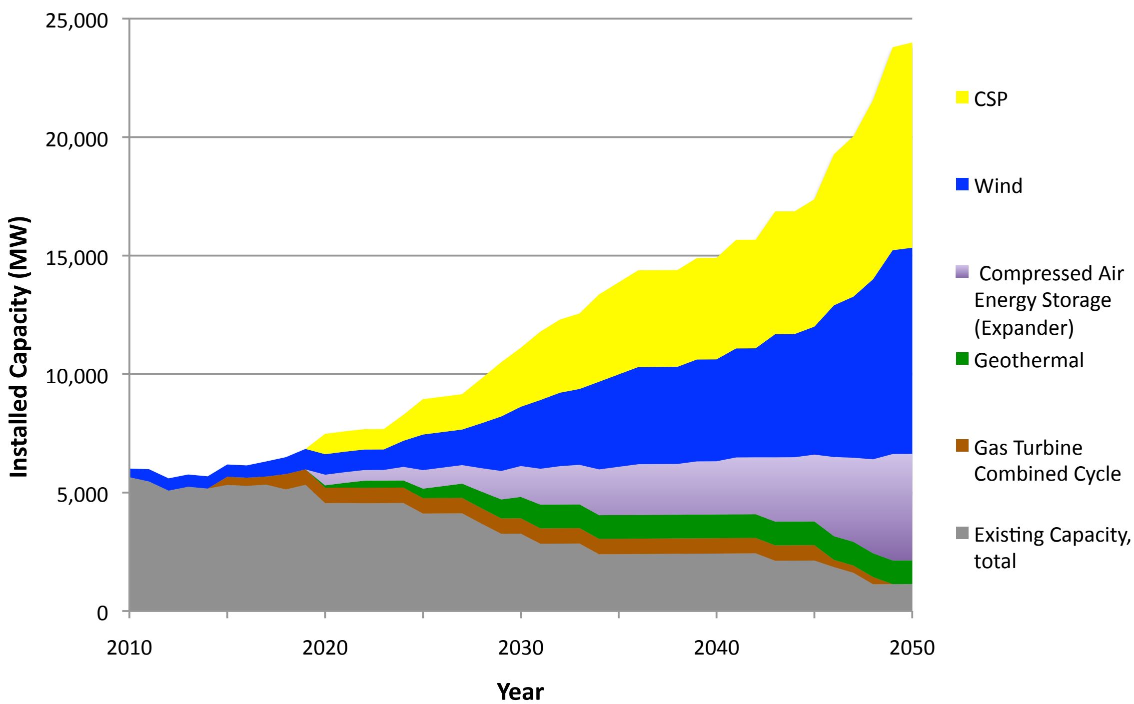


Figure 9. Installed Capacity in the Renewables + Natural Gas Scenario (and with CCS)

