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Senate Committee on Business and Commerce
The Senate of Texas
P. O. Box 12068
SHB 370
Austin, Texas 78711
Via email: bc@senate.state.tx.us

Subject: Drought Impact on Electric Generation Capacity

Dear Chair Carona and Committee Members:

The Texas Water Development Board has projected that water demand in Texas will increase over the next 50 years from 18 million acre-feet per year in 2010 to about 22 million acre-feet per year in 2060. Although the Sierra Club and other groups take issue with some of the demand projections made in the state and regional water plans and believe that those plans underestimate the contribution that water conservation and drought management may make to meeting those demands, it is nevertheless true that water is critically important to meet the needs of Texans to grow food, run businesses, wash, cook, and drink now and in the future. We need to manage each drop of our water supplies carefully to meet our needs, and we should take steps now to decrease the amount of water used to meet those needs wherever possible. These actions are imperative because of the history of recurring droughts in Texas; and projections that droughts may be an even greater part of our future than they have been in the past.

A part of the demand for water in Texas is water to generate electricity through our traditional sources of electric power generation. Over the 50-year planning horizon in the state water plan, water demand for steam-electric power generation is projected to increase from 700,000 acre-feet pear year to 1,600,000 acre-feet per year. Under that scenario the proportion of Texas water going for steam-electric power generation would increase from 3.8% to 7.3%.

At the same time that water demand is projected to increase, water available during a drought is projected to decrease from 17 to about 15.3 million acre-feet.[1] Even at today's water demand levels, state water supplies during drought conditions are 3.6 million acre-feet per year short of the total amount of water needed. The gap between available supply and demand is projected to grow to 8.3 million acre-feet by 2060.

This letter presents estimates of water demand at existing power plants in Texas that use a steam-electric production process fired by subbituminous, bituminous, or lignite coal. It identifies potential water savings to be realized by converting existing water-cooled coal-fired electrical generating plants to less water-demanding technologies.

Building a water-efficient electric generation infrastructure would not only conserve valuable water supplies. It would also provide an electric power system that is reliable in the face of Texas' variable weather conditions.

I developed this information as part of a study for the Sierra Club on potential water savings from converting coal-fired electrical power generation to more water-efficient technologies. Key findings of my study are these:

- **Available data regarding water use for steam electric generation is unreliable.**
- **The annual water demand of existing coal-fired facilities is about 279,000 acre-feet per year.**
- **Available alternative electric generation technology has the capacity to significantly reduce water consumption for electrical power generation, and in some cases, even taking that consumption to zero .**

[1] Texas Water Development Board, *Water for Texas; 2012 State Water Plan,* draft, January 2012, http://www.twdb.state.tx.us/publications/reports/state_water_plan/2012/draft_2012_swp_1.pdf, January 2, 2012.

- **By encouraging water-efficient electric generation infrastructure, Texas can preserve the availability of water supplies for other essential uses and improve the reliability of the power availability during drought conditions.**

These findings are discussed in more detail below and result in my two key recommendations:

1. Prioritize accurate data collection and accounting of water withdrawals, return flows and consumption at all Texas steam-electric facilities.

2. Develop a plan to incentivize construction of a water-efficient electrical system to improve reliability and conserve water supplies.

Lack of Reliable Water Use Information

Although steam-electric power generation is widely recognized as a water-intensive industry, both state and national level data collection efforts have failed to prioritize accurate water use information. Information on water use at Texas coal-fired electric generating units collected by the Texas Water Development Board, the Texas Commission on Environmental Quality, the U. S. Geological Survey, the U. S. Energy Information Administration, and the U. S. National Energy Technology Laboratory exhibit one or more of these problems:

- Electrical power generating units do not appear in the database;
- Generating units are present, but data on water use and/or consumption are missing;
- Data on water use and/or consumption are present, but the numbers are unreasonable, or are inconsistent with each other or other data; and therefore are clearly wrong;
- Data on water use and/or consumption are present, but do not distinguish between amounts withdrawn, used, and/or consumed. Reasonable interpretation of their significance cannot be made.

