The West's Renewable Energy Future: A Contribution by National Grid

July 2008

nationalgrid

THE WEST'S RENEWABLE ENERGY FUTURE

A CONTRIBUTION BY NATIONAL GRID

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LIST OF ACRONYMS

AC	Alternating Current
APS	Arizona Public Service Company
AWEA	American Wind Energy Association
BAU	Business-As-Usual
CCS	Carbon Capture and Storage
CDEAC	Clean and Diversified Energy Advisory Committee
CEC	California Energy Commission
CO_2e	Carbon Dioxide Equivalent
CPUC	California Public Utilities Commission
CSP	Concentrating Solar Power
DSM	Demand Side Management
DSW	Desert Southwest (Arizona, Nevada and Southern California)
EPA	Environmental Protection Agency
GHG	Greenhouse Gas
GWh	Gigawatt Hour
HVDC	High Voltage Direct Current
IOU	Investor Owned Utility
IRP	Integrated Resource Plan
ITC	Investment Tax Credit
KV	Kilovolt
LCOE	Levelized Cost of Energy
$MMtCO_2e$	Million Metric Tons of Carbon Dioxide Equivalent
MW	Megawatt
MWh	Megawatt Hour
NREL	National Renewable Energy Laboratory
PTC	Production Tax Credit
PV	Photovoltaic
RETI	Renewable Energy Transmission Initiative
RMATS	Rocky Mountain Area Transmission Study
RPS	Renewable Portfolio Standard
TTP	Tehachapi Transmission Project
TWE	TransWest Express
TWRA	Tehachapi Wind Resource Area
WCI	Western Climate Initiative
WECC	Western Electricity Coordinating Council
WGA	Western Governors' Association
WREZ	Western Renewable Energy Zones

1 EXECUTIVE SUMMARY

This Report has been prepared by National Grid and Energy Strategies, LLC. National Grid owns and operates significant electric transmission assets in the Northeast and the UK and is a leading contributor on electric transmission policy issues.[i] Energy Strategies is an energy consulting firm based in Salt Lake City, Utah that has supported National Grid's development efforts in the West.

This Report has been prepared to contribute to the current debate on the West's renewable energy future, including the recently initiated Western Governors' Association (WGA) sponsored Western Renewable Energy Zones (WREZ) project. It builds on National Renewable Energy Laboratory (NREL) databases of renewable energy resources and compliments the work already undertaken by the California state agencies and public utilities with Phase 1A of the Renewable Energy Transmission Initiative (RETI) study.

Population in the West is growing rapidly which is, in turn, driving an increasing demand for energy in the region. In addition, many states have implemented Renewable Portfolio Standards (RPSs) requiring a certain percentage of electricity sales to come from renewable resources. This Report concludes that the US portion of the Western Electricity Coordinating Council (WECC) region will require 116,000 GWh per year of new renewable energy sources to meet 2020 RPS goals, requiring an investment in excess of $100 billion. The Desert Southwest (DSW) region (that, for the purpose of this Report, consists of Arizona, Nevada and Southern California) will require approximately 50 percent of this total, or about 55,000 GWh by 2020.

The analysis in this Report also considers the impact of the Western Climate Initiative (WCI) and possible federal greenhouse gas (GHG) legislation on the electricity sector. While it is still not entirely clear how the WCI will affect the electricity sector, this Report concludes that it is credible to assume that the WCI could stimulate even greater demand for new renewable energy resources than RPSs. Similarly, there is some uncertainty about the design and extent of federal GHG legislation, but the prospect of such legislation has already sent market signals to Western utilities, many of which have begun to evaluate a cost associated with carbon dioxide emissions in their resource plans. This acts as a further stimulus to develop new renewable energy.

Between RPS requirements and GHG reduction goals the demand for new renewable energy is considerable. The RETI report recognized wind and solar as two of the more viable, large scale renewable technologies. Based on NREL data, the potential of Arizona, California and Nevada's concentrating solar power (CSP) and wind resources is 2.2 million GWh per year and 85,000 GWh per year, respectively. The potential of Wyoming's Class 6 and 7 wind energy resources is 235,000 GWh per year and the potential of Wyoming's Class 4 and above wind energy resources is 944,000 GWh per year.

