Morgan, Lewis & Bockius LLP
1111 Pennsylvania Avenue, NW
Washington, DC 20004
Tel. 202.739.3000
Fax: 202.739.3001
www.morganlewis.com

Morgan Lewis
COUNSELORS AT LAW

Jonathan M. Rund
Associate
202.739.5061
jrund@MorganLewis.com

December 8, 2009

Ann Marshall Young, Chair
Dr. Gary S. Arnold
Dr. Alice C. Mignerey
Atomic Safety and Licensing Board
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001

Re: Luminant Generation Company LLC (Comanche Peak Nuclear Power Plant, Units 3 and 4), Docket Nos. 52-034 and 52-035

Dear Licensing Board Members:

The purpose of this letter is to provide notification that Luminant Generation Company LLC and Comanche Peak Nuclear Power Company LLC, applicants in the above-captioned matter (jointly, Luminant), recently filed the attached letter, dated December 8, 2009, with the NRC on the docket for Comanche Peak Units 3 and 4. The attached letter contains a planned amendment to Luminant's Environmental Report that evaluates alternative generation sources consisting of combinations of renewable energy sources, energy storage, and natural gas-fired generation. The attached letter relates to Contention 18, which was admitted by the Board in LBP-09-17.

Sincerely,

Signed (electronically) by Jonathan M. Rund
Jonathan M. Rund
Morgan, Lewis & Bockius LLP
1111 Pennsylvania Avenue, NW
Washington, DC 20004
Phone: 202-739-3000
Fax: 202-739-3001
E-mail: jrund@morganlewis.com

Counsel for Luminant

Attachment

cc: Service List

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

In the Matter of LUMINANT GENERATION COMPANY LLC (Comanche Peak Nuclear Power Plant Units 3 and 4)	)))))))	Docket Nos. 52-034-COL 52-035-COL December 8, 2009

CERTIFICATE OF SERVICE

I hereby certify that on December 8, 2009, a copy of a letter dated December 8, 2009 from Jonathan M. Rund to the Members of the Licensing Board was served by the Electronic Information Exchange on the following recipients:

Administrative Judge
Ann Marshall Young, Chair
Atomic Safety and Licensing Board Panel
U.S. Nuclear Regulatory Commission
Mail Stop T-3F23
Washington, DC 20555-0001
E-mail: ann.young@nrc.gov

Administrative Judge
Dr. Alice C. Mignerey
Atomic Safety and Licensing Board Panel
U.S. Nuclear Regulatory Commission
Mail Stop T-3F23
Washington, DC 20555-0001
E-mail: acm3@nrc.gov

Administrative Judge
Dr. Gary S. Arnold
Atomic Safety and Licensing Board Panel
U.S. Nuclear Regulatory Commission
Mail Stop T-3F23
Washington, DC 20555-0001
E-mail: gxa1@nrc.gov

Office of the Secretary
U.S. Nuclear Regulatory Commission
Rulemakings and Adjudications Staff
Washington, DC 20555-0001
E-mail: hearingdocket@nrc.gov

James Biggins, Esq.
Susan H. Vrahoretis, Esq.
Anthony Wilson, Esq.
Office of the General Counsel
U.S. Nuclear Regulatory Commission
Mail Stop O-15D21
Washington, D.C. 20555-0001
E-mail: James.Biggins@nrc.gov;
Susan.Vrahoretis@nrc.gov;
Anthony.Wilson@nrc.gov

Robert V. Eye, Esq.
Counsel for the Intervenors
Kauffman & Eye
112 SW 6th Ave., Suite 202
Topeka, K.S. 66603
E-mail: bob@kauffmaneye.com

Office of Commission Appellate Adjudication
U.S. Nuclear Regulatory Commission
Mail Stop: O-16C1
Washington, DC 20555-0001
E-mail: ocaamail@nrc.gov

Signed (electronically) by Jonathan M. Rund
Jonathan M. Rund
Morgan, Lewis & Bockius LLP
1111 Pennsylvania Avenue, NW
Washington, DC 20004
Phone: 202-739-3000
Fax: 202-739-3001
E-mail: jrund@morganlewis.com

Counsel for Luminant

Luminant

Rafael Flores
Senior Vice President &
Chief Nuclear Officer
rafael.flores@luminant.com

Luminant Power
P O Box 1002
6322 North FM 56
Glen Rose, TX 76043

T 254.897.5590
F 254.897.6652
C 817.559.0403

CP-200901664
Log # TXNB-09079

Ref. # 10 CFR 52

December 8, 2009

U. S. Nuclear Regulatory Commission
Document Control Desk
Washington, DC 20555
ATTN: David B. Matthews, Director
Division of New Reactor Licensing

SUBJECT: COMANCHE PEAK NUCLEAR POWER PLANT, UNITS 3 AND 4
DOCKET NUMBERS 52-034 AND 52-035
COMBINED LICENSE APPLICATION PART 3, ENVIRONMENTAL REPORT
REVISION 1, UPDATE TRACKING REPORT REVISION 0

REFERENCE: ASLB Panel Memorandum and Order, "Ruling on Standing and Contentions of Petitioners, and Other Pending Matters," August 6, 2009 (ML092180908)

Dear Sir:

Luminant Generation Company LLC (Luminant) herein submits the first Update Tracking Report for the Comanche Peak Nuclear Power Plant Units 3 and 4 Combined License Application, Revision 1, Part 3, Environmental Report. The marked-up pages provide information that addresses Contention 18 as stated on page 82 of the referenced document:

> The Comanche Peak Environmental Report is inadequate because it fails to include consideration of alternatives to the proposed Comanche Peak Units 3 and 4, consisting of combinations of renewable energy sources such as wind and solar power, with technological advances in storage methods and supplemental use of natural gas, to create baseload power.

Should you have any questions regarding this report, please contact Don Woodlan (254-897-6887, Donald.Woodlan@luminant.com) or me.

There are no commitments in this letter.

I state under penalty of perjury that the foregoing is true and correct. Executed on December 8, 2009.

Sincerely,

Luminant Generation Company LLC

Donald R. Woodlan for

Rafael Flores

Attachment: COL Application Part 3, Environmental Report Revision 1, Update Tracking Report Revision 0

Email Distribution w/attachment

mike.blevins@luminant.com
Rafael.Flores@luminant.com
mlucas3@luminant.com
jeff.simmons@energyfutureholdings.com
Bill.Moore@luminant.com
Brock.Degeyter@energyfutureholdings.com
rbird1@luminant.com
Matthew.Weeks@luminant.com
Allan.Koenig@luminant.com
Timothy.Clouser@luminant.com
Ronald.Carver@luminant.com
David.Volkening@luminant.com
Bruce.Turner@luminant.com
Eric.Evans@luminant.com
Robert.Reible@luminant.com
donald.woodlan@luminant.com
John.Conly@luminant.com
JCaldwell@luminant.com
David.Beshear@txu.com
Ashley.Monts@luminant.com
Fred.Madden@luminant.com
Dennis.Buschbaum@luminant.com
Carolyn.Cosentino@luminant.com

Luminant Records Management

masahiko_kaneda@mnes-us.com
masanori_onozuka@mnes-us.com
ck_paulson@mnes-us.com
joseph_tapia@mnes-us.com
russell_bywater@mnes-us.com
diane_yeager@mnes-us.com
kazuya_hayashi@mnes-us.com
mutsumi_ishida@mnes-us.com
nan_sirirat@mnes-us.com
masaya_hoshi@mnes-us.com
rjb@nei.org
kak@nei.org
michael.takacs@nrc.gov
cp34update@certrec.com
michael.johnson@nrc.gov
David.Matthews@nrc.gov
Balwant.Singal@nrc.gov
Hossein.Hamzehee@nrc.gov
Stephen.Monarque@nrc.gov
jeff.ciocco@nrc.gov
michael.willingham@nrc.gov
john.kramer@nrc.gov
Brian.Tindell@nrc.gov
Elmo.Collins@nrc.gov
Loren.Plisco@nrc.com
Laura.Goldin@nrc.gov
James.Biggins@nrc.gov
Susan.Vrahoretis@nrc.gov
sfrantz@morganlewis.com
tmatthews@morganlewis.com

Attachment

COL Application Part 3, Environmental Report Revision 1, Update Tracking Report Revision 0

(This attachment includes marked-up Environmental Report (ER) pages 9.2-30 through 9.2-50 and 9.2-65 through 9.2-70. Because of text additions and deletions, the page numbers on the marked-up pages may not coincide with the page numbers in ER Revision 1.)

December 7, 2009

Comanche Peak Nuclear Power Plant, Units 3 & 4
COL Application

Part 3

Environmental Report Revision 1

Update Tracking Report

Revision 0

Revision History

Revision	Date	Update Description
-	11/20/2009	COLA Revision 1 Transmittal See Luminant Letter no. TXNB-09074 Date 11/20/2009
0	12/7/2009	Updated Chapters: Ch. 9

Chapter 1

Chapter 1 Tracking Report Revision List

Change ID No.	Section	ER Rev. 1 Page	Reason for change	Change Summary	Rev. of ER T/R

Chapter 2

Chapter 2 Tracking Report Revision List

Change ID No.	Section	ER Rev. 1 Page	Reason for change	Change Summary	Rev. of ER T/R

Chapter 3

Chapter 3 Tracking Report Revision List

Change ID No.	Section	ER Rev. 1 Page	Reason for change	Change Summary	Rev. of ER T/R

Chapter 4

Chapter 4 Tracking Report Revision List

Change ID No.	Section	ER Rev. 0 Page	Reason for change	Change Summary	Rev. of ER T/R

Chapter 5

Chapter 5 Tracking Report Revision List

Change ID No.	Section	ER Rev. 1 Page	Reason for change	Change Summary	Rev. of ER T/R

Chapter 6

Chapter 6 Tracking Report Revision List

Change ID No.	Section	ER Rev. 1 Page	Reason for change	Change Summary	Rev. of ER T/R

Chapter 7

Chapter 7 Tracking Report Revision List

Change ID No.	Section	ER Rev. 0 Page	Reason for change	Change Summary	Rev. of ER T/R

Chapter 8

Chapter 8 Tracking Report Revision List

Change ID No.	Section	ER Rev. 1 Page	Reason for change	Change Summary	Rev. of ER T/R

Chapter 9

Chapter 9 Tracking Report Revision List

Change ID No.	Section	ER Rev. 1 Page	Reason for change	Change Summary	Rev. of ER T/R
CTS-00920	9.2.2.11	9.2-30	Address ASLB Contention 18	Added Section 9.2.2.11 to provide discussion of energy alternatives in combination with energy storage.	0
CTS-00920	9.2.5	9.2-44 through 9.2-49	Address ASLB Contention 18	Included references found in Section 9.2.2.11.	0

Chapter 10

Chapter 10 Tracking Report Revision List

Change ID No.	Section	ER Rev. 1 Page	Reason for change	Change Summary	Rev. of ER T/R

plant on land use, ecological resources, protected species, human health, aesthetics, cultural resources, water quality, waste management, air quality, and socioeconomics.