Other studies examining water use data for electric power generation arrived at the same conclusion:

> *"One difficulty in estimating water consumption for electricity production involves the multiple yet often conflicting sources of information on water usage."*[2] and
>
> *"Federal datasets on water use in power plants have numerous gaps and methodological inconsistencies."* [3]

Recommendation: Prioritize accurate data collection and accounting of water withdrawals, return flows and consumption at all Texas steam-electric facilities. Data should include information on individual generating units, electrical production, fuel type, boiler efficiency, firing technology, cooling technology, and emission controls for equivalent time frames. These supplemental data would allow a check on water reporting accuracy, and allow the state to develop more accurate predictions of future water demands for similar electrical generation scenarios.

Estimated Water Demand

Based on 2009 data, coal-fired power plants in Texas together have a net summer capacity of 20,247 megawatts, about one-fifth of the entire Texas electrical generating capacity. The annual electrical production by coal-fired plants in 2009 was 139,106,597 megawatt hours, which was 35% of Texas electrical generation. Of the ten largest plants in Texas by 2009 generating capacity, six are fired primarily by coal.[4]

Coal at these facilities is burned to convert boiler water to pressurized steam, which drives turbines that produce electrical power. Boiler water must be almost pure to prevent internal boiler fouling and scaling. Treating water to a condition of near-purity is expensive; so boiler water is re-used many times in the steam-electric generation process. The boiler makeup

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[2]King, Carey, Ian Duncan, Michael Webber, *Water Demand Projections for Power Generation in Texas,* Bureau of Economic Geology, prepared for Texas Water Development Board, August 31, 2008, page 12.
[3] Macknick, Jordon, Robin Newmark, Garvin Heath, and KC Hallet, *A Review of Operational Water Consumption and Withdrawal Factors for Electricity Generating Technologies,* National Renewable Energy Laboratory, Technical Report NREL/TP-6A20-50900, March 2011.
[4] U.S. Energy Information Administration, *State Electricity Profiles 2009*, April 2011, pages 260 - 262, http://www.eia.gov/cneaf/electricity/st_profiles/sep2009.pdf, December 26, 2011.

water used to produce steam-electric generation is a relatively small amount of the total water used at a coal-fired power plant.

After steam moves through the electrical turbine, however, it is no longer pressurized; it has lost the energy needed to produce electricity. Before it can be re-boiled for the next pass through the electricity-generating turbines, the steam must be condensed back to water. It is the process of converting liquid water to steam that generates pressure to drive the turbines. Steam condensation before it is re-pressurized in the boiler is an ***essential*** step in the steam-electric generating process.

Every existing coal-fired power plant in Texas uses water to condense steam. The same thermodynamic process that, on one side of the heat transfer plate, converts steam to water, on the other side evaporates water out of the Texas water supply. Figure 1 illustrates this process.

Without water for the steam condensation process, no electricity can be produced from a water-cooled steam-electric generation process. A letter from Governor Riley of Alabama to President Bush in October 2007 describes potential consequences of water curtailment during drought on the reliability of the regional electric power grid.[5]

Reported and estimated water demand at coal-fired electrical generating facilities in Texas is presented in Table 1. This table illustrates missing and inaccurate reporting described above. The best estimate of the actual water demand for these coal-fired facilities in Texas is 279,000 acre-feet per year, based on the estimated 2005 generation of 150 million megawatt-hours of electricity.

This estimated water demand for cooling is based primarily on water consumption estimates made using the Integrated Environmental Control Model (IECM) developed by Carnegie Mellon University for the U.S. Department of Energy's National Energy Technology

[5] Riley, Governor Bob, letter to President Bush, October 22, 2007, http://blog.al.com/spotnews/2007/10/rileyletteBush.pdf, January 4, 2012.

