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SUSTAINABLE ENERGY STUDY #27

Black & Veatch Study Identifies 5,000 MW of Renewable Energy Resources in Arizona:

In a report "Arizona Renewable Energy Assessment" completed in September 2007, Black & Veatch, a leading global engineering, consulting and construction company, has identified more than 5,000 megawatts (MW) of untapped renewable energy resources in Arizona, enough to meet the energy needs of more than 1.5 million customers.

Arizona's three largest utilities, Arizona Public Service (APS), Salt River Project and Tucson Electric Power (TEP), commissioned a renewable energy assessment to determine the availability of the state's renewable energy resources. Black & Veatch was selected to conduct the research because of the company's global expertise in renewable energy studies and projects.

"The purpose of this study was to learn the types of renewable resources that could be developed within Arizona," said Ryan Pletka, Project Manager for Black & Veatch. "This study will assist Arizona's utilities in identifying opportunities that will help them meet their renewable energy goals."

According to the Black & Veatch study, more than 4,300 MW of electricity could be produced using solar thermal generation. In addition, nearly 1,500 MW of electricity could be developed from wind power generation. Other resources could provide as much as 175 MW of electricity through a combination of hydropower, biomass and geothermal technologies. However, further review will be needed to determine the comparative value of developing these in-state renewable energy resources versus purchasing electricity from out of state.

"As states continue to institute renewable energy standards, utilities need to have a clear understanding of their renewable resources," said Dean Oskvig, President and CEO of Black & Veatch's global energy business. "Black & Veatch's proprietary models and tools enable us to provide clients with a thorough analysis for the development of sustainable solutions that meet their economic, environmental and energy goals."

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Executive Summary [excerpts]:

Black & Veatch Corporation has prepared this report for Arizona Public Service Company, Salt River Project, and Tucson Electric Power Company (APS/SRP/TEP).

The purpose of this report is to assess the prospects for significant renewable energy development in Arizona. The scope of the study is limited to Arizona projects that would export power to the grid (that is, not distributed energy projects). This study includes a review of the current status of renewable energy in Arizona, characterization of renewable power generation technologies, assessment of Arizona's renewable resources, and an assessment of key risk factors. This section summarizes the key findings in these areas.

Background and Objective

Electricity produced in Arizona is mostly from traditional natural gas, coal, and nuclear resources. Hydroelectric contributes about 6 percent, while non-hydro renewable resources are currently very small (0.07 percent). To stimulate further development of renewable energy, the Arizona Corporation Commission adopted final rules in 2006 to substantially increase Arizona's Renewable Energy Standard (RES). The new RES mandates that impacted utilities (including TEP and APS) obtain 15 percent of their energy from renewable resources by 2025. SRP has also adopted a renewable energy goal similar to the RES.

The objective of this report is to assess the full potential of Arizona renewable energy resources while accounting for the economics of developing those resources.

Large scale renewable energy development will be necessary to meet the renewable mandates set forth in the Southwest. Although Arizona is well known for its solar resources, solar is currently the most expensive renewable energy resource. By comparison, Arizona is thought by many to have relatively limited opportunities for comparatively lower cost renewables, such as wind, biomass, geothermal and hydroelectric. This study assesses the relative potential of all resources and forecasts which are most likely to be developed over the next 20 years. It is important to note that this report concentrates on the potential of the renewable energy resources themselves.

It does not, beyond the inclusion of transmission interconnection costs, address the potential cost or availability of transmission capacity needed to deliver these resources to load. Further, out-of-state resources and their impact on the Arizona renewable energy market are not included in the scope of this review.

This study was undertaken in two phases. The Interim Report reviewed a broad range of renewable energy technologies and concluded with recommendations for further study in Phase 2. Phase 2 of the project characterizes the most promising options in greater detail and identifies potential projects for possible implementation.

Renewable Energy Technology Options

Nineteen renewable and advanced energy technologies were assessed in Phase 1. The technologies were split into eight categories. Each technology was described with respect to its principles of operation, applications, resource characteristics, cost and performance, environmental impacts, and outlook for Arizona applications. Of these, direct fired and cofiring of solid biomass, biogas (both anaerobic digestion and landfill gas), solar electric (parabolic trough and parabolic dish engine), solar photovoltaic (commercial and utility-scale), conventional hydroelectric and pumped storage, wind, and geothermal were recommended for further study in Phase 2 due to their large potential and/or low cost.