In terms of cost, because there are large-scale natural gas energy projects approaching the size of the proposed CPNPP Units 3 and 4, there is sufficient information available on the costs of constructing or operating a large natural gas power project. From the available information, the costs of generating power equal to that of the proposed CPNPP Units 3 and 4 make natural gas power plants an economic alternative. The capital costs for natural-gas-fired power plants are estimated at approximately $544/kW. Electrical generation costs utilizing natural gas as fuel are in the range of $35/MWh to $48/MWh or $0.035/kWh to $0.048/kWh.

Based upon the evaluation criteria, natural gas is reasonable energy alternative to the proposed CPNPP Units 3 and 4. Electrical power derived from natural gas is a developed and proven technology that is utilized for energy generation in the ERCOT service area. There is the potential that natural gas power plants could provide baseload generating capacity and availability equal to the proposed CPNPP Units 3 and 4. Natural gas would have greater environmental impacts than the proposed CPNPP Units 3 and 4. The costs of natural gas fuel plants are well-known and would make the use of this technology economically practical. Generating capacity from this technology equivalent to that capacity of the proposed CPNPP Units 3 and 4 is achievable within the time frame of the proposed project.

Given this potential feasibility as a competitive energy alternative, a more detailed evaluation of natural gas-fired power is presented in Subsection 9.2.3.2. The discussion in Subsection 9.2.3.2 includes the plant size and land requirements, fuel quality and consumption estimates, emissions evaluations, economic costs evaluation, and potential environmental and health restrictions or impacts. As stated in the introductory paragraphs in Subsection 9.2.2, the use of this energy technology is consistent with U.S. national policy, which includes maintaining a diverse energy supply and the use of domestic energy sources with lower greenhouse gas emissions than fuels like petroleum liquids.

9.2.2.11 Alternatives Requiring New Generation in Combination with Energy Storage CTS-00920

Due to the unpredictable and intermittent nature of renewable energy sources such as solar or wind power, these technologies are considered to be peaking and not a baseload power supply, as discussed in Subsections 9.2.2.1 and 9.2.2.2. There have been no technological advances in energy storage technology that would enhance the feasibility of wind or solar products to function as a baseload power supply comparable to CPNPP Units 3 and 4. There have been no technological advances that would change the conclusion in Subsections 9.2.2.1 and 9.2.2.2 that solar and wind power are not feasible alternatives for baseload energy supply comparable to CPNPP Units 3 and 4.

As part of the alternatives analysis in the following subsections, the concept of combining either wind or solar power generation with an energy storage technology to produce baseload power generation comparable to CPNPP Units 3 and 4 is evaluated in the context of the evaluation criteria presented in NUREG-1555. The basic concept evaluated is that the primary baseload power could be produced by solar or wind units with some of the excess energy placed into storage. The stored energy would then be utilized to produce power when the renewable power resources are either not available or not available at sufficient strength to produce the required baseload power. CTS-00920

As part of this evaluation, the concept of using a natural gas facility to supplement the wind and solar power generation with the storage capacity is also evaluated. In this conceptual scenario, a natural gas power plant could be activated when the baseload power requirements could not be met, such as when the wind and solar power is interrupted and the stored energy supply exhausted. In actuality, due to the intermittent and unpredictable availability of solar and wind power and the finite capacity of the energy storage units, the baseload power would have to be generated by the natural gas plant and the use of the natural gas plant could be temporarily suspended or reduced when solar and wind power or stored energy is available.

The alternative of using natural gas to provide baseload power comparable to CPNPP Units 3 and 4 was fully evaluated in Subsections 9.2.2.10 and 9.2.3.2. The alternative of combining technologies, including using a baseload power (such as natural gas or coal) with an intermittent renewable power (such as wind or solar power) was evaluated in Subsection 9.2.3.3, including Subsections 9.2.3.3.1 through 9.2.3.3.5.

As discussed in these subsections, combining a renewable power source with a baseload power technology is not an environmentally preferable alternative to CPNPP Units 3 and 4. The alternatives evaluation presented in the following subsections does not change the conclusions in Subsections 9.2.2.1, 9.2.2.2, 9.2.2.10, 9.2.3.2 and 9.2.3.3 that natural gas, wind, and solar, either individually or in combination with each other and energy storage, are not viable alternatives to CPNPP Units 3 and 4 that could both produce baseload power comparable to that generated by CPNPP Units 3 and 4 and be environmentally preferable to CPNPP Units 3 and 4.

9.2.2.11.1 Available Alternatives Requiring New Generation in Combination with Energy Storage

Luminant does not view nuclear, solar, wind, natural gas, or other energy sources as alternative competing energy production technologies. Rather, Luminant believes that baseload energy technologies (like nuclear, coal, and natural gas), technologies that provide peaking or intermittent power generation (like wind and solar power), along with energy storage, are all essential components needed to create and maintain an integrated, diverse, flexible, and dependable energy system reliably serving the public needs. The energy demands of society are so great and the logistics to reliably satisfy these demands are so complicated and interdependent that the entire range of baseload, peak load, and intermittent energy sources and storage options must be fully utilized to maintain a functioning power grid.

With this philosophy, Luminant is committed to exploring and attempting to utilize the feasible options for generating power. As of 2008, Luminant was the largest purchaser of wind-generated electricity in Texas and the fifth largest purchaser of wind-generated power in the United States. Mitsubishi, the reactor supplier for CPNPP Units 3 and 4, was the seventh largest producer of wind turbines with over 516 MW of turbine capacity installed in 2008 (AWEA, 2009). Luminant, in conjunction with Shell Wind Energy, is developing plans for potential wind power projects in Briscoe County, Texas that could collectively generate a total of 3000 MW of power. As part of these wind power projects, the potential for developing energy storage capabilities is also being evaluated (EFH, 2007). As the power industry continues to evolve, Luminant intends to maintain a critical role in pursuing, developing, and implementing feasible power options in appropriate applications. CTS-00920

Based on the discussions in Subsection 9.2.2, the utilization of renewable power generation options includes challenges because the generation source is intermittent, unpredictable, and not always available at a sufficient strength to provide reliable baseload power. The potential for using renewable power sources might be enhanced if the generation source is combined with an energy storage technology that could increase the availability, reliability and predictability of the power deliverability. The two primary renewable power generation sources in this category are wind and solar power.

The theory behind the combination of renewable power generation with energy storage is that, when the generation capacity is available, the amount of power produced could, at times, exceed the demand for power at that time. Excess energy could be stored and returned later to the electrical grid when the renewable power generation resource is either not available or is available at a diminished level that is insufficient to satisfy the demand for power.

Therefore, in order for this combination of technologies to function, the renewable energy source would have to be sized to be larger than the baseload power level, in this case 3200 MW. This need to have a generation capacity greater than the baseload requirements in order to place energy into storage would cause environmental impacts to a level greater than the impacts of a generation source rated at the baseload value alone. For example, if a solar or wind generation source was conservatively assumed to be available for 12 hours every day and if the energy storage technology was conservatively assumed to be 100 percent efficient, a solar or wind power generator rated at 6400 MW would be needed for 12 hours to provide 3200 MW of baseload generation for 12 hours and 3200 MW of power generation from the storage units for 12 hours. In reality, the solar or wind generation would have to be much greater because neither solar nor wind generation is available at full load for 12 hours per day and energy storage technologies do not approach 100 percent efficiency in energy transfer capability.

To assess the generation combined with storage option, the potential storage options are discussed first in the following subsection. The combinations of renewable power generation with the options that are considered the most advanced at this time, along with supplemental natural gas, are then evaluated in the subsequent subsections.

9.2.2.11.2 Energy Storage Options

There are a number of potential energy storage options that might be considered for the technology combination of power generation with energy storage. These storage technologies include (DOE 2009; ESC 2002; PEI 2008):

- Pumped hydropower storage
- Compressed air energy storage (CAES)
- Batteries
- Hydrogen

- Molten salt CTS-00920
- Flywheels
- Supercapacitors

The feasibility of utilizing these storage options to generate baseload power comparable to that of CPNPP Units 3 and 4 in the relevant ERCOT service area is discussed below.

9.2.2.11.2.1 Pumped Hydropower Storage

Pumped hydropower (hydro) storage is a proven technology with power facilities in existence that can generate up to 1000 MW of peaking power. Pumped hydropower facilities consist of a storage reservoir located in an elevated location over a lower receiving reservoir or body of water. During non-peak power demand hours, when the energy costs are lower, water is pumped from the lower receiving reservoir or water body into the topographically higher storage reservoir. During peak power demand hours, when the energy prices are higher, water is released from the upper reservoir through turbines to generate power and returned to the lower receiving reservoir or water body (DOE 2009; ESC 2002).

Pumped hydro storage as an energy storage methodology in the relevant ERCOT service area has the same challenges as new or expanded hydropower projects that could generate baseload power comparable to CPNPP Units 3 and 4. The need for both an upper and lower reservoir would double the land requirements and environmental impacts of a new or expanded hydropower project discussed in Subsection 9.2.2.3. For the same reasons that hydropower is not a viable baseload alternative in Texas, as discussed in Subsection 9.2.2.3, pumped hydro storage is not a viable energy storage option to be used in combination with renewable power generation methods for producing baseload power in Texas.

9.2.2.11.2.2 Compressed Air Energy Storage (CAES)

Like pumped hydro storage, CAES are generally operated as a peaking plant with energy being placed into storage during the less expensive, non-peak demand hours and being generated from the storage units during the higher priced, peak demand hours. CAES involves using compressors powered by the generation source to pump air into a storage facility, such as an underground cavern. The compressed air is then used in combination with a heat source, such as natural gas, to drive turbines and generate electricity. To generate the electricity from the CAES, the natural gas usage is between one third and one half the amounts needed to generate the same amount of electricity at a natural gas generating plant (DOE 2009; ESC 2002). Due to the cost differential between peak and non-peak hour and the reduction in the volume of natural gas used to generate a specific amount of power, a CAES facility can be economically attractive method of producing peak power (RES 2005; PEI 2008).

No large scale, baseload CAES facilities are in operation anywhere in the world. No CAES facilities combined with either wind or solar power are in operation. However, a 200 to 300 MW CAES facility integrated with 75 to 150 MW wind farms is proposed in Iowa, referred to as the Iowa Stored Energy Park (ISEP, 2006; PEI 2008).