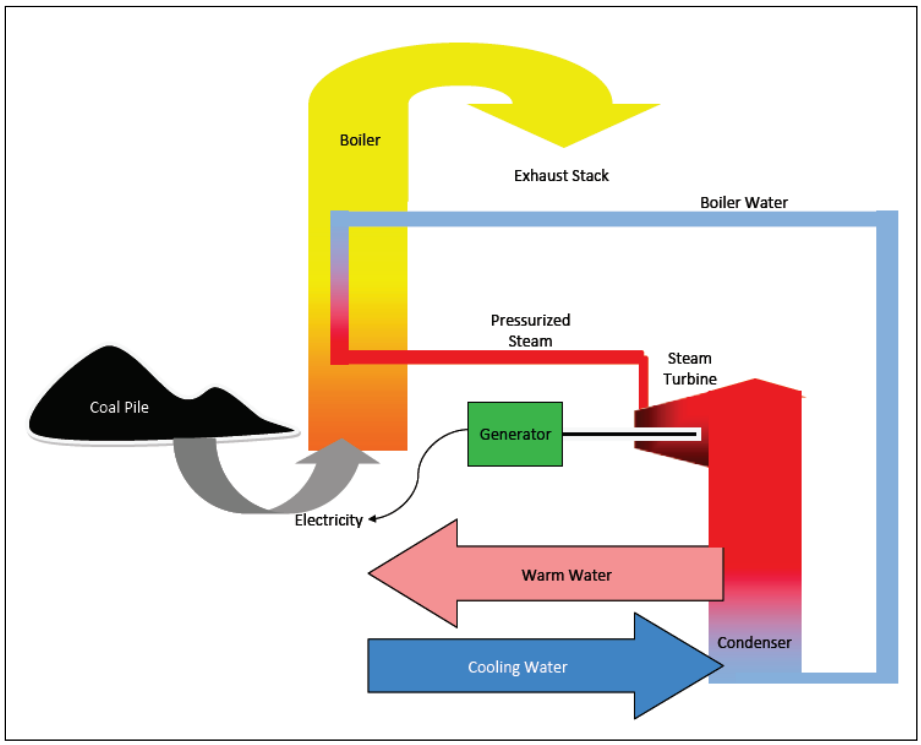

Figure 1. Diagram of Coal-fired Electrical Generation Process

Laboratory (NETL).[6] IECM estimates water consumption based on user input regarding the type of power plant boiler, fuel sources, emission controls, average environmental conditions, and carbon dioxide capture and storage technology.

IECM fails, however, to calculate evaporation losses associated with once-through cooling. It misses, therefore, water that is lost by evaporation from Texas lakes and rivers ***after*** the heated cooling water is returned. For power plants with once-through cooling systems, an estimate of water use was made using cooling water demand factors developed by research by the Texas Bureau of Economic Geology.[7]

[6] http://www.cmu.edu/epp/iecm/about.html, December 26, 2011.
[7] King, Carey, Ian Duncan, Michael Webber, *Water Demand Projections for Power Generation in Texas,* Bureau of Economic Geology, prepared for Texas Water Development Board, August 31, 2008, page 12.

Table 1. Estimated Water Use for Coal-Fired Electric Generation in Texas in acre-feet per year

Facility	NETL Nameplate Capacity (Megawatts)	Water Source	Primary Cooling System	NETL 2005 Water Consumption	TWDB 2005 Water Use	Estimated Water Consumption Using Macknick Factors	IECM Estimated Water Consumption	Estimated Water Consumption
W A Parish	2,698	Smithers Lake	Recirculating with cooling pond(s) or canal(s)	14,113	328,043	26,801	32,761	32,761
Limestone	1,706	Lake Limestone	Recirculating with forced draft cooling tower(s)	33,485	20,979	18,441	31,219	31,219
Harrington	1,080	Municipality	Recirculating with induced draft cooling tower(s)	14,127	5,852	15,726	20,574	20,574
Tolk	1,136	Wells	Recirculating with induced draft cooling tower(s)	13,765	15,097	15,642	20,484	20,484
J T Deely	932	San Antonio River	Recirculating with cooling pond(s) or canal(s)	13,547	25,653	14,144	18,787	18,787
Welsh	1,674	Swauano Creek Reservoir	Recirculating with forced draft cooling tower(s)	1,159	11,660	13,787	34,116	34,116
Coleto Creek	600	Coleto Creek Reservoir	Recirculating with cooling pond(s) or canal(s)	1,449	490,808	12,201	11,193	11,193
Gibbons Creek	454	Gibbons Creek	Recirculating with cooling pond(s) or canal(s)	0	407,314	8,596	8,910	8,910
Fayette Power Project	1,690	Fayette County Lake	Once through with cooling pond(s) or canal(s)	0	19,268	12,774	neglects forced evaporation	12,774
Pirkey	721	Brandy Branch Reservoir	Recirculating with cooling pond(s) or canal(s)	5,796	12,420	7,219	8,755	8,755
Sandow	591	Lake Alcoa	Recirculating with cooling pond(s) or canal(s)	0	no data	6,512	12,884	12,884
Oklaunion	720	Municipality	Recirculating with induced draft cooling tower(s)	7,607	7,529	6,255	8,742	8,742
Martin Lake	2,379	Martin Lake	Once through with cooling pond(s) or canal(s)	0	170	21,004	neglects forced evaporation	21,004
Monticello	1,979	Monticello Reservoir	Once through with cooling pond(s) or canal(s)	0	24,471	17,042	neglects forced evaporation	17,042
San Miguel	410	Wells	Recirculating with forced draft cooling tower(s)	[1]	7,363	4,121	4,978	4,978
Twin Oaks Power One	350	Wells	Recirculating with forced draft cooling tower(s)	2,753	no data	3,600	7,703	7,703
Big Brown	1,186	Fairfield Lake	Once through with cooling pond(s) or canal(s)	0	6,093	2,703	neglects forced evaporation	2,703
J K Spruce	566	San Antonio River	Once through with cooling pond(s) or canal(s)	9,490	included w/ JT Deely	4,823	neglects forced evaporation	4,823
			Total:	**117,291**	**1,382,721**	**211,391**	**221,105**	**279,451**