These potential energy figures are all highly theoretical and overlook various practical and cost issues. However, they serve to illustrate that these are the two jewels of the region's resource potential and that they dwarf the potential capacity for all other renewable technologies and resources in the region combined. A further illustration of Wyoming's wind potential is that NREL data shows that over 50 percent of the best quality (Class 6 and 7) wind resources in the continental US are located in Wyoming. This vast Wyoming resource is, however, remote from large load centers and new long-distance transmission is required to move this power to market.

National Grid has been the lead developer of the TransWest Express (TWE) transmission project. TWE is a proposed 3,000 MW, $3B, 500 kV, HVDC transmission line that will run from wind rich southeast Wyoming to a terminal in southern Nevada from where the markets in Arizona, Nevada[1] and Southern California can be accessed. The project is due to be operational by 2014.

Because Wyoming wind is remote from the DSW markets this Report considers the costs and issues associated with building new interstate transmission (based on the TWE project) and compares the delivered cost of Wyoming wind against CSP and other generation solutions for the DSW. This Report concludes that:

- The best Wyoming wind is the lowest cost renewable energy solution for the DSW, with a delivered cost range of $72 to $101 per MWh (2008$).
- Wyoming wind, delivered to the DSW, is significantly less expensive than CSP resources. As a less mature industry the future cost of CSP in the DSW is harder to predict but is forecasted to remain a more expensive solution in the range of $143 to $220 per MWh (2008$).
- Under nearly all scenarios evaluated wind is competitive with natural gas fired generation as an energy resource.

The Report concludes, therefore, that Wyoming wind is the lowest cost, largest volume, renewable energy solution available for the DSW region. The Report further observes that wind generation requires no water and uses land more efficiently than other resource options. This makes Wyoming wind an obvious choice for the DSW markets that will need significant amounts of renewable energy in the coming years. However, the Report also explains that wind, as an intermittent resource, can place stresses on the operation of the grid. As the level of wind penetration in the WECC region increases additional studies on the operational and cost implications will be required.

A project such as TWE has the ability to deliver 13,500 GWh per year of Wyoming wind. This is a significant addition (12 percent and 25 percent of US portion of WECC's and the DSW's 2020 RPS needs, respectively) given the scale of the need for renewables and the scale of Wyoming's potential to satisfy that need. While TWE will substantially help meet RPS requirements, the large size of the need suggests that multiple large scale projects are required to meet the demands of the region.

This Report concludes that the utilization of Wyoming's wind resources provides an optimum solution in helping the West meet its renewable energy and GHG reduction targets. It also concludes that TWE could play a fundamental role in providing transmission capacity to deliver Wyoming's wind resources to the DSW markets.

[1] TWE will deliver energy to the Marketplace Hub in southern Nevada. Although, southern Nevada and northern Nevada are not currently linked, Sierra Pacific Resources is in the process of developing a 250 mile transmission line to link the two areas. The authors expect this transmission line to be completed before TWE, and thus TWE would be able to meet the needs of both northern and southern Nevada.

2 INTRODUCTION

The West is the fastest growing region in the United States. It is expected to grow by more than 45 percent in population between 2000 and 2030. In addition, many Western states are adopting aggressive renewable energy standards and GHG reduction goals. These three factors combine to create a significant demand for investment in renewable energy infrastructure. Because most renewable generation is located far from load, a significant portion of this investment will need to be in new transmission capacity.

Even before the Western states established ambitious climate change goals the limitations of the region's transmission infrastructure were recognized by policymakers. In 2001, the WGA sponsored a report that concluded that significant transmission investment was required in the West. In 2004 regional Governors sponsored the Rocky Mountain Area Transmission Study (RMATS) and in 2006 the WGA sponsored the Clean and Diversified Energy Advisory Committee (CDEAC). These reports concluded that significant investment in transmission is required.

This Report looks deeper into this transmission question with a focus on connecting remote renewable energy resources to major load centers. This Report has been co-authored by National Grid and Energy Strategies, LLC to compliment the work already undertaken by several California state agencies with Phase 1A of the RETI study. Together, these reports serve as a starting point for the broader regional review of renewable energy needs for the forthcoming WGA sponsored WREZ project.

Many studies on renewable energy options invariably focus on transmission, as this has historically been the largest single barrier to delivering remote renewables. National Grid has been developing transmission in the West since 2004 and has led the development of the proposed TWE transmission project since 2006. The team is, therefore, familiar with the issues and costs associated with interstate transmission development in the West.