Renewable Resource Assessment

Additional research was performed for technologies that were recommended in the first phase of the project. The objective was to assess the renewable energy resources that are suitable for development in the near- to mid-term (next 20 years). Potential development prospects were identified, levelized generation costs were calculated, and supply curves were developed for each resource. An end result of this process was the identification of a list of over 100 hypothetical renewable energy projects that might be developed to meet demands for renewable energy in Arizona.

Direct Fired and Cofired Biomass

Although biomass resources are limited, direct-fired biomass and cofired biomass technologies were identified as promising technologies in the first stage of the analysis.

Sufficient resource was identified in central Arizona to support a 20 MW direct-fired combustion plant in the vicinity of Maricopa. This facility would be a low emission, fuel-flexible fluidized bed that would burn a variety of biomass fuels, including mill residues, urban wood waste from Phoenix and Tucson, and agricultural residues. The two potential cofiring projects are a 10 MW facility located at TEP’s Springerville Generating Station and a 10 MW facility located at APS’s Cholla Generating Station. To counter potential negative impacts on the boilers, the cofiring projects were assumed to use a gasification system close-coupled to the existing boiler. The cofiring projects would utilize forest and mill residues.

Considering the other renewable energy options evaluated in this study, the costs of the two cofiring projects are relatively low (about $60/MWh in 2010), and the costs of cofiring are certainly lower than the direct fired project (about $162/MWh in 2012). In general, the costs of biomass in Arizona are high compared to other states due to limited available low cost biomass and the small scale of the potential projects.

While cofiring is lower cost than direct fired biomass plants, there are a couple of significant barriers to its implementation. Initiating a biomass cofiring project may require the host coal plant to reopen existing air permits, even though cofiring generally reduces emissions. The risk and cost of reopening existing permits is not included in the cofiring cost estimate, but it may be a significant deterrent to cofiring projects. Further, electricity demand in Arizona is increasing faster than any other state (600 MW increase per year). Biomass cofiring converts capacity to a renewable source rather than adds capacity, and thus may be less attractive than new capacity additions.

If the cofiring projects face too many obstacles, an additional direct fired biomass facility could be developed in Northern Arizona in lieu of the cofiring projects.

Landfill Gas

Black & Veatch utilized the Environmental Protection Agency Landfill Methane Outreach Program (LMOP) database of landfills in Arizona to assess 25 potential sites.

Black & Veatch attempted to contact each of the landfills to verify data and assess the suitability for power development. Based on this review, fifteen potential projects were identified, totaling 9.7 MW of capacity and 68 GWh of annual generation. This capacity is much smaller than what would be expected for similar sized landfills in other states due to Arizona’s dry climate. Most of these projects could be available by 2010 if development were prioritized. Projects costs vary, but most projects are projected to generate power for around $90/MWh.

The overall prospects for landfill gas generation are small. Landfill gas projects can take less time to develop than large solar or wind projects, so landfill gas may play a more significant role in the near term.

Anaerobic Digestion

The utilization of biogas generated from anaerobic digestion of animal manure was identified as a technically feasible option in the first stage of the analysis. Potential anaerobic digestion projects were identified based on large concentrations of livestock (swine, dairy, and poultry) operations within an area. Four anaerobic digestion projects were identified, ranging from 1.5 to 3.5 MW. The projects total 9.9 MW of capacity and 69 GWh of annual generation. The costs for the anaerobic digestion projects range from $70/MWh to $140/MWh (in 2010), largely dependent on project scale.

While this resource has a relatively limited generation potential, anaerobic digestion projects could be executed relatively quickly and with low levels of risk.

Solar Thermal Electric

There is large potential for solar thermal development in Arizona. The review focused on the only commercially proven technology: parabolic trough. Parabolic dish

Stirling systems are promising, but unproven; their costs were assessed in a side scenario study.

The potential for solar thermal was characterized in a different manner than other technologies. Rather than being limited by resource availability, the technology is limited by equipment availability, development timelines, and ultimately economics.

Due to supplier constraints, it was assumed that the first 100 MW trough plant in Arizona would not be completed until 2011. It is assumed that the near term supply chain constraints in the industry will be alleviated by 2013, and two to four 200 MW plants could be constructed per year thereafter. Generic projects were characterized in four areas of the state: Phoenix, Yuma, Stoval, and Tucson.

Unlike most other technologies evaluated for this study, it is expected that significant technical and cost advances will be realized for solar thermal trough plants. In addition, parabolic dish engine technology may also be deployed on a commercial level, and this technology could become competitive over the term of this study (through 2025).

The supply curve for solar thermal trough plants is relatively flat with the lowest cost projects generating power for about $160/MWh (hypothetical 2007 project, includes 30 percent investment tax credit). The flat supply curve means that a lot of solar thermal can be developed for about the same cost. This cost is substantially higher than non-solar resources profiled in this study. The potential supply of solar thermal potential is vast, and exceeds the near-term demands for renewable energy in Arizona.