Water units: acre-feet per year

[1] The NETL water use value for San Miguel (340,498) appears to be a database error and was disgarded in this analysis.

Alternative Water Efficient Power Generation Technology

The existing coal-fired steam electric power generation process in Texas uses about 607 gallons of water per megawatt-hour for the steam condensation process. Proven generation technology exists today to produce electricity using much less water. Figure 2 compares the cooling water use rate of Texas' existing coal-fired power plants with the cooling water use rate of alternative technologies. These estimates were made using cooling water demand factors developed by research by the National Renewable Energy Laboratory[8]

Potential water savings to be achieved by converting the existing coal-fired plants to a water efficient electrical generation process are illustrated by Figure 3.

If future regulatory conditions require carbon sequestration, water demand for coal-fired generation will increase significantly beyond the current levels.[9] Figure 4 illustrates different water demands for alternative technologies, including the water demands for carbon sequestration.

Recommendation: Develop a plan to incentivize construction of a water-efficient electrical system to improve reliability and conserve water supplies. Prioritize implementation of the plan in water-short regions of Texas west of and including the Brazos G Water Planning Region.

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[8] Macknick, Jordon, Robin Newmark, Garvin Heath, and KC Hallet, *A Review of Operational Water Consumption and Withdrawal Factors for Electricity Generating Technologies,* National Renewable Energy Laboratory, Technical Report NREL/TP-6A20-50900, March 2011.
[9] Water demand for carbon sequestration is well-documented in King, et al., 2008, in Macknick et al, 2011, and in numerous other publications.