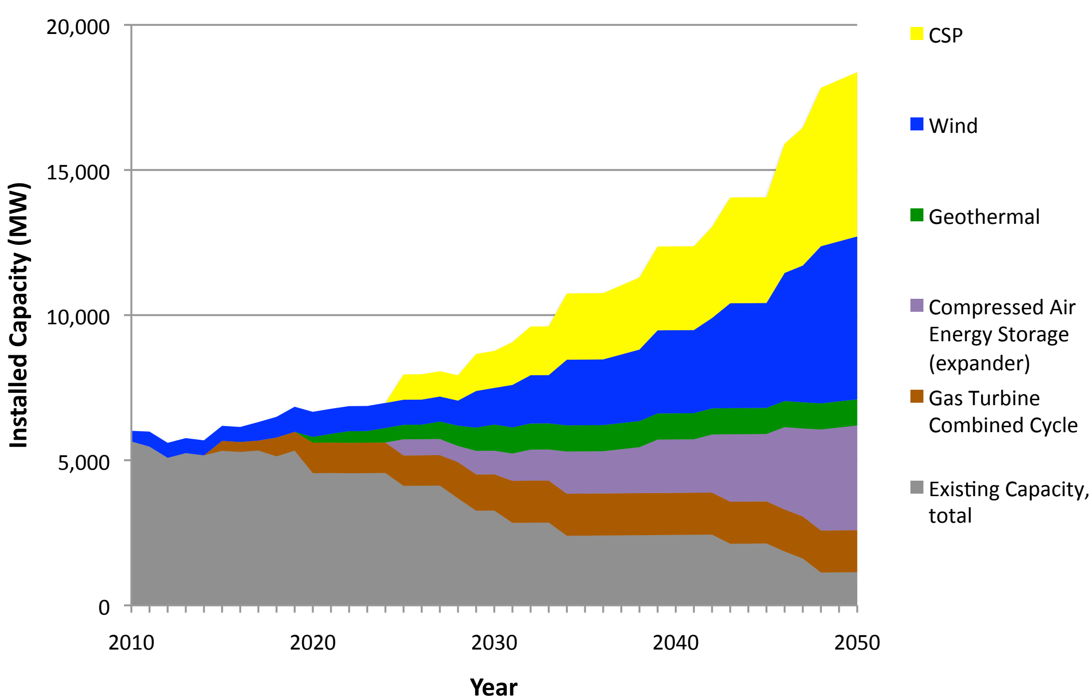


Figure 10. Installed Capacity Nuclear + Coal with Carbon Capture and Storage

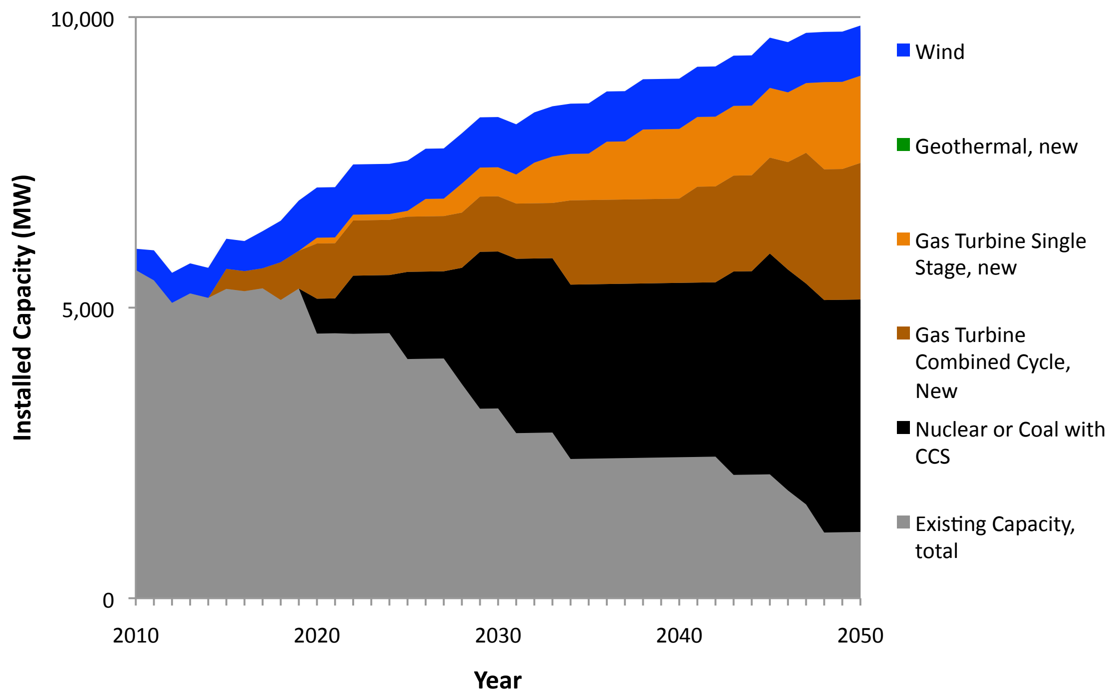
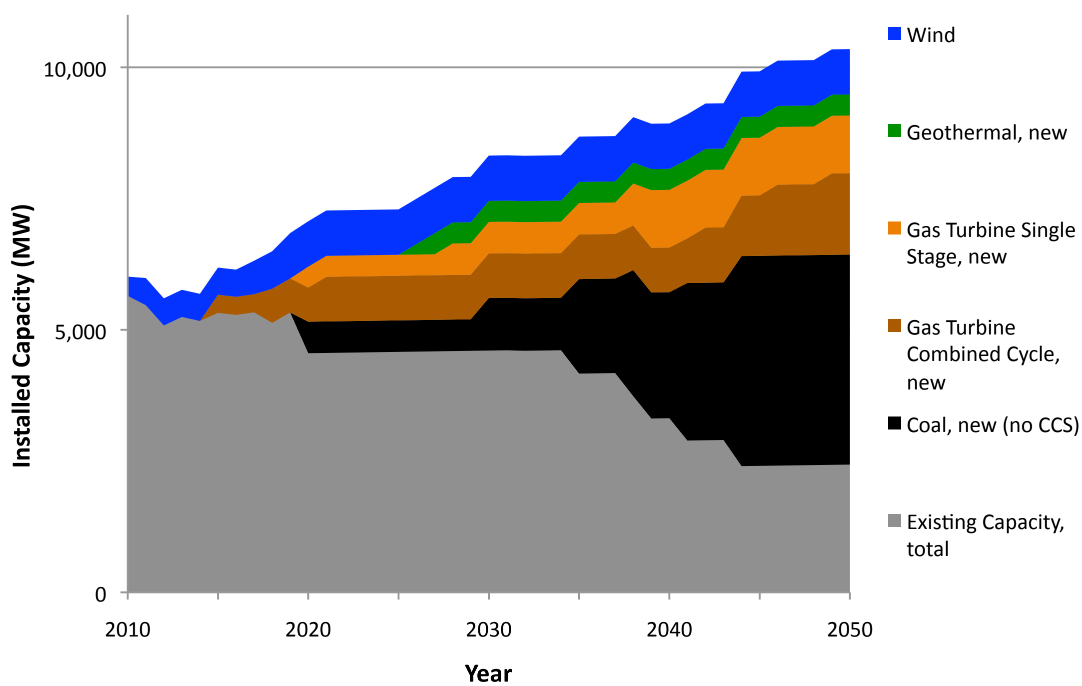