Solar Photovoltaic

As with solar thermal technologies, constraints on the deployment of solar photovoltaic projects are not related to resource; the constraints are mainly capital costs and equipment availability. The review focused on deployment of larger photovoltaic systems (5-10 MW). Concentrating photovoltaic technology was also addressed as a possible future technology.

Even with significant cost reductions, costs for solar photovoltaic and concentrating photovoltaic projects are too high (greater than $240/MWh) to compete with the other renewable energy technologies surveyed. However, an advantage of solar photovoltaics is that smaller projects may be able to come online in the very near-term (2008 and 2009). As such, they are one of the few in-state technologies available to meet near-term renewable energy demand.

Alternative project and cost structures for solar PV projects are currently being refined, and they have the potential to substantially lower the “all-in” cost of energy from solar PV. Given the high capital costs for PV, any improvement in capital structure or financing costs has a relatively strong impact on the final levelized cost. These structures have not been modeled in this report.

Hydroelectric

Seven hydroelectric projects were identified as potentially promising. The total combined capacity of the seven projects identified is 81.8 MW, with an energy generation potential of 320 GWh/yr. A single project, adding generation at Glen Canyon dam, makes up about 90 percent of this total. The projects were identified based on government information, and details were difficult to verify. Of the seven projects, Glen Canyon, Tucson and Waddell are the only projects that could be reasonably located.

Glen Canyon and Waddell have the most head and flow available compared to other sites. They also have existing hydropower installed and therefore show the most potential for further study. The Glen Canyon project is the lowest cost project of all the renewable energy projects surveyed for this study. It is forecast to cost about $50/MWh in 2015, the year it is projected to be available. The other hydroelectric projects are all projected to be much more expensive, at costs over $150/MWh in 2013, the first year they are projected to be available.

Drought conditions of recent years have reduced water resources throughout the Western US in recent years, including Lake Powell. Continued drought conditions may decrease the actual statewide hydroelectric potential.

Wind Power

While the wind resource is generally less attractive in Arizona compared to surrounding states, wind was identified as one of the more promising resources in the first phase of the study. To identify specific areas conducive to the development of a utility-scale wind energy projects, information was gathered on Arizona’s estimated wind resource, transmission infrastructure, environmental restrictions, and federal land areas.

After reviewing many potential sites for constructability, transmission proximity, wind resource, and other constraints, six sites were chosen as the most promising for near-term development. While it is possible that other wind sites could be developed in Arizona, these sites are less attractive based on this analysis.

The total combined capacity of the six sites identified is 990 MW, with an energy generation potential of 2,550 GWh/yr. (The 500 MW of already planned wind projects are not included in this total). Costs for most projects are estimated to be about $75 to $100/MWh in 2010, which is the year when wind is first expected to be available. While the wind resources in Arizona are modest when judged against many other states, compared to other renewable energy options in Arizona, prospects for wind are good due to the relatively low cost. Arizona wind resources, however, are stronger in the winter when electricity demand is low, and weaker in the summer when demand is higher.

Assessment of the seasonal value of energy (or avoided cost, more generally) was not included in the scope of this study.

Geothermal

Geothermal was identified as a relatively unknown, but potentially promising resource in the first phase of this study. The two known geothermal resources with the highest temperatures are located in the eastern part of the state: the Clifton Hot Springs and the Gillard Hot Springs projects. Interpretation of preliminary data suggests that resource temperatures may enable binary power generation.

Because the projects are still in their early exploratory state, there is not enough data available to accurately characterize the geothermal projects with a high degree of precision. Even identifying the potential project size is still speculative. For this reason, generic 20 and 15 MW projects were assumed. At best, these assumptions identify “place-holder” projects that must be further defined as more information about the true potential of each site is discovered. Because of their small-scale and long lead time (which places them after the assumed expiration of the production tax credit), costs for the two projects are relatively high ($149/MWh and $163/MWh in 2014). Nevertheless, this cost is still competitive with solar resources that are expected to be developed in the same timeframe.

Forecasted Renewable Energy Development

Black & Veatch has developed a model to help utilities, states, and other entities develop renewable energy plans. For the utilities represented in this study, Black & Veatch evaluated Arizona's renewable energy development potential in light of increased demand for renewable energy stimulated, in part, by the Renewable Energy Standard. The model was then used to forecast renewable energy development in the state through 2025.