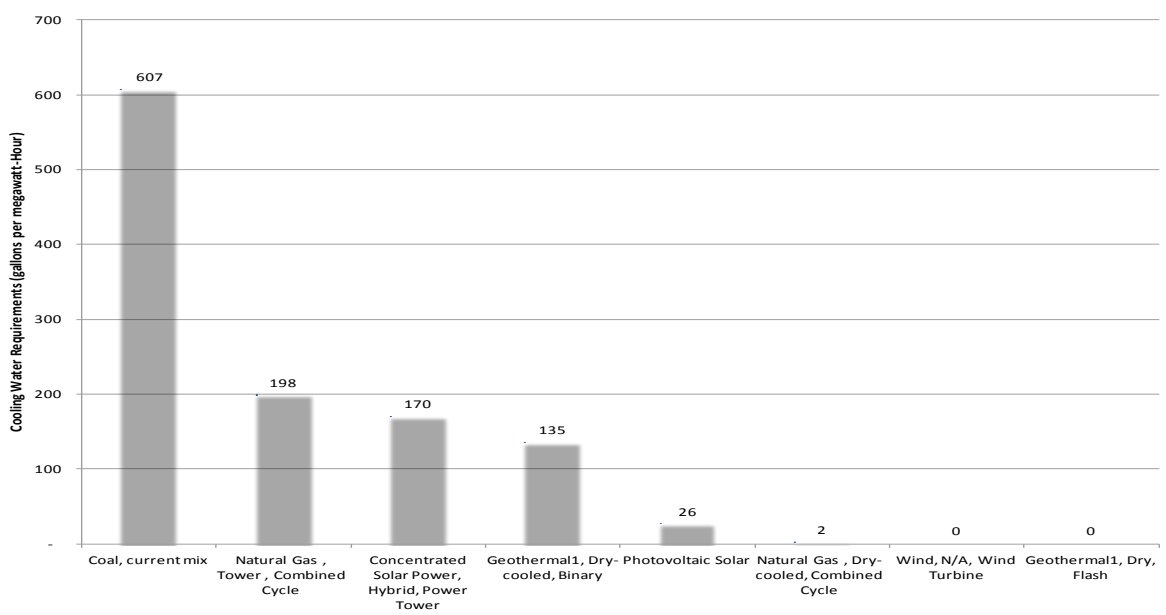

Figure 2. Cooling Water Requirements for Alternative Electric-Generation Technologies

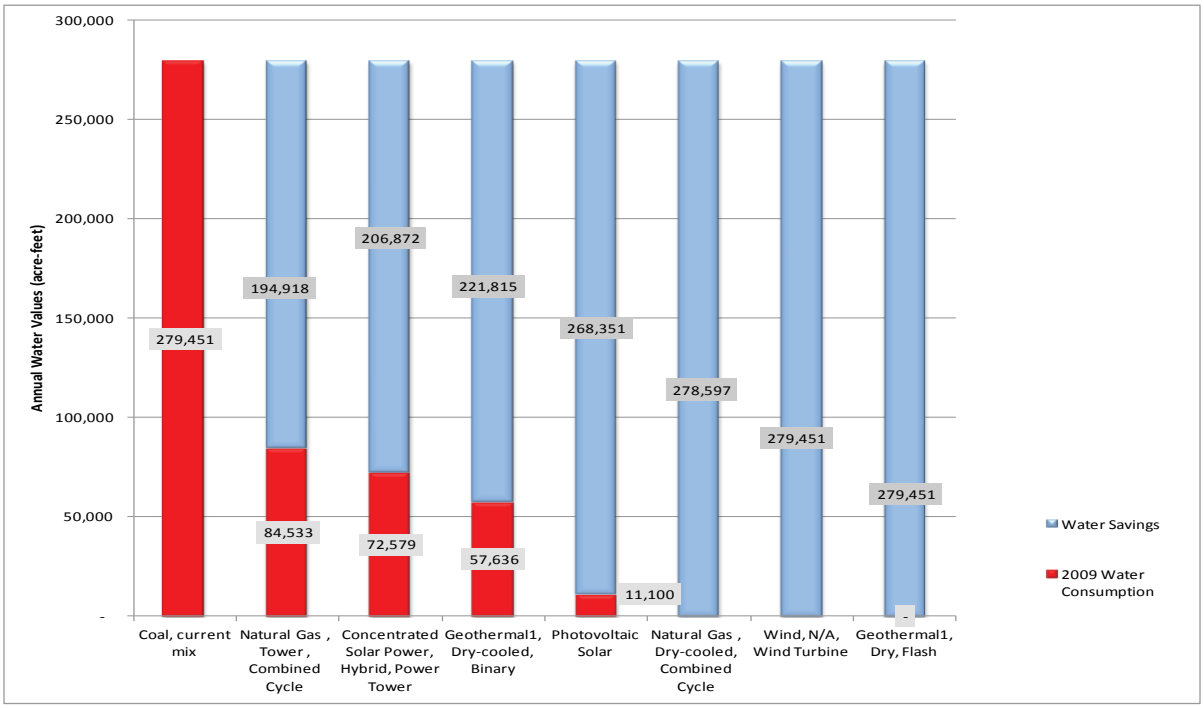

Figure 3. Potential Water Savings From Implmenting Alternative Electric Power Generation Technologies