Two CAES facilities combined with natural gas power plants, a 110 MW facility in Alabama and a 290 MW plant in Germany, have been built and are in operation (ESC 2002). A CAES facility that is to be powered with energy from generation facilities on the power grid is proposed for Norton, Ohio. The Norton, Ohio CAES facility, which is still in the project development and permitting stage, is planned to eventually provide 2700 MW of peaking power generation (PEI 2008). These three CAES facilities, none of which is combined with either wind or solar power, are primarily for peaking purposes rather than baseload generation (PEI, 2008). The Norton, Ohio project is somewhat different from the other CAES projects in that a pre-existing mine will be utilized. The size and the mining engineered construction of the pre-existing mine allows a much greater planned capacity for the Norton, Ohio facility as compared to other CAES projects. CTS-00920

The development of CAES facilities in the relevant area, the ERCOT region, has a number of challenges. Large land areas that possess the suitable geologic formations for large scale underground storage capacity are required. A source of natural gas or another equivalent heat source is required as part of the CAES facility. For the amount of electricity to be generated, CAES has environmental impacts similar to a natural gas generation unit although on a smaller scale.

There are no large-scale CAES systems in Texas. As a result, the economics and feasibilities of such a system in Texas are speculative. The construction of the turbine generation portion of the design is probably on a scale similar to a gas turbine generation station of the same size since very similar equipment would be required. The identification of, and development of, the storage cavern is an additional cost which has not been assessed in Texas. While the existing projects in Alabama and Germany combined with natural gas power and the proposed ISEP are on the scale of 110 to 290 MW (ESC 2002), these facilities are peaking plants and do not approach the 3200 MW needed to be an alternative baseload energy storage method for CPNPP Units 3 and 4.

Of the energy storage options available, CAES appears to be the most suitable for evaluation in combination with wind power. Luminant, in association with Shell-Wind Energy, is evaluating the potential of combining CAES with wind power projects in Texas (EFH 2007). Since this option of combining technologies may be feasible, the potential impacts of combining wind power with CAES storage are evaluated in Section 9.2.2.11.3.1.

9.2.2.11.2.3 Batteries

Batteries are used for energy storage in many applications. When combined with intermittent sources, such as wind or solar power, batteries can help to supply more reliable power for off-grid applications. When used for in-grid connections, batteries can serve as backup sources of power. Advantages include the fact that batteries can be portable, the technology has been tested, energy can be stored for consumption at a later period of time, and batteries can be charged and discharged multiple times. Overall, however, batteries are expensive and have relatively short lives, which increase the long-term expense (DOE 2009; ESC 2002).

Battery storage on the scale needed to provide baseload energy from storage comparable to CPNPP Units 3 and 4 has not been accomplished in Texas or anywhere, in large part for the reasons stated above. Duke Energy is proposing a demonstration project that would combine battery storage to provide 20 MW of peak power from the 151 MW Notrees Windpower Project in

Texas (REW, 2009). If completed and successful, the Duke demonstration project would be the largest power operation combining battery storage with wind energy. However, this demonstration project is still in the planning stages and would provide peaking power that will be substantially less than the baseload power generation of CPNPP Units 3 and 4. Therefore, the use of renewable energy in combination with battery storage is not a reasonable alternative for producing baseload power equivalent to CPNPP Units 3 and 4. CTS-00920

9.2.2.11.2.4 Hydrogen

In theory, hydrogen can be used to store energy. Hydrogen can be generated and then used to generate electricity via a mechanism such as a fuel cell. Such techniques have only been demonstrated on a small scale. The use of such storage on a large scale is only theoretical and is not expected to be practical on a large scale in the near future if ever. Fuel cells were discussed as an alternative in Subsection 9.2.2.8 and the limitations cited in that subsection do not depend on the source of the energy applied to the fuel cells. Therefore, the use of renewable energy in combination with hydrogen storage is not a reasonable alternative for producing baseload power equivalent to CPNPP Units 3 and 4.

9.2.2.11.2.5 Molten Salt

Molten salt batteries, sometimes called thermal batteries, use molten salt as the electrolyte. Molten salt batteries have a high power density, which means these batteries are useful in applications that require high levels of power but for which space is limited. Molten salt batteries have been used to power devices like missiles and artillery fuses. The application of thermal batteries has been limited almost entirely to military uses. These batteries have varying designs and one of the most common is a lithium salt battery, which is being studied for use in automobiles. The cost of such batteries is high and in many cases the sources for construction are limited. While suitable for some applications, molten salt batteries have not been used for large-scale energy storage.

There are no commercial baseload power plants that operate in conjunction with molten salt batteries. However, some energy projects have been proposed that would utilize molten salt batteries to provide storage capacity for the power generated by concentrated solar power plants. These proposed projects include a 200 MW and a 340 MW concentrating solar thermal power (CSP) plants near Kingman, Arizona and a 280 MW CSP plant near Gila Pass, all of which are proposed to utilize molten salt storage (CSA 2009; Abengoa 2009; Technology for Life 2009). Although still in the development stages, molten salt batteries appear to be considered a promising potential storage options combined with CSP.

Molten salt can also be used to store heat. The sun's energy is concentrated by a field of hundreds or even thousands of mirrors (called "heliostats") onto a receiver located on top of a tower (NREL 2006; SNL 2009). This energy heats molten salt flowing through the receiver- and the salt's heat energy is then used to generate electricity in a conventional steam turbine generator. The molten salt retains heat efficiently, so it can be stored for hours or even days before it loses its capacity to generate electricity (SNL 2009). Solar Two, a demonstration power tower located in the Mojave Desert in California, generated about 10 MW of electricity before the project was discontinued in 1999 (NREL 2001).

In these systems, the molten salt at 550°F is pumped from a “cold” storage tank through the receiver, where it is heated to 1,050°F and then on to a “hot” tank for storage. When power is needed from the plant, hot salt is pumped to a steam generating system that produces steam to power a turbine generator. From the steam generator, the salt is returned to the cold tank, where it is stored and eventually reheated in the receiver (SNL 2009). CTS-00920

With thermal energy storage, power towers could have the potential to operate at an annual capacity factor of up to 65 percent (CEC 2003), which means a solar power facility could potentially operate for 65 percent of the year without the need for a back-up fuel source. Without thermal energy storage, solar technologies like this are limited to annual capacity factors near 25 percent. The ability of power towers to operate for extended periods of time on stored solar energy separates this technology from other solar energy technologies. However, these technologies are still in the demonstration phase of development (CEC 2003). Molten salt storage has potential and is being developed in conjunction with solar energy. Therefore, the use of solar power generation combined with molten salt storage is evaluated further in Section 9.2.2.11.3.2.

9.2.2.11.2.6 Flywheels

Flywheels store energy through the inertia of a spinning disk. The amount of energy that can be stored depends upon the size of the disk. Long-term storage (more than minutes) is difficult to achieve with the desired level of efficiency. Flywheels are best used in stability applications such as in smoothing out the performance of a combustion engine or in smoothing out the voltage and frequency on a circuit. Flywheels can serve as backup power for low-power applications or as a source of short-term power support for high-power applications (DOE 2009; ESC 2002). No large-scale applications exist and there are no known plans to build such a large-scale power facility utilizing flywheels. Therefore, the use of renewable energy in combination with flywheels is not a reasonable alternative for producing baseload power equivalent to CPNPP Units 3 and 4.

9.2.2.11.2.7 Supercapacitors

There are multiple designs for electrical energy storage in supercapacitors and these designs are best suited for fast response, short duration applications. Supercapacitors are characterized by relatively low storage capabilities but have high charging and discharging rates. Supercapacitors can be used for backup during outages, for stabilizing voltage and frequency, and as a bridging power source in applications that need an uninterruptible power supply. Although supercapacitors have low maintenance and may have long lives, these devices are relatively expensive. There are no current case studies of supercapacitors being used as a large-scale source of power (DOE 2009). Therefore, the use of renewable energy in combination with supercapacitors is not a reasonable alternative for producing baseload power equivalent to CPNPP Units 3 and 4.

9.2.2.11.2.8 Other Storage Options

Other energy storage methods are possible, such as superconducting magnets. These options are generally in the research and development stage and do not offer a potential for large-scale energy storage in the foreseeable future (DOE 2009; ESC 2002). Therefore, the use of renewable energy in combination with other energy storage, other than the storage options previously discussed, is not a reasonable alternative for producing baseload power equivalent to CPNPP Units 3 and 4. CTS-00920

9.2.2.11.3 New Generation and Energy Storage Combinations

As discussed in Subsection 9.2.2.11.2, there are no large-scale facilities in existence that combine renewable energy sources with energy storage to produce baseload power. Furthermore, this combination of technologies as a baseload power source has not been demonstrated and proven. The projects that are being proposed and/or developed in the US and around the world use renewable energy generation combined with energy storage as either a peaking or an intermediate, intermittent power source.

At this time, the two most promising alternatives appear to be wind power generation combined with CAES storage and solar power generation with molten salt storage. However, even with technological advances that have been made or appear to be feasible, renewable energy generation combined with storage methods and supplemental use of natural gas, do not offer the potential as an alternate baseload power generation comparable to the CPNPP Units 3 and 4 and are not environmentally preferable to CPNPP Units 3 and 4. To more fully demonstrate this conclusion, the options of wind power combined with CAES storage; solar power combined with molten salt storage; and these generation and storage combinations supplemented by natural gas are assessed in the subsections below using the environmental evaluation criteria listed in NUREG-1555.

9.2.2.11.3.1 Wind Power Generation in Combination with CAES

For this energy technology combination, it is conservatively assumed that wind would be used to generate electricity for both 3200 MW of baseload power and 3200 MW of storage capacity, when adequate wind is available. Sufficient baseload energy must be put into storage when the wind resources are available to account for the lack of power generation capabilities for the periods of time when adequate wind resources are unavailable and for the inefficiency of the CAES process. Under this alternative, natural gas would be needed to recover the energy captured in the CAES process, but would not be used as a source of supplemental power generation if wind generation or generation from the storage facility is not available for extended periods of time. The use of natural gas to generate supplemental power to compensate for the lack of wind power or generation from storage is evaluated in Subsection 9.2.2.11.3.3.

One of the restrictions to this alternative is the diurnal nature of the wind resource in Texas. The wind availability is the direct inverse of the electrical load demand; with the wind being the strongest during the nighttime and early morning hours and weakest during the daytime hours (RES 2005). Only about 8.7 percent of the wind power in Texas generates electrical power that is available to reliably meet peak power demand (PEL 2009). Not only is wind an intermittent and unpredictable source of power, but in Texas, the wind resource is mainly available during non-peak and intermediate load demand periods and predominantly unavailable during the peak demand periods for power (RES 2005).