Figure 11. Installed Capacity in the Business-As-Usual (BAU) Scenario



Comparing alternative the alternative approaches—main findings

A transition to an essentially fully renewable and reliable electricity system in Utah is technically feasible with available and proven technologies. However, a centralized approach incurs significant added cost due to spilled energy—that is, energy that can neither be directly used, nor stored. The eUtah 100% renewable energy scenario results in annual spilled energy of about $1.4 billion annually in 2050, over 20 percent of the total. It is possible to reduce the amount of spilled energy, and the associated high costs, by incorporating elements of an intelligent grid, including distributed generation (like rooftop solar photovoltaics), distributed storage (like residential batteries, for instance), and smart appliances that know when to turn on at times when energy is most plentiful, and lowest cost and off when supply is low.

An energy portfolio consisting of renewable energy (75%), natural gas (25%), and energy storage, coupled with significant increases in energy efficiency, is the most cost-effective way to take the first steps to meet Utah's growing energy needs if we do not build new coal plants. This scenario uses a high penetration of renewable energy complemented with natural gas. It is compatible with creating an intelligent grid that will reduce spilled energy. The configuration also has lower spilled energy costs relative to the eUtah 100% renewable energy scenario by about $500 million annually by 2050. The Renewables + Natural Gas approach also represents the most cost-effective way to reduce carbon dioxide emissions when compared with the other approaches. Carbon dioxide emissions can be further reduced by 93 percent of 2010 emissions with carbon capture and sequestration of natural gas emissions, but at an additional cost of about $10 per ton of carbon dioxide. This scenario has the added benefit of only increasing total annual natural gas consumption by 13% relative to the amount of natural gas we consume in electrical generation today.

The risk of carbon-related costs is high, if Utah continues to rely on coal without carbon capture for its electricity generation. The costs of reducing carbon dioxide emissions are estimated to be in the $40 to $137 per metric ton range in the eUtah study. For carbon emissions costs of $45 per metric ton, toward the low end of this range (and the lowest non-zero value used by Utah's major utility in its investment planning), the present value of carbon emission costs in the 2020 to 2050 period in the Business as Usual scenario would be $10 billion. This risk is reflected in current investment practices among many utilities (including PacifiCorp) which, for the most part, are focusing on natural gas combined cycle plants and wind energy rather than on coal.

A "nuclear-only" strategy that focuses on new nuclear reactors as Utah's baseload generating source entails the highest investment risk among the low carbon dioxide approaches studied. Nuclear power plant unit sizes are large and lead times are long compared to other types of generation. Even if one largely ignores the large unit size (as has been done in this study), the peak amount of capital committed to ongoing nuclear projects in a "nuclear only" baseload scenario would be about twice as large as in the Renewables + Natural Gas scenario: around $14 Billion for the former and around $7 Billion for the latter. This higher risk does not reflect potential problems such as the cost of delays, which have been rife in nuclear power history in the United States. The high risk of nuclear reactors is reflected in the unwillingness of Wall Street to finance them.