This Report evaluates several energy solutions that could meet the needs of the DSW markets (Arizona, Nevada and Southern California). The economic scenarios developed in this Report compare the scale and cost of potential **incremental** resources in Wyoming to the scale and cost of potential **incremental** resources elsewhere in the region. Resource cost comparisons are provided using the levelized cost of energy (LCOE) per MWh in 2008$. This economic analysis is a preliminary screening analysis and is not intended to be a comprehensive production cost, market simulation, or detailed integration analysis. It should be noted, however, that National Grid commissioned PA Consulting Group to perform an independent production cost economic analysis of the DSW market to verify the conclusions for the TWE project. Their analysis reached similar conclusions as found within this Report.

National Grid and Energy Strategies hope that readers view this Report as an important contribution to the debate on the West's (and particularly the DSW's) energy future.

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3 REGIONAL ENVIRONMENTAL GOALS AND NEEDS

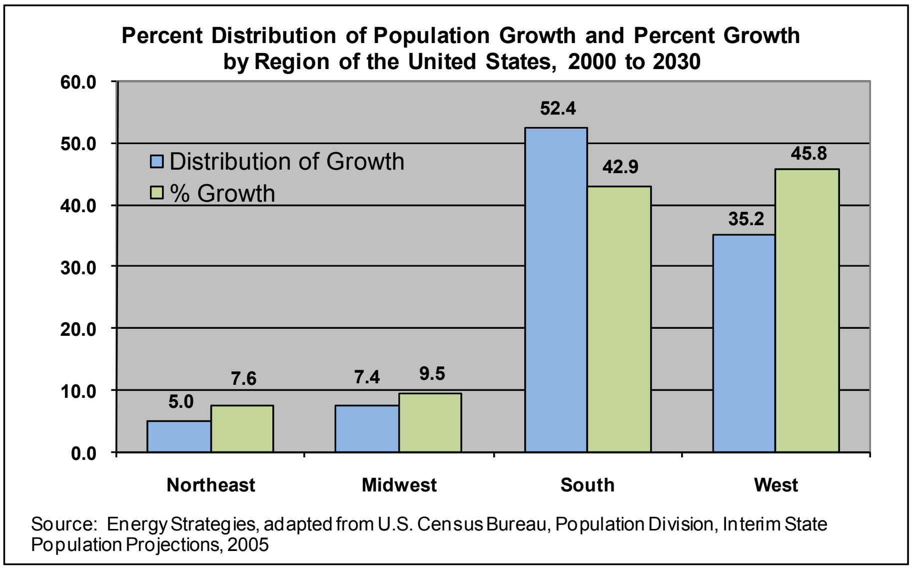
This section examines the environmental goals and energy needs of the Western United States and the DSW region. This discussion specifically addresses:

- Regional population growth
- Increases in energy demand
- Regional RPS goals
- Regional GHG reduction goals

3.1 WESTERN US POPULATION GROWTH

According to the US Census Bureau, the Western United States is the fastest growing region in the United States and is expected to grow by more than 45 percent between 2000 and 2030. The West[2] and the three state region of Nevada, Arizona and California will account for 35 percent and 25 percent, respectively, of the expected US population growth during that same time period (Figure 1).[ii] Nevada and Arizona are the two fastest growing states in the country and are expected to grow nearly 3 to 4 times faster than the national population growth rate. While California is not in the top ten states for expected growth rates, it accounts for over 15 percent of the expected absolute US population growth with more than 12.5 million new residents expected by 2030 (Table 1).[iii]

Figure 1



[2] The US Census Bureau's definition of the West differs from this Report's definition of the West or the Western United States, in that the US Census Bureau's definition of the West includes Alaska and Hawaii, while this Report's does not. For the US Census Bureau's definition of US regions see: http://www.census.gov/const/regionmap.pdf.

Table 1 - US Census Bureau, Interim Population Projections, 2005

State	2000 Census Population	2030 Projected Population	Change: 2000 to 2030 Number	Change: 2000 to 2030 Percent	Change: 2000 to 2030 Rank in Percent Change
Nevada	1,998,257	4,282,102	2,283,845	114%	1
Arizona	5,130,632	10,712,397	5,581,765	109%	2
California	33,871,648	46,444,861	12,573,213	37%	13
United States	281,421,906	363,584,435	82,162,529	29%	
Total Region (AZ, CA, NV)	41,000,537	61,439,360	20,438,823	50%	
Regional as a % of Total US			25%		

3.2 ELECTRICITY SALES GROWTH AND ENERGY EFFICIENCY