By applying energy storage, such as with CAES, the lack of wind power during peak demand periods can be ameliorated, to an extent. The combination of wind power in Texas with CAES would be a typical utilization of the energy storage concept. The power would be placed into storage during the non-peak demand hours and would then be taken from storage and utilized during the peak demand hours. Therefore, with storage, wind could be utilized in Texas as a form of peaking power, whereas wind is currently primarily restricted to non-peak and intermediate power generation. However, the limitations caused by the intermittent and unpredictable availability of wind, as well as the finite storage capacity of a CAES facility, would prevent wind combined with storage from being a baseload power source comparable to CPNPP Units 3 and 4. CTS-00920

Criterion 1 - Developed, proven, and available in the relevant region ERCOT

Wind power, as a developed, proven, and available technology in the relevant region, was discussed in Subsection 9.2.2.1. However, wind power is not available as baseload power and only 8.7 percent of the wind power in Texas generates electrical power that is available as peak capacity (PEL 2009). There are no wind power and CAES storage facilities in operation in either Texas or any other place in the world. There are no power generation facilities combining wind power with any storage technology in operation in the world.

There are two CAES facilities in operation, the 290 MW Huntorf facility in Germany and the 110 MW McIntosh plant in Alabama. Neither of these plants is operated in conjunction with wind power generation and neither is used for baseload energy production. A 268 MW CAES plant has been proposed in conjunction with 75 to 100 MW of wind farms in Iowa, but this Iowa Stored Energy Park is only in the planning and development stage. A 2700 MW CAES project has been proposed in Norton, Ohio that would be connected to the power grid for the non-peak power required for compression. Luminant and Shell-Wind Energy are proposing wind farm projects in Texas totaling 3000 MW and are evaluating the potential for incorporating CAES facilities in conjunction with the wind farm projects. The ability to generate baseload power comparable to that proposed by CPNPP Units 3 and 4 using wind power combined with CAES has yet to be demonstrated and has not been developed or proven, and is not available in the relevant area, or at any location in the world.

Criterion 2 - Capacity equivalent to the planned generation

As discussed in Subsection 9.2.2.1, although wind power is a developed and available technology, wind power is not capable of generating baseload power comparable to that of the proposed CPNPP Units 3 and 4. As discussed above, wind power combined with CAES is not currently available and this combination of technologies is still under development. The only two CAES projects in operation, the 290 MW Huntorf facility in Germany and the 110 MW McIntosh plant in Alabama (ESC 2002), produce significantly less power, are charged by natural gas or other power sources on the power grid, and are used for peaking or contingency purposes. The proposed Iowa Stored Energy Park is much smaller than CPNPP Units 3 and 4, will not provide baseload power, and is still in the planning and development stage.

The proposed 2,700 MW CAES project in Norton, Ohio is planned to be connected to the power grid for non-peak power for compression (PEI 2008). Less than 80 percent the size of CPNPP Units 3 and 4, the Norton, Ohio CAES project will not be linked to wind farms, is not planned for baseload power, and is still in the planning and development stages. The Norton, Ohio project proposes to convert an existing mine into a CAES facility, which allows a project to be planned that is much larger in scale than the other existing and proposed CAES facilities. However, the feasibility of such a conversion has not been previously attempted and has not been demonstrated. The operation of a CAES facility in a bedded sedimentary formation also has not been attempted or demonstrated, as the existing CAES facilities are in salt formations specifically engineered for storage. The Norton, Ohio project proponents plan to utilize off-peak power from the power grid to charge the CAES and will not be utilizing wind power. Even if the full 2700 MW of peaking power capacity can be realized, the Norton, Ohio project will still not demonstrate the ability to provide 3200 MW of baseload from wind power. CTS-00920

Luminant and Shell-Wind Energy are evaluating wind farm projects in Texas that will collectively total 3000 MW. The feasibility of combining CAES to these wind farm projects to some extent is being considered. However, the feasibility to construct and operate these wind farm and CAES projects is still being evaluated and has not been demonstrated. In addition, these projects, if feasible to build and operate, will not generate baseload power comparable to CPNPP Units 3 and 4.

Therefore, the ability to generate baseload power on the scale comparable to CPNPP Units 3 and 4 through the combination of wind power and CAES has not been demonstrated. The feasibility of using wind power combined with storage with CAES for baseload power is still speculative. More realistically, the use of storage would help wind power, which is currently available during mainly non-peak hours to be more available during intermediate demand and peak demand hours, improving the value of wind power as an intermediate or peaking technology.

Criterion 3 - Available during the same time frame

As discussed in Subsection 9.2.2.1, wind power is considered to not be available as a technology capable of generating baseload power comparable to that of the proposed CPNPP Units 3 and 4 within the project time frame. As discussed above, wind power combined with CAES is not currently available and this combination of technologies is still under development. The most advanced project is the proposed Iowa Stored Energy Park (ISEP 2006). The Iowa Stored Energy Park is much smaller than CPNPP Units 3 and 4, will not provide baseload power, and is still in the planning and development stage. Luminant, in partnership with Shell Wind Energy, is proposing wind farms in Briscoe County, Texas that collectively would generate 3000 MW of power. Luminant and Shell Wind Energy are evaluating the feasibility of combining CAES facilities into the operations of the wind farms (EFH 2007).

No wind power projects exist that incorporate energy storage, such as CAES. The feasibility of combining these technologies to provide baseload power has not been demonstrated or proven. No facilities are currently proposed utilizing wind power generation with energy storage, such as CAES, that would yield baseload power comparable to that of CPNPP Units 3 and 4. Since this combination of technologies is not currently available, has not been demonstrated, and is not proposed on the scale of CPNPP Units 3 and 4, wind power combined with CAES storage is not considered to be available to provide comparable baseload power within the project timeframe.

Criterion 4 - No unusual environmental impacts or exceptional costs

As discussed in Subsection 9.2.2.1, wind power, as a technology by itself, is considered to have potential environmental impacts greater than those impacts expected of CPNPP Units 3 and 4.

Due to the large land requirements, wind power projects comparable to CPNPP Units 3 and 4 have the potential for LARGE impacts on land use and aesthetics, MODERATE impacts on ecological resources, protected species, and cultural resources, and SMALL impacts on water quality, air quality, human health, and waste management. A potential positive, MODERATE impact on socioeconomics would also be expected. CTS-00920

By combining CAES into a wind power generation scenario, the anticipated environmental impacts would be greater than the impacts from a wind power project alone. Therefore, a wind power project with CAES generating 3200 MW of power is expected to have greater environmental impacts than CPNPP Units 3 and 4. A wind power and CAES project would be expected to have MODERATE impacts on water quality, air quality, and waste management. The water quality impacts would be increased by the large amount of freshwater that would be required to create the CAES storage caverns in either salt dome or bedded salt deposits found in Texas. The disposal of the large volumes of salt water, along with other impurities in the rock formations, from the cavern creation process would further impact water quality and increase waste management impacts. The use of natural gas in the CAES compression and energy generation processes will increase air impacts related to a wind power facility.

The Princeton Environmental Institute (PEI 2008) estimated that a CAES facility capable of generating baseload power for 88 hours would require a land area of approximately 14 percent of the wind turbine array. In Subsection 9.2.2.1, based upon the size of the Horse Hollow Wind Energy Center, the size of a wind farm to generate 3200 MW of energy was estimated to be between 452,000 to 816,000 ac of land. For 88 hours of power generation, a CAES facility could therefore cover between 63,280 and 114,420 ac of land. Since the CAES facility and wind farm may not be in the same geographic location, the impacts related to the CAES acreage would be in addition to the impacts of the wind farm.

Combining CAES storage with wind power generation would actually increase the land area of the wind farm, and by extension, increase the anticipated environmental impacts. Under this alternative scenario, a wind farm would have to generate 3200 MW of power for baseload power and generate the equivalent of 3200 MW for storage for each hour that the wind power is not able to generate power. If wind power generation is available for 12 hours a day, the wind farm would have to generate enough energy to be stored in the CAES facility to provide power for the 12 hours when the wind farm is off-line. In this simplest of scenarios, 6400 MW of power would have to be generated during the wind farm operation; doubling the land size and impacts of the wind farm due to the CAES storage. The potential for LARGE impacts on land use, aesthetics and ecological resources would, therefore, be expected.

Based upon the evaluation criteria discussed above and in Subsection 9.2.2.1, wind power in combination with CAES is not a reasonable energy alternative to CPNPP Units 3 and 4. First, wind power combined with CAES storage is not developed, proven, or available in the relevant region. Second, wind power combined with energy storage, such as in a CAES facility, has not been shown to be feasible as a technology capable of producing baseload energy capacity equivalent to that proposed for CPNPP Units 3 and 4. Third, the combination of a wind power and CAES project comparable to CPNPP Units 3 and 4 are not expected to be available during the same time frame as CPNPP Units 3 and 4. Finally, a wind power project combined with CAES would be expected to have significant environmental impacts and this technology combination is not environmentally preferable to CPNPP Units 3 and 4.

9.2.2.11.3.2 Solar Power Generation in Combination with Molten Salt Storage CTS-00920

For this energy combination alternative, it is conservatively assumed that solar power technology would be used to generate electricity for both 3200 MW baseload power and to place 3200 MW of energy into storage when an adequate source of solar energy is available. The solar power facility would have to generate power both at a baseload level of 3200 MW and at a level to store sufficient power into storage to provide 3200 MW of power for the time period that solar power generation is not feasible. The design capacity of the solar generation would have to exceed the desired baseload rate to account for the unavailability of solar energy for potentially extended periods of time (both nighttime hours and hours during the daytime when there is insufficient incident sun light) and the inefficiency of the molten salt storage process.

Under this alternative, the combination of solar power generation with storage using molten salt is evaluated as a stand-alone technology option. Natural gas would not be used under this alternative for supplemental generation if solar generation is not available for extended periods of time or when the storage capacity in the molten salt structure has been exhausted. The option of using supplemental natural gas with solar power and energy storage is evaluated in Subsection 9.2.2.11.3.3.

Energy storage projects are basically a form of commodity trading. Like other types of commodities, the energy is purchased and placed into storage when the cost of energy is the least expensive, which occurs mainly during hours of non-peak energy use, particularly at night and on weekends. The energy is then taken out of storage to produce power and sold when the cost of energy is higher, mainly during the hours of peak energy usage, particularly during daylight hours during the work week. The energy storage units are operated based upon the lower cost to put the energy into storage during the non-peak usage hours compared to the higher price that can be charged when the power is generated out of the storage unit during the peak hours of energy usage. Due to the cost differential between the non-peak and peak hours, energy storage can be cost-effective means of energy generation even though more power is utilized in the power storage project than is produced from the storage project (ESC 2002; PEI 2008; REL 2005).