Water consumption is greatest in the Nuclear + Coal with CCS scenario, and least in the eUtah 100% renewable energy scenario. The various renewable scenarios would use 15 to 20 billion gallons less water per year than the Business-As-Usual scenario in the year 2050. The Nuclear + Coal with CCS scenario uses even more water than BAU—four to five billion gallons a year more by 20250—due to the high water requirements of carbon capture and storage. While the cost of water currently prevailing in large transactions does not indicate a significant cost reduction for the renewable energy scenarios, the opportunity cost of water could be very high. Utah population is growing more rapidly than the rest of the country and the pressure on water resources is already considerable. Moreover, high water use technologies carry a greater risk of not being able to meet generation expectations in times of prolonged drought. Wet cooling for geothermal plants is the main water use in the renewable scenarios. Wet (rather than dry) cooling is assumed because dry cooling results in a significant de-rating of geothermal plants.

Table 3 & 4. Cost Analysis and Comparative findings for the different scenarios. Note: Costs are for generation only; transmission and distribution costs are not included. **Water consumption in 2010 is estimated on the same basis as future water use for thermal plants.*

Present Situation (2010)			BAU Scenario (2050)			eUtah Scenario		
Cost	4.2	¢/kWh	Cost	7.4	¢/kWh	Cost	13.2	¢/kWh
Water Consumed	15*	Billion Gallons	Water Consumed	33	Billion Gallons	Water Consumed	12	Billion Gallons
CO_2 Emissions	20	Million Metric Tons	CO_2 Emissions	34	Million Metric Tons	CO_2 Emissions	1	Million Metric Tons
Financial Risk		n/a	Financial Risk		Moderate	Financial Risk		Low
Coal	2.4	Gigawatts	Coal	4	Gigawatts	Coal	0	Gigawatts

Nuclear + Coal w/ CCS			Renewables + Nat. Gas			Renewable + Nat. Gas w/ CCS		
Cost	11.4	¢/kWh	Cost	11	¢/kWh	Cost	11.6	¢/kWh
Water Consumed	37	Billion Gallons	Water Consumed	13	Billion Gallons	Water Consumed	17	Billion Gallons
CO_2 Emissions	6	Million Metric Tons	CO_2 Emissions	4	Million Metric Tons	CO_2 Emissions	1.3	Million Metric Tons
Financial Risk		High	Financial Risk		Low	Financial Risk		Low
Coal	2	Gigawatts	Coal	0	Gigawatts	Coal	0	Gigawatts

Recommendations

Put in place advanced building and appliance standards that reflect the potential for efficiency to reduce electricity bills. This is part of the foundation for moving towards a future electricity sector that will be reliable, economical, and low risk—both financially and environmentally. The University of Utah is already pointing the way with its standards for new buildings. Those could be a starting point for the commercial sector, with gradual further strengthening between now and 2030. We have not evaluated in detail the goal of the American Institute of Architects which has endorsed achievement of zero net energy buildings (residential and commercial) by 2030. A careful, Utah-specific study of its feasibility for new buildings is highly desirable, especially if done in combination with the design of a 21st century electricity system (see recommendation 3).

Encourage a direction compatible with the Renewables + Natural Gas scenario for centralized generation components, and start evaluating large-scale energy storage projects. The short term direction for centralized generation indicated by this study is about the same as that being adopted by many utilities, including PacifiCorp: focus on wind and combined cycle natural gas plants. It is a reasonable way to approach the electricity sector at low risk and is compatible with the Renewables +Natural Gas scenario. But it is not sufficient to continue to focus mainly on new centralized generation. PacifiCorp's additions to wind capacity in the 2009 to 2020 period are planned to total more than 1,000 MW in its East sector, which includes Utah and Wyoming. Yet it appears to have no active plans to develop compressed air energy storage. Such storage could convert its intermittent wind capacity into a dispatchable resource of several hundred megawatts. Since compressed air energy storage is the most economical large-scale storage in the Utah context, it is very important to identify sites, estimate their cost and environmental impact, and conduct economic reviews of their location relative to other future elements in the electricity system, including transmission lines and solar and wind generating facilities.

Development of at least 200 megawatts of Utah's geothermal capacity should be considered by PacifiCorp and/or other utilities and companies in the state. Geothermal energy is an important component of reducing the cost of low carbon dioxide approaches and increasing the fraction of renewable electricity in Utah.