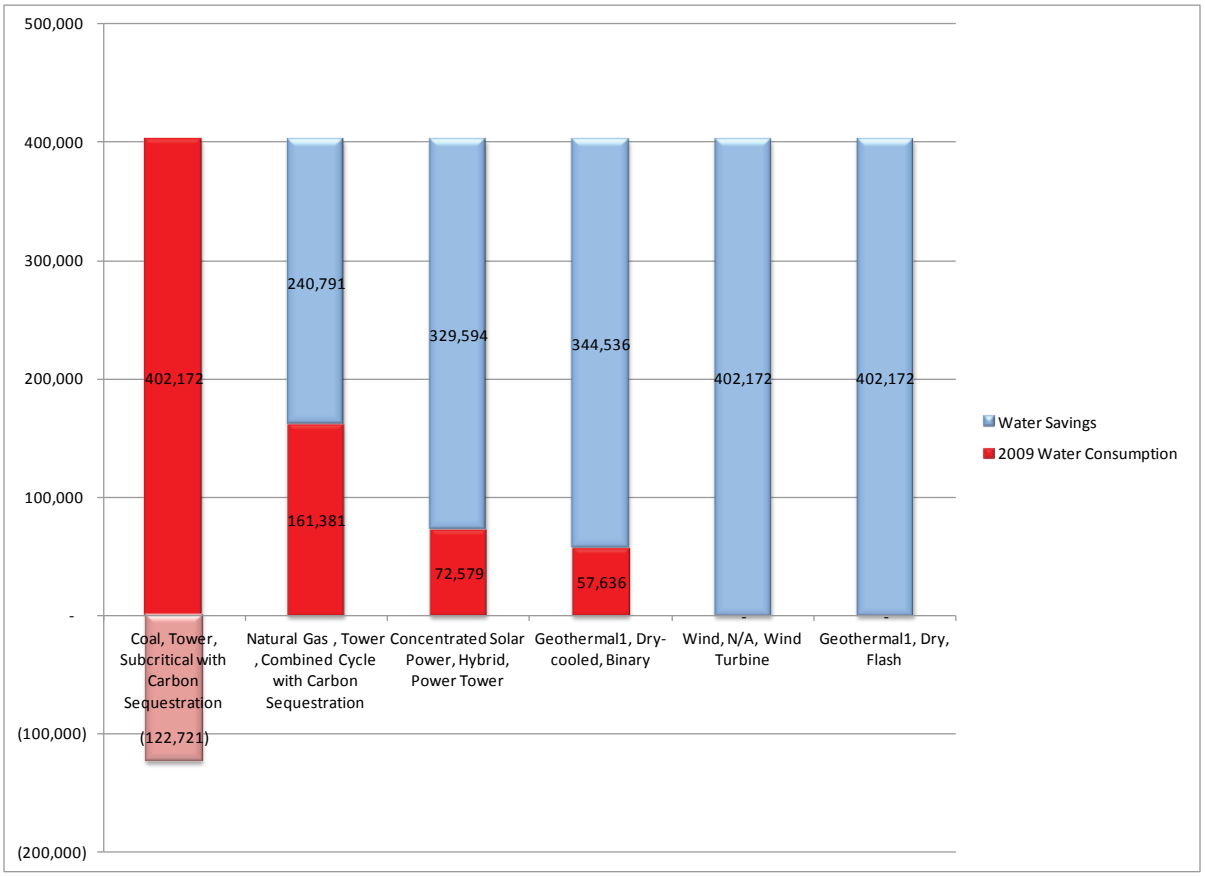

Figure 4. Water Demands for Alternative Power Generation Technologies Considering Carbon Sequestration

Conclusion

In summary neither the United States as a whole, nor Texas in particular, has any accurate measure of the quantity of State water being used to generate electricity. We do know, however, that we currently rely upon a power system that uses coal-fired steam-electric generation for more than one-third of its capacity; and that this generation technology, in particular, requires a lot of water per megawatt-hour of production. If carbon sequestration requirements become part of the regulatory frame for coal-fired generation, water demands per megawatt-hour of production using coal will nearly double. Furthermore, generation technologies currently exist to produce power with much less or almost no water use at all. Thus, my recommendations are:

- Prioritize accurate data collection and accounting of water withdrawals, return flows and consumption at all Texas steam-electric facilities.

- Develop a plan to incentivize construction of a water-efficient electrical system to improve reliability and conserve water supplies.

Texas would be well-advised to develop a plan to encourage an electrical power-generation system that emphasizes local priorities and Texas-based resources. In this way, the system will be both diverse and water-efficient, and will ensure that the energy-water nexus supports responsible use of the state's natural resources. Otherwise we may end up with built capacity that we cannot use because the water supply is simply not available during drought conditions to support it.

Sincerely,

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President
Glenrose Engineering, Inc.

4 January 2012