The concept of combining solar power with storage projects, either by molten salt, hydropower, gas, CAES, or other storage technology, is somewhat contrary to the driving forces behind storage projects and could make the energy storage concept infeasible. Electric storage projects are net consumers of electricity; i.e., the storage projects consume more power than the projects generate. However, storage projects are usually profit-makers because the storage projects consume power during the cheaper non-peak hours and produce electricity during the more expensive peak use hours (ESC 2002; PEI 2008; REL 2005).

If storage projects were combined with solar power, the energy input for energy storage would be produced during the peak use and cost hours; i.e., during the daytime when solar power can be produced. The power would then be generated from the storage units during the non-peak use and cost hours to balance the lack of power generation from the solar projects. The projects would consume a greater amount of expensive electricity during the peak power demands period and generate a lesser amount of cheaper power mainly during the non-peak power demand hours; possibly affecting the feasibility of a combined solar power and storage project.

Criterion 1 - Developed, proven, and available in the relevant region ERCOT CTS-00920

As discussed in Subsection 9.2.2.2, in the ERCOT region, solar energy has been developed as only small scale, local power sources. No large-scale, baseload solar power generation plants have been developed. As discussed in Subsection 9.2.2.2 (under Criterion 1), solar power generation could be combined with thermal storage tanks to allow greater flexibility in dispatching electric power but no large-scale or baseload storage facilities, including molten salt storage systems, have been developed. The combination of solar with molten salt storage is not a developed, proven, available energy source in the relevant region, the ERCOT area.

Nationwide, solar power plants with molten salt storage are being proposed but have not been built and the technology is still being developed and demonstrated. Four CSP plants with molten salt storage are being proposed in Arizona. These four power proposed projects would total 1100 MW, collectively about one-third the capacity of CPNPP Units 3 and 4, and would not be used as baseload power (CSA 2009; Abengoa 2009; Technology for Life 2009; Lockheed Martin 2009). The technology combination appears to be feasible but is not developed, proven, and available as a baseload power source comparable to CPNPP Units 3 and 4.

Criterion 2 - Capacity equivalent to the planned generation

As discussed Subsection 9.2.2.2, solar power cannot provide baseload generating capacity and availability equal to CPNPP Units 3 and 4. Combining solar power with molten salt storage could help address the availability challenge, but would also require significantly greater levels of power generation from solar. As discussed in Subsection 9.2.2.2, the total levels of solar power generation projected to be developed in Texas are significantly less than the power to be provided by proposed CPNPP Units 3 and 4. The combination of solar power generation with molten salt storage may increase the length of time that a solar power facility could provide power over the course of a typical day but would not satisfy the shortfall of equivalent capacity.

Four projects are being proposed in Arizona that would combine CSP with molten salt storage. These proposed projects are a 200 MW and a 340 MW CSP plants with molten salt storage near Kingman, a 280 MW CSP plant with molten salt storage near Gila Pass, Arizona and a 290 MW CSP plant with storage in the Harquahala Valley, Arizona (CSA 2009; Abengoa 2009; Technology for Life 2009; Lockheed Martin 2009). All of these plants are significantly smaller than CPNPP Units 3 and 4 and will be peaking and intermediate power generation plants, rather than baseload plants. The Arizona plants would collectively total one-third of the power generation of CPNPP Units 3 and 4. A number of solar power projects are proposed in California that would collectively generate 1300 MW of power, less than half of the CPNPP Units 3 and 4, and, again, these projects collectively would not provide baseload power. Therefore, as discussed in Subsection 9.2.2.2, solar power does not appear capable of generating baseload power generation equivalent to CPNPP Units 3 and 4, even when combined with a storage technology such as molten salt storage.

Criterion 3 - Available during the same time frame

As discussed in Subsection 9.2.2.2, generating baseload capacity equivalent to CPNPP from solar power is not considered achievable within the project time frame. The combination of solar power generation with molten salt storage is still being developed and the feasibility as a large-scale, baseload power plant has not been demonstrated. Therefore, this technology is not considered to be available as a comparable baseload option within the project time frame. CTS-00920

Criterion 4 - No unusual environmental impacts or exceptional costs

As discussed in Subsection 9.2.2.2, a solar power plant, with power capacity comparable to CPNPP Units 3 and 4, would be expected to have environmental impacts in excess of the CPNPP Units 3 and 4. Due to the large land area requirements, a solar power plant is expected to have LARGE impacts on land use and aesthetics; MODERATE impacts on ecological resources, protected species, and cultural resources; and SMALL impacts on water quality, air quality, human health, and waste management. A MODERATE positive impact on socio-economics would also be expected from solar power generation.

Combining molten salt facility with a CSP plant would increase the land area and related impacts associated with the solar power farm. As discussed in Subsection 9.2.2.2, a solar power plant capable of generating 3200 MW of power was projected to cover between approximately 27,755 ac and 38,000 ac of land. Therefore, if (in a best case scenario) sufficient sunlight is available to generate 12 hours of 3200 MW baseload power, the molten salt storage facility would have to provide the next 12 hours of 3200 MW power each day. Assuming that the energy transfer between generation to storage and back into generation is 100 percent efficient with no loss, the solar power plant would have to generate twice the baseload requirement, or 6400 MW of power to provide 24 hours of energy.

Just the simple requirement to generate power for both baseload and storage would double the size of the solar plant required. In terms of land requirements, the footprint of the solar power facility would, therefore, range from approximately 55,510 ac to 76,000 ac. Additional acreage would be needed for the molten salt storage towers and the various pieces of equipment needed to operate the molten salt storage facility and generate power from storage units. LARGE impacts on land use, aesthetics and ecological resources would be, therefore expected. The handling of the molten salt may also increase the waste management impacts.

In terms of socio-economics, the combination of solar power generation with storage would be expected to have a LARGE adverse impact. As discussed previously, under this technology combination, energy stored at the most expensive, peak hour prices would be placed into storage because solar power can only be generated during the daytime hours. The power would then be generated from storage at the lower intermediate and non-peak hour prices. With each day, substantial economic losses will be suffered due to the differential between the higher peak hour costs when the power is put into storage and the lower intermediate or non-peak costs when the power is generated from storage.

Based upon the evaluation criteria discussed above and in Subsection 9.2.2.2, solar power technologies in combination with storage, such as molten salt storage, is not a reasonable energy alternative to the proposed project. First, solar power combined with storage is not developed, proven, and available in the relevant region (ERCOT) or even in other areas of the United States. Second, solar power generation combined with storage has not been proven to provide power generation capacity equivalent to CPNPP Units 3 and 4. Third, solar power generation with storage with the capacity to generate baseload power equivalent to CPNPP Units 3 and 4 is not considered to be available during the same time frame as the proposed project.

Finally, if such a facility where feasible, a solar power generation and storage project would be expected to have significant adverse environmental impacts and those impacts are expected to be in excess of those associated with CPNPP Units 3 and 4. CTS-00920

9.2.2.11.4 Renewable Energy Sources Combined with Storage and Natural Gas Power Generation

There are two primary scenarios for the combination of renewable energy sources with energy storage and natural gas power generation. Under the first scenario, the baseload power would be generated principally by the renewable energy source and, when the renewable energy power generation is not available, the baseload power would be generated from the energy storage facility. The renewable energy source would also be used to charge the energy storage facility. The natural gas power plant would be used to supplement the baseload power from the renewable energy source and energy storage operations. The natural gas plant would generate baseload power when the renewable energy source and the energy storage operations cannot produce power; the natural gas plant would supplement the baseload power generation when either the renewable energy source or energy storage operations generate less than the requisite 3200 MW of energy; and the natural gas plant would be used to charge the energy storage facility when the renewable energy source can generate the baseload power but cannot generate enough surplus power to charge the energy storage facility. This scenario is referred to as the renewable energy sources combined with storage and supplemented by natural gas power generation.

Under the second scenario, the primary source of the baseload power would be the natural gas plant. Power from the renewable energy source or from the energy storage facility displace the natural gas plant generation at the times that power from the renewable energy source or the energy storage facility is available. Alternatively, the renewable energy source could be used primarily to charge the energy storage facility when the renewable energy source is available and the natural gas plant continues to provide the baseload power. Under this second scenario, the natural gas plant would be operating at a capacity less than 3200 MW when power is available from either the renewable energy source or from the energy storage facility. This scenario is referred to as natural gas power generation supplemented by renewable energy sources combined with storage in the subsequent sections.

The power generation scenario selected would affect the power capacity, and therefore size, of the facilities required. Under the first scenario, in which natural gas would supplement renewable power combined with energy storage, all three power sources (the renewable power facility, the energy storage facility and the natural gas plant) would all have to be sized to generate 3200 MW of baseload power. Under the second scenario, in which renewable power combined with energy storage would supplement the baseload natural gas plant, only the natural gas plant would have to be sized to provide 3200 MW of baseload power. The renewable energy facility and energy storage facility could be sized for a smaller generation capacity, provided that the natural gas plant is kept in operation at a level that would maintain the collective 3200 MW of baseload power. The two scenarios of combining renewable energy, energy storage and natural gas power production are reviewed in the following subsections.

9.2.2.11.4.1 Renewable Energy Sources Combined with Storage and Supplemented by Natural Gas Power Generation CTS-00920

The concept behind this alternative is that the primary baseload power could be produced by solar or wind units with some of the excess energy placed into storage and from the charged energy storage facility. The natural gas plant could be activated when the wind and solar power is interrupted and the stored energy supply exhausted. The natural gas plant could also be used as supplemental load when the energy available from either the renewable energy source or energy storage facility is at some level below the targeted 3200 MW.

As discussed in Subsections 9.2.2.11.3.1 and 9.2.2.11.3.2, neither wind power with storage nor solar power with storage is capable of providing baseload power comparable to CPNPP Units 3 and 4. In fact, there may be periods of time at which the renewable source may be unavailable and the storage units are depleted and there may be no energy generation possible. When the renewable power and storage units cannot produce sufficient power, a natural gas plant capable of generating 3200 MW of power would be needed under this alternative. This alternative, to provide baseload power comparable to CPNPP Units 3 and 4, would require:

- a 3200 MW renewable power plant (either wind or solar) to generate power when the renewable resource is available;
- a 3200 MW storage facility (either CAES with wind power or molten salt storage with solar power) to generate power when the renewable resource is not available; and
- a 3200 MW natural gas power plant to generate power when the renewable resource not available and the storage units are depleted and the baseload power cannot be generated.