Considering carbon capture and storage (CCS) with natural gas combined cycle plants should be a priority. Utah is already a leader in carbon capture and storage technology research and development with coal. It should add CCS with new and existing natural gas combined cycle power plants to this R&D portfolio. Conversion of existing natural gas combined cycle power plants may be more economical than converting existing coal-fired power plants. This study indicates that within the framework of a central station generation approach, a combination of renewable energy sources and natural gas with CCS would be the most economical approach to an electricity sector with very low CO2 emissions. A pilot project to retrofit an existing combined cycle plant should be considered as part of the Utah CCS R&D program.

Lay the foundation for a low-risk, clean, reliable, 21st century renewable electricity system. Utah has ample renewable energy resources—greater than its own foreseeable electricity requirements. Developing them would obviously be a great boost to the Utah economy, especially in the context of coal reserves in existing mines being rather limited (about 12 years' supply at current rates of consumption). This has been recognized in the draft of the Governor's Utah Energy Initiative: "Given the current situation with coal as a primary fuel for base-load electric generation, Utah needs to develop every viable renewable energy project it can identify."

In order to facilitate this goal, including the development of Utah's vast potential to generate electricity from distributed solar photovoltaic panels on residential and commercial rooftops, Utah should consider creating a demonstration city for a renewable, efficient, intelligent electricity system. St. George, for example, appears to be an ideal candidate for such a demonstration project. It already has a pioneering project in which individuals can own small amounts of solar photovoltaic generation in a city-utility built project, combining individual ownership with economies of scale.

Furthermore, a Twenty-First Century Electricity Center should be established, perhaps at the University of Utah. The University of Utah is among the leading public universities in the United States and a leader in energy research. As noted in this report, it also has a sustainability program, which includes highly efficient new buildings. A Twenty-First Century Electricity Center at the University could provide the leadership and intellectual heft that will be needed to develop pilot projects, to interpret the data, and to develop and refine the models that will guide the way to a cost-efficient renewable electricity system that has distributed as well as centralized elements and that is founded in an efficient consuming sector that communicates with production and storage facilities. The center could have an advisory board comprised of state, utility, industrial, construction, and architectural experts as well as members from other Utah academic institutions and from non-governmental organizations. Sponsorship of such a Center by USTAR, a state agency that is already in the thick of bringing advanced technology leadership to Utah, might help bring together the diversity of expertise areas needed in such a Center.

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About *The Blueprint*

The Blueprint is a companion publication to the much longer, book-length technical study entitled **eUtah: A Renewable Energy Roadmap**, authored by Dr. Arjun Makhijani, President of the Institute for Energy and Environmental Research (IEER).

Its purpose is to set a context for why the eUtah study was undertaken, illustrate how to approach the design of an electricity system based largely in renewable sources of energy, describe the five scenarios included in the study, and then present major findings and recommendations for Utah citizens and policy makers to consider.

This special first-run edition of *The Blueprint* is being printed in conjunction with the public release of the eUtah study at an event in Salt Lake City, Utah, held on December 14, 2010.

The full eUtah study is available for download at **www.eUtahProject.org**

Sponsoring Foundations

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Alta Lodge
Alta Ski Resort
Bambara
Black Diamond
Brewvies
Brighton Ski Resort
Cactus and Tropicals
Café Diablo
Café Rio
Caffe Ibis
Cali's Natural Foods
Canyon Culinary
Centered City Yoga
Children's Theater
Clayhaus Photography
Coffee Garden
Cucina Deli
Discovery Gateway
Edwin Firmage Photography
Gibbs Smith Publisher
Great Basin Chiropractic
Hale Centre Theatre
I.J. and Jeanné Wagner Jewish Community Center
Jack Mormon Coffee
Lunatic Fringe Salon
Moki Pottery
Patagonia
Ravensfell Music Works
Red Butte Garden
Red Cliffs Lodge
Riversong Massage
Rockreation
Salt Lake Acting Company
Sapa Sushi Bar and Asian Grill
Sundance Catalog
Thanksgiving Point
The Flower Shop
The Pie Pizzeria
Tony Caputo's Market and Deli
Tracy Aviary
Trio
Uinta Yurt
Utah Museum of Natural History
Wasatch Touring
Wild Rose

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Arjun Makhijani
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