The model evaluates the total lifecycle cost of renewable energy projects, including capital and operating costs, performance, and transmission system interconnection. Projections are made for future changes in technology cost and performance based on Black & Veatch's experience. By allowing the model to consider all possible renewable energy resources in Arizona, the study assesses the full potential of all renewable energy resources while accounting for the economics of developing those resources. The model does not include transmission system upgrades (other than interconnection costs) or system integration costs for intermittent resources (e.g. wind).

The model also does not assess value (i.e., avoided cost) of the resource as determined by its degree of firmness or time of delivery (e.g. on-peak vs. off-peak). In selecting projects, utilities may consider these factors, which may result in a different order of resource/project development. Further, although long term transmission constraints have not been reviewed, a long term analysis should include a transmission development plan.

A portion of Arizona's renewable energy demands can be met with lower cost non-solar resources, especially wind. However, by 2017, it is projected that lower cost non-solar resources will be exhausted and large-scale solar thermal plants will then be built at a rate of 200 to 400 MW per year through 2025. Other insights from the model include:

• Non-solar resources limited – Arizona has a variety of renewable energy resources that could be developed; however, other than solar, these resources appear relatively limited. In the mid to near-term, developable potential for new biomass, geothermal, and hydroelectric projects combined could contribute about 952 GWh/yr, or 1 percent of the electricity that was generated in Arizona in 2005. Wind could contribute about 2.5 percent. With energy storage, solar could theoretically supply the entire electricity needs of the state. (Note that these totals exclude 825 GWh/yr of additional existing and already planned projects, most of which is wind).

• Non-solar resources important – Despite the relatively limited potential of wind, biomass, geothermal and hydroelectric resources, they serve an important role in forestalling the need to install expensive solar. However, the relatively limited potential of these resources compared to surrounding states may serve as a deterrent for large, out-of-state renewable energy project developers.

• Regional renewable energy markets – This study did not include an assessment of regional renewable energy supply and demand. Neighboring states, namely California, New Mexico, and Nevada, also have aggressive renewable energy standards. These states may have more economical renewable energy sources than Arizona (for example, Salton Sea geothermal resources and New Mexico wind); however, given their own aggressive instate demands and transmission limitations, they may not be a dependable source for Arizona. While the importation of renewable energy may help to defer Arizona's needs, it is not likely to fully satisfy them.

• Lowest cost resources – The most promising project opportunities from an economic perspective involve enhancements to existing facilities: adding a unit at the existing Glen Canyon hydroelectric project and biomass cofiring at the Cholla and Springerville coal plants. These projects are around $60/MWh or less.

• Solar about twice cost of other resources – Solar is the most expensive of the renewable resources profiled in this study. The lower cost solar resources (about $161-176/MWh in 2007) are about twice as expensive as the bulk of the non-solar resources (about $70-110/MWh in 2007). The base case model included only proven, fully commercial solar technologies such as solar photovoltaics and solar thermal trough. If forecasted technology improvements are realized, dish engine technologies have the potential to be cost competitive with conventional parabolic trough systems.

• Arizona's reliance on solar is unique – Arizona appears unique in the U.S. in its dependence on in-state solar energy to meet its renewable energy demands. It is estimated that 65 percent of the Arizona renewable demand in 2025 will be met by solar. Generally speaking, other states in the Southwest U.S. will likely be less reliant on solar to meet their renewable energy requirements. This is because other states generally have a larger base of nonsolar renewables that they can rely on for near-term needs. By comparison, Arizona's non-solar resources are relatively limited. Solar technologies will play a key part of renewable's future in Arizona.

• Consideration of avoided costs is important and necessary – This project did not assess the differential value (i.e., avoided cost) of renewable resources.

Avoided cost is typically determined by assessing a resource's capacity value (based on degree of "firmness" at the time of a utility's system peak demand) and its energy value (based on time of delivery). In selecting projects to develop or procure, utilities may consider these factors, which may result in a different order of resource/project development than shown in the supply curves in this report. This is important when comparing resources such as wind and solar. For example, wind energy projects only provide fractional capacity value (often estimated at 20 percent of the nameplate capacity) and are more likely to offset low cost energy resources during the winter and spring. Solar resources can readily provide firm capacity with gas hybridization or thermal storage. Further, solar is generally coincident with times of higher capacity needs. There are numerous methods to calculate avoided cost, and costs are specific to individual utility systems.

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The 229-page "Arizona Renewable Energy Assessment" is available on the Black & Veatch Web site at:

http://www.bv.com/resources/energy_brochures/renewables/rsrc_AZ_RenewableEnergyAssessment.pdf.

A news release about the report can be found at:
http://www.bv.com/wcm/press_release/10232007_7222.aspx