Therefore, this alternative combination would increase the environmental impacts as compared to the alternative of generating 3200 MW of power from a natural gas plant alone. The alternative of using natural gas supply to provide baseload power comparable to CPNPP Units 3 and 4 was fully evaluated in Subsections 9.2.2.10 and 9.2.3.2. As discussed in those subsections, if a natural gas plant could generate baseload power comparable to CPNPP Units 3 and 4, the natural gas plant would not be environmentally preferable to CPNPP Units 3 and 4. As discussed below, supplementing the natural gas plant with either wind or solar power, with energy storage units, would not change the conclusions of those subsections, namely that natural gas generation is not a preferable alternative capable of generating baseload power comparable to CPNPP Units 3 and 4.

Criterion 1 - Developed, proven, and available in the relevant region ERCOT

As discussed in Subsection 9.2.2.10, in the ERCOT region, natural gas energy has been developed as a baseload energy provider. If properly sized, a natural gas power plant could generate baseload power comparable to CPNPP Units 3 and 4 without the need for solar or wind power generation or energy storage. However, as discussed in Subsections 9.2.2.11.3.1 and 9.2.2.11.3.2, neither wind power with CAES storage nor solar power with molten salt storage are developed, proven, or available in the relevant (ERCOT) region or any other area in the United States. Therefore, a renewable power source combined with an energy storage option supplemented by natural gas is not developed, proven, or available in the relevant (ERCOT) region. CTS-00920

Criterion 2 - Capacity equivalent to the planned generation

As discussed in Subsection 9.2.2.10, in the ERCOT region, natural gas energy has been developed as a baseload energy provider. If properly sized, a natural gas power plant could generate baseload power comparable to CPNPP Units 3 and 4 without the need for solar or wind power generation or energy storage. However, as discussed in Subsections 9.2.2.11.3.1 and 9.2.2.11.3.2, neither wind power with CAES storage nor solar power with molten salt storage have the capacity to generate baseload power equivalent to the power to be generated by CPNPP Units 3 and 4. Therefore, a renewable power source combined with an energy storage option supplemented by natural gas does not have the capacity to generate baseload power equivalent to the planned generation from CPNPP Units 3 and 4; unless the majority of the baseload power was provided by natural gas plant with only intermittent power from the renewable source or the storage units.

Criterion 3 - Available during the same time frame

As discussed in Subsection 9.2.2.10, in the ERCOT region, natural gas energy has the potential to be available as baseload power within the timeframe determined for CPNPP Units 3 and 4. As discussed Subsections 9.2.2.11.3.1 and 9.2.2.11.3.2, neither wind nor solar power combined with storage options is available as baseload energy sources within the project timeframe. Therefore, a renewable power source combined with an energy storage option supplemented by natural gas would not be available within the project time frame; unless the majority of the baseload power was provided by natural gas plant with only intermittent power from the renewable source or the storage units.

Criterion 4 - No unusual environmental impacts or exceptional costs

The potential environmental impacts associated with wind power combined with a CAES facility and with solar power combined with a molten salt storage facility are discussed in Subsections 9.2.2.11.3.1 and 9.2.2.11.3.2, respectively. The potential environmental impacts that could be attributed to natural gas power generation are discussed Subsections 9.2.2.10 and 9.2.3.2.

Combining either wind or solar power with natural gas generation with an additional energy storage facility would result in cumulative impacts since each technology would have to have the capacity to produce 3200 MW of power individually. As discussed in Subsection 9.2.2.11.3.1 and 9.2.2.11.3.2, LARGE impacts on land use, aesthetics, ecological resources, protected species and cultural resources would be, expected from either wind or solar power with storage. MODERATE impacts on water quality, air quality, and waste management could be expected depending on which of the renewable power options is used. Solar power generation with storage could have a LARGE adverse socioeconomic impact, as discussed in Subsection 9.2.2.11.3.2.

As discussed in Subsection 9.2.2.10, the use of natural gas as the energy source is expected to have SMALL to MODERATE impacts on land use, ecological resources, protected species, human health, aesthetics, cultural resources, water quality, waste management, air quality, and socio-economics. As discussed above, the technology combination alternative would require the renewable power plant, the energy storage units, and the natural gas plant must all have the capability to produce 3200 MW of energy in order to provide baseload capacity comparable to CPNPP Units 3 and 4. Therefore, the construction-based impacts of the renewable power source, the storage facility and the natural gas plant would be cumulative and additive. The operational impacts of the renewable and storage mechanisms would also be additive. The operational impacts of natural gas would be reduced, because the natural gas plant would not be operating when the renewable and storage mechanism are operating. Therefore, under this alternative, the adverse environmental impacts are expected to be either MODERATE or LARGE for a number of environmental parameter except for possibly gaseous emissions and human health, which might be reduced to SMALL due to the reduction in operation of the natural gas component of the combination. CTS-00920

Based upon the evaluation criteria discussed above and in Subsections 9.2.2.1, 9.2.2.2, 9.2.2.10, and 9.2.3.2, a renewable power technology (such as wind or solar power) in combination with a storage technology (such as CAES or molten salt batteries) and supplemented by natural gas is not considered to be a reasonable energy alternative to the proposed project. First, such a combination of power technologies, as a single project, is not developed, proven, and available in the relevant region (ERCOT) or even in other areas of the United States. Second, such a combination of power technologies, as a project, has not been proven to provide power generation capacity equivalent to CPNPP Units 3 and 4. Third, such a combination of power technologies, as a project, with the capacity to generate baseload power equivalent to CPNPP Units 3 and 4 is not considered to be available during the same time frame as the proposed project. Finally, if such a power project where feasible, such a combination of power technologies, as a project, would be expected to have significant adverse environmental impacts and would not be environmentally more preferable than CPNPP Units 3 and 4.

9.2.2.11.4.2 Natural Gas Power Generation Supplemented by Renewable Energy Sources Combined with Storage

Under this alternative, the primary source of the 3200 MW of baseload power would be generated from a natural gas-fired power plant. When available, power from the renewable power source and the energy storage facility would be used to supplement the power generated from the natural gas power plant, thereby reducing the operation of the natural gas power plant. The energy storage facility can be charged from either the natural gas power plant or the renewable energy source, when sufficient renewable energy is available. This alternative, to provide baseload power comparable to CPNPP Units 3 and 4, would require:

- a 3200 MW or lesser capacity renewable power plant (either wind or solar) to generate power when the renewable resource is available;
- a 3200 MW or lesser capacity energy storage facility (either CAES with wind power or molten salt storage with solar power) to generate power when the renewable resource is not available; and
- a 3200 MW natural gas power plant to generate baseload power that could be ramped back when supplemental power is available from the renewable resource and the energy storage units.

Since this alternative would require both renewable energy facilities and energy storage facilities in addition to a 3200 MW natural gas power plant, this combination technology alternative would have greater environmental impacts than just a natural gas power plant alone. CTS-00920

The alternative of using natural gas supply to provide baseload power comparable to CPNPP Units 3 and 4 was fully evaluated in Subsections 9.2.2.10 and 9.2.3.2. As discussed in those subsections, if a natural gas plant could generate baseload power comparable to CPNPP Units 3 and 4, the natural gas plant would not be environmentally preferable to CPNPP Units 3 and 4. As discussed below, supplementing the natural gas plant with either wind or solar power, with energy storage units, would not change the conclusions of those subsections, namely that natural gas generation is not a preferable alternative capable of generating baseload power comparable to CPNPP Units 3 and 4.

Criterion 1 - Developed, proven, and available in the relevant region ERCOT

As discussed in Subsection 9.2.2.10, in the ERCOT region, natural gas energy has been developed as a baseload energy provider. If properly sized, a natural gas power plant could generate baseload power comparable to CPNPP Units 3 and 4 without the need for solar or wind power generation or energy storage. However, as discussed in Subsections 9.2.2.11.3.1 and 9.2.2.11.3.2, neither wind power with CAES storage nor solar power with molten salt storage are developed, proven, or available in the relevant (ERCOT) region or any other area in the United States. Therefore, a 3200 MW baseload power operation consisting of a natural gas power plant supplemented by a renewable power source combined with energy storage is not developed, proven, or available in the relevant (ERCOT) region.

Criterion 2 - Capacity equivalent to the planned generation

As discussed in Subsection 9.2.2.10, in the ERCOT region, natural gas energy has been developed as a baseload energy provider. If properly sized, a natural gas power plant could generate baseload power comparable to CPNPP Units 3 and 4 without the need for solar or wind power generation or energy storage. However, as discussed in Subsections 9.2.2.11.3.1 and 9.2.2.11.3.2, neither wind power with CAES storage nor solar power with molten salt storage have the capacity to generate baseload power equivalent to the power to be generated by CPNPP Units 3 and 4. Therefore, although a renewable power source combined with an energy storage option supplemented by natural gas does not have the capacity to generate baseload power equivalent to the planned generation from CPNPP Units 3 and 4; the option of producing the majority of the baseload power from a natural gas plant with only intermittent power from the renewable source or the storage units might be feasible. This conclusion assumes that such a combination of energy technologies is feasible.

Criterion 3 - Available during the same time frame

As discussed in Subsection 9.2.2.10, in the ERCOT region, natural gas energy has the potential to be available as baseload power within the timeframe determined for CPNPP Units 3 and 4. As discussed Subsections 9.2.2.11.3.1 and 9.2.2.11.3.2, neither wind nor solar power combined with storage options is available as baseload energy sources within the project timeframe. Therefore, although a renewable power source combined with an energy storage option supplemented by natural gas would not be available within the project time frame; an option in which the majority of the baseload power was provided by natural gas plant with only intermittent power from the renewable source or the storage units may be available within the project time frame. This conclusion assumes that such a combination of energy technologies is feasible. CTS-00920

Criterion 4 - No unusual environmental impacts or exceptional costs

The potential environmental impacts associated with wind power combined with a CAES facility and with solar power combined with a molten salt storage facility are discussed in Subsections 9.2.2.11.3.1 and 9.2.2.11.3.2, respectively. The potential environmental impacts that could be attributed to natural gas power generation are discussed Subsections 9.2.2.10 and 9.2.3.2.

The technology combination of a natural gas plant capable of generating 3200 MW of baseload power supplemented by a renewable energy source combined with an additional energy storage facility would result in cumulative construction and land use impacts that would be greater than the impacts caused by a 3200 MW natural gas power plant alone. As discussed in Subsection 9.2.2.11.3.1 and 9.2.2.11.3.2, LARGE impacts on land use, aesthetics, ecological resources, protected species and cultural resources would be, expected from either wind or solar power with storage. The magnitude of these impacts could be moderated if the installed generating capacity of the wind and solar facilities were reduced and replaced with additional natural gas power generating capacity. However, in such an event, the reduction in construction impacts would be offset by the increase in the operational impacts resulting from the combination of the power technologies due to the greater use of natural gas.

As discussed in Subsection 9.2.2.10, the use of natural gas alone as the energy source is expected to have SMALL to MODERATE impacts on land use, ecological resources, protected species, human health, aesthetics, cultural resources, water quality, waste management, air quality, and socio-economics. As a result, a natural gas plant alone is not an environmentally preferable alternative to CPNPP Units 3 and 4.

If a renewable energy source combined with an energy storage facility were used to supplement the operation of a natural gas plant, the impacts from the operation of the natural gas plant on water and air quality would be reduced relative to the impacts of operating a natural gas plant alone. However, even under the best case scenario involving the lowest level of operation of the natural gas plant, the combination of power technologies would not be environmentally preferable to CPNPP Units 3 and 4 due to the environmental impacts associated with land use combined with the cumulative impacts of the three technologies. As the use of natural gas increases in this technology combination, the impacts on air and water quality increase. As the use of the renewable energy source and energy storage facilities increases in this technology combination, the impacts associated with land use increases. Thus regardless of the mix of the technologies, the combination of natural gas with renewable energy sources and energy storage facilities would not be environmentally preferable to CPNPP Units 3 and 4, even if it were feasible to generate comparable baseload power through these technology combinations.

Based upon the evaluation criteria discussed above and in Subsections 9.2.2.1, 9.2.2.2, 9.2.2.10, and 9.2.3.2, the option of combining a natural gas power plant with a renewable power technology (such as wind or solar power) in combination with a storage technology (such as CAES or molten salt batteries) is not a reasonable energy alternative to the proposed project. First, such a combination of power technologies, as a single project, is not developed, proven, and available in the relevant region (ERCOT) or even in other areas of the United States. Second, such a combination of power technologies, as a single project, has not been proven to provide power generation capacity equivalent to CPNPP Units 3 and 4, unless the vast majority of the power is generated by natural gas. Third, such a combination of power technologies, as a single project, with the capacity to generate baseload power equivalent to CPNPP Units 3 and 4 is not considered to be available during the same time frame as the proposed project unless the vast majority of the power is generated from natural gas. Finally, if such a power project where feasible, such a combination of power technologies, as a single project, would be expected to have significant adverse environmental impacts and would not be environmentally more preferable than CPNPP Units 3 and 4. CTS-00920

9.2.2.11.5 Conclusions of Combining New Generation Power Sources with Storage

A number of potential combinations of renewable energy sources with energy storage facilities either with or without natural gas have been evaluated and discussed in the preceding subsections. The use of solar or wind power combined with energy storage options and supplemented by natural gas to provide baseload power comparable to that proposed for CPNPP Units 3 and 4 has been evaluated and discussed in the subsections above. The use of natural gas supplemented by a renewable energy source in combination with energy storage has been evaluated and discussed in the subsections above. This evaluation does not change the conclusions in Subsections 9.2.2.1, 9.2.2.2, 9.2.2.10, 9.2.3.2 and 9.2.3.3 that natural gas, wind, solar; and energy storage either individually or in combination, are not viable alternatives that could both produce baseload power comparable to that generated by CPNPP Units 3 and 4 and be environmentally preferable to CPNPP Units 3 and 4. Renewable energy sources combined with energy storage facilities, operated either with or without natural gas, capable of generating baseload power comparable to CPNPP Units 3 and 4 are not environmentally preferable alternatives to CPNPP Units 3 and 4.

When compared to standard baseload options such as nuclear, natural gas and coal generation, none of the combinations of a renewable energy source with an energy storage technology can provide equivalent baseload electricity. Options which rely on renewable energy sources and energy storage are best suited for power peaking or stabilizing purposes. Renewable energy sources and energy storage options are not currently, or projected to be, used for baseload power applications.

9.2.3 ASSESSMENT OF ALTERNATIVE SOURCES AND SYSTEMS

Luminant has identified a broad range of strategies to generate baseload power. Subsection 9.2.2 discusses the pertinent options addressing the particular need for power to be addressed by the proposed CPNPP Units 3 and 4. This subsection further evaluates the environmental effects from the reasonable alternatives and compares them to the proposed CPNPP Units 3 and 4. For the reasons discussed in Subsection 9.2.2, these alternatives are coal and natural-gas-fired generation. The environmental impacts discussed in this subsection and summarized in Table 9.2-1 are representative of the alternate energy sources.

However, per NUREG-1555, a full-cost benefit analysis is not required, as none of the alternatives have been found to be environmentally preferable.

9.2.5 REFERENCES

(Abengoa 2009) Projects In USA: Arizona: Location Gila Bend Near Phoenix: Type of Project 280 MWe, CPS. Abengoa Solar. http://www.abengoasolar.es/sites/solar/en/our_projects/usa/arizona/index.html. Accessed September 23, 2009. CTS-00920

(AWEA 2009) Annual Wind Industry Report Year Ending 2008. American Wind Energy Association. Washington, D.C.

(BSII 2006) Big Stone II Plant Project overview. http://www.bigstoneii.com/PlantProject/PlantProjectOverview.asp. Accessed February 2008.

(BTI 2000) Projects. Fuel Cells 2000. Breakthrough Technologies Institute (BTI). http://www.fuelcells.org/db/projects.php. Accessed February 2008.

(BW 2005) Alternate Power: A Change Is in the Wind. Business Week, July 4, 2005, News Analysis and Commentary. http://www.businessweek.com/magazine/content/05_27/b3941036_mz011.htm?chan=search. Accessed February 2008.

(CCI 2007) Chambers County Incinerator. Chambers County Resource Recovery & Recycling Facility http://chamberscountyincinerator.com/about.asp. Accessed February 2008.

(CEC 2003) “Renewable Resources Development Report.” Sacramento, CA. California Energy Commission Contract No. 500-03-080F http://www.energy.ca.gov/reports/2003-11-24_500-03-080F.PDF. November 2003. Accessed September 28, 2009. CTS-00920

(CEED 2006) Geothermal Energy in Gulf Coast Texas. Center for Energy and Economic Diversification. http://www.utpb.edu/ceed/renewableenergy/gulf_coast_texas.htm. Accessed February 2008.

(CGT 2007) Geothermal Powerplants. Cogeneration Technologies. http://www.cogeneration.net/geothermal_powerplants.html. Accessed January 2008.

(CSA 2009) Navajo County to host world’s largest solar project. Jayne Hanson, Today’s News Herald. Reprinted from County Supervisors Association of Arizona website. http://www.countysupervisors.org/news/view_article.cfm. Accessed September 23, 2009. CTS-00920

(CSP undated) CSP Technologies Overview. U.S. Department of Energy CSP Technologies. www.energylan.sandia.gov/sunlab/overview.htm#cost. Accessed January 2008.

(DOE 2001) How Hydropower Works. Idaho National Laboratory. June 2001.U.S. Department of Energy. http://hydropower.id.doe.gov/hydrofacts/pdfs/01-ga50627-01-brochure.pdf. Accessed February 2008.

(DOE 2009) Distributed Energy Program: Case Studies – Energy Storage Technologies. U.S. Department of Energy. http://www.eere.energy.gov/de/cs_energy_storage.html. Accessed September 4, 2009. CTS-00920

(EERE 2005) Wind Energy Resource Potential. U.S. Department of Energy. Energy Efficiency and Renewable Energy. www1.eere.energy.gov/windandhydro/wind_potential.html. September 2005. Accessed February 2008.

(EERE 2006) Furthering Energy Independence. U.S. Department of Energy. Energy Efficiency and Renewable Energy. Solar Energy Technology Program. www1.eere.energy.gov/office_eere/pdfs/solar_fs.pdf. July 2006. Accessed February 2008.

(EFH 2007) Luminant and Shell Join Forces to Develop a Texas-Sized Wind Farm. Energy Future Holdings News Release. http://www.energyfutureholdings.com/news/newsrel/detail.aspx Accessed September 9, 2009. CTS-00920

(EIA 2006) Net Generation by Energy Source by Type of Producer. October 2006. U.S. Department of Energy. Energy Information Administration. www.eia.doe.gov/cneaf/electricity/epa/epat1p1.html. Accessed February 2008.

(EIA 2006b) Assumptions to the Annual Energy Outlook. DOE/EIA-0554(2006). March 2006. U.S. Department of Energy. Energy Information Administration. www.eia.doe.gov/oiaf/aeo/assumption/pdf/ 0554(2006).pdf. Accessed February 2008.

(EIA 2007) Cost and Quality of Fuels for Electric Plants 2005 and 2006. Table 14.A. Receipts and Average Delivered Cost of Natural Gas by Type of Purchase, Census Division, and State: Total (All Sectors), 2006. October 2007. U.S. Department of Energy. Energy Information Administration. www.eia.doe.gov/cneaf/electricity/cq/cq_sum.html.

(EIA 2007a) Summary Statistics: Receipts and Cost of Fossil Fuels for the Electric Power Industry by Sector, Btus. October 2007. U.S. Department of Energy. Energy Information Administration. www.eia.doe.gov/cneaf/electricity/epm/tablees2b.html.

(EPA 1998) Bituminous and Subbituminous Coal Combustion. Air Pollutant Emission Factors. Volume 1, Stationary Point Sources and Area Sources, Section 1.1. September 1998. U.S. Environmental Protection Agency. www.epa.gov/ttn/chief/ap42/. Accessed February 2008.

(EPA 2000) Stationary Gas Turbines. Air Pollutant Emission Factors. Volume 1, Stationary Point Sources and Area Sources, Section 3.1, AP-42. April 2000. U.S. Environmental Protection Agency. www.epa.gov/ttn/chief/ap42/ch03/final/c03s01.pdf. Accessed February 2008.

(EPRI 2005) Status & Trends for Stationary Fuel Cell Power Systems. 2005. Electric Power Research Institute. http://www.mitstanfordberkeleynano.org/events_past/0507%20-%20Fuel%20Cell/Stanford%20Fuel%20Cell%20Symposium.pdf. Accessed February 2008.

(ERCOT 2006) Analysis of Transmission Alternatives for Competitive Renewable Energy Zones in Texas. ERCOT System Planning, December 2006. Electric Reliability Council of Texas, Inc.

http://www.ercot.com/news/presentations/2006/ATTCH_A_CREZ_Analysis_Report.pdf. Accessed April 2008.

(ERCOT 2007) ERCOT Quick Facts. May 2007. ERCOT fact sheet. Electric Reliability Council of Texas, Inc. www.ercot.com/about/profile/index.html. Accessed February 2008.

(ERCOT 2007a) System Planning 2007. Report on the Capacity, Demand, and Reserves in the ERCOT Region. Electric Reliability Council of Texas, Inc. http://www.ercot.com. Accessed February 2008.

(ERCOT 2007b) Nuts and Bolts of Connecting Projects to ERCOT, Impacts of CREZ on Transmission Build-out and Wind Power Opportunities in the Texas Market Workshop. November 28, 2007. Electric Reliability Council of Texas, Inc. http://www.ercot.com/news/presentations/2007/Bojorquez_-_Nuts_and_Bolts_of_Wind_Integration_-_11282007.ppt. Accessed February 2008.

(ERCOT 2007c) Unit Data121807. Unit Information. EXCEL data spreadsheet, December 18, 2007. Electric Reliability Council of Texas, Inc. (FCT undated) Advantages – Disadvantages. Fuel Cell Today. http://www.fuelcelltoday.com/media/pdf/education-kit/Advantage-Disadvantages.pdf. Accessed February 2008.

(ESC 2002) Energy Storage, The Missing Link in the Electricity Value Chain; an ESC White Paper. Energy Storage Council. St. Louis, Missouri. CTS-00920

(FCT undated) Advantages - Disadvantages. Fuel Cell Today. http://www.fuelcelltoday.com/media/pdf/education-kit/Advantage-Disadvantages.pdf. Accessed February 2008.

(FPL 2006) Horse Hollow Wind Energy Center now largest wind farm in the world. September 7, 2006 press release. Florida Power and Light. www.fplenergy.com/news/contents/090706.shtml. Accessed February 2008.

(FPL 2007) Horse Hollow Wind Energy Centers. project fact sheets, 2007. Florida Power and Light. http://www.fplenergy.com/portfolio/pdf/horsehollow.pdf. Accessed February 2008.

(FPSC 2003) An Assessment of Renewable Electric Generating Technologies for Florida. January 2003. Florida Public Service Commission and the Department of Environmental Protection. www.psc.state.fl.us/publications/ pdf/electricgas/Renewable_Energy_Assessment.pdf. Accessed February 2008.

(GAO 2004) Renewable Energy, Wind Power's Contribution to Electric Power Generation and Impact on Farms and Rural Communities. GAO-04-756. September 2004. U.S. General Accountability Office. http://www.gao.gov/new.items/d04756.pdf. Accessed February 2008.

(GEA undated) All about Geothermal Energy – Basics. Undated. Geothermal Energy Association. http://www.geo-energy.org/aboutGE/basics.asp. Accessed February 2008.

(GEPS 2000) GE Combined-Cycle Product Line and Performance. Chase & Kehoe, GER-3574G, October 2000. Geothermal Energy Association. www.gepower.com/prod_serv/products/tech_docs/en/downloads/ger3574g.pdf. Accessed February 2008.

(GTC 2005) Reliability of IGCC Power Plants. Higman, DellaVilla, & Steele. October 2005. Gasification Technologies Conference, San Francisco. www.gasification.org/Docs/ 2005_Papers/38HIGM%20Paper.pdf. Accessed February 2008.

(IEC 2006) Wind Energy Economics. Wind Energy Manual. 2006. Iowa Energy Center. www.energy.iastate.edu/renewable/wind/wem/economic_issues.htm. Accessed February 2008.

(ISEP 2006) About the Iowa Stored Energy Park. Website for Iowa Stored Energy Park. http://www.isepa.com/about_isep.asp. Accessed September 4, 2009. CTS-00920

(Lockheed Martin 2009) Lockheed Martin to Support Utility-scale Solar Power Plant in Arizona. Lockheed Martin News Release. http://www.lockheedmartin.com/news/press_releases/2009/052209_LM_Starwood_Energy.html. Accessed September 23, 2009.

(NETL undated) Combustion - Fluidized-Bed Combustion, Program Overview. undated. U.S. Department of Energy. National Energy Technology Laboratory (NETL). www.netl.doe.gov/technologies/coalpower/Combustion/FBC/fbc-overview.html. Accessed February 2008.

(NETL 1999) Market-Based Advanced Coal Power Systems Final Report. DOE/FE-0400. 1999. U.S. Department of Energy. National Energy Technology Laboratory (NETL). http://www.netl.doe.gov/technologies/coalpower/refshelf/marketbased_systems_report.pdf. Accessed February 2008.

(NETL 2005) Final Technical Report for the JEA Large-Scale CFB Combustion Demonstration Project. Prepared by Black & Veatch. Submitted to U.S. Department of Energy National Energy Technology Laboratory (NETL). http://www.netl.doe.gov/technologies/coalpower/cctc/resources/pdfs/jacks/Final_Technical_Report_Compendium.pdf. June 24, 2005. Accessed February 2008.

(NETL 2007) Cost and Performance Baseline for Fossil Energy Plants. DOE/NETL 2007/1281. Bituminous Coal and Natural Gas to Electricity, Final Report (Original Issue Date, May 2007), Revision 1, August 2007.

(NINI 2004) Levelized Costs for Nuclear, Gas and Coal for Electricity, Under the Mexican Scenario. 2004. National Institute of Nuclear Investigations. www.osti.gov/bridge/servlets/purl/840500-YJxBpR/native/840500.pdf.

(NJCEP 2005) Frequently Asked Questions – Off Shore Wind Systems. April 14, 2005. NJ Clean Energy Program. http://www.njcleanenergy.com/renewable-energy/technologies/wind/wind-working-group/faqs/faqs. Accessed February 2008.

(NP 2007) Project Info. 2007. Nacogdoches Power. http://www.nacogdochespower.com/ProjectInfo.html. Accessed February 2008.

(NREL 2001) Concentrating Solar Power: Energy from Mirrors. National Renewable Energy Laboratory produced for U.S. Department of Energy report # DOE/GO-102001-1147 FS 128. Golden, Colorado. CTS-00920

(NREL 2002) Fuel from the Sky: Solar Power's Potential for Western Energy Supply. July 2002. US National Renewable Energy Laboratory. www.nrel.gov/csp/pdfs/32160.pdf. Accessed February 2008.

(NREL 2006) Economic, Energy, and Environmental Benefits of Concentrating Solar Power in California. Black and Veatch Subcontract Report NREL/SR-550-39291 produced for National Renewable Energy Laboratory, Golden Colorado. CTS-00920

(NRRI 2007) What Generation Mix Suits Your State? Tools for Comparing Fourteen Technologies across Nine Criteria. 2007. National Regulatory Research Institute. http://coalcandothat.com/pdf/35%20GenMixStateToolsAndCriteria.pdf. Accessed February 2008.

(PEI 2008) Compressed Air Energy Storage: Theory, Resources, and Applications for Wind Power. Princeton Environmental Institute, Energy Systems Analysis Group. Princeton, New Jersey. CTS-00920

(PEL 2009). 2008 State of the Market Report for the ERCOT Wholesale Electricity Markets. Potomac Economics, LTD. Austin, Texas.

(PEPEI 2009) Duke to develop storage for Texas wind farm. Power Engineering/Power Engineering International website. http://pepei.pennnet.com. Accessed November 25, 2009.

(PG&E 2007) PG&E Signs Agreement with Solel for 553 Megawatts of Solar Power. news release July 25, 2007. PG&E. http://www.pge.com/news/news_releases/q3_2007/070725a.html. Accessed February 2008.

(REPP 2003) Geothermal Energy for Electric Power, Renewable Energy Policy Project. December 2003. Renewable Energy Policy Project. http://www.repp.org/repp/index.html. Accessed February 2008.

(RES 2005) The Economic Impact of CAES on Wind in TX, OK, and MN, prepared for the Texas State Energy Conservation Office. Ridge Energy Storage and Grid Services, L.P. Houston, Texas. CTS-00920

(REW 2009) Duke Receives US $22M Grant for Wind Power Storage. Renewable Energy World website. http://www.renewableenergyworld.com. Accessed November 25, 2009.

(RTII 2003) Beyond-The-Floor Analysis For Existing And New Coal- And Oil-Fired Electric Utility Steam Generating Units National Emission Standards For Hazardous Air Pollutants. December 2003. RTI International. www.epa.gov/ttn/atw/utility/beyond_floor_012804.pdf. Accessed February 2008.

(SECO 2007) Texas Solar Energy. 2007. State Energy Conservation Office. http://www.seco.cpa.state.tx.us/re_solar.html. Accessed February 2008.

(SECO 2007a) Texas Biomass Energy. 2007. State Energy Conservation Office. http://www.seco.cpa.state.tx.us/re_biomass.html. Accessed February 2008.

(SNL 2009) Concentrating Solar Power. Sandia National Laboratories. http://www.sandia.gov/csp/. Accessed September 8, 2009. CTS-00920

(Solarbuzz 2007) Fast Solar Energy Facts. Global Performance. March 2007. Solarbuzz LLC. www.solarbuzz.com/FastFactsIndustry.html. Accessed February 2008.

(SORR undated) Biomass Energy: Cost of Production. undated. State of Oregon, Renewable Resources. www.oregon.gov/ENERGY/RENEW/Biomass/Cost.shtml. Accessed February 2008.

(Technology for Life 2009) Albiasa Solar to Build a 200 MW Concentrating Solar Power Plant in Arizona. Technology for Life website. http://technology4life.wordpress.com/2009/04/21/albiasa-solar-to-build-a-200-mw-concentrating-solar-power-plant-in-arizona. Accessed September 23, 2009. CTS-00920

(TCEQ 2007) Air Quality and the State Implementation Plan. Texas SIP 101. January 2007. Texas Commission on Environmental Quality. www.tceq.state.tx.us/implementation/air/sip/sipintro.html. Accessed February 2008.

(TCEQ 2007a) History of the Texas State Implementation Plan. May 2007. Texas Commission on Environmental Quality. www.tceq.state.tx.us/assets/public/implementation/air/sip/miscdocs/SIPHistory_updated.pdf. Accessed February 2008.

(TCPS 1995) Texas Environmental Almanac. 1995. Texas Center for Policy Studies. http://www.texascenter.org/almanac/TXENVALMANAC.html. Accessed February 2008.

(TGLO 2007) Land Office Awards Texas' first geothermal lease. press release February 6, 2007. Texas General Land Office. http://www.glo.state.tx.us/news/docs/2007-Releases/02-06-07-Geothermal-AWARD.pdf. Accessed February 2008.

(UC 2004) The Economic Future of Nuclear Power. August 2004. The University of Chicago. http://www.anl.gov/Special_Reports/NuclEconSumAug04.pdf. Accessed February 2008.

(VERA 1995) Texas Renewable Energy Resource Assessment. 1995 Report to the Texas Sustainable Energy Development Council. Virtus Energy Research Associates. http://www.vera.com/re_home.htm. Accessed February 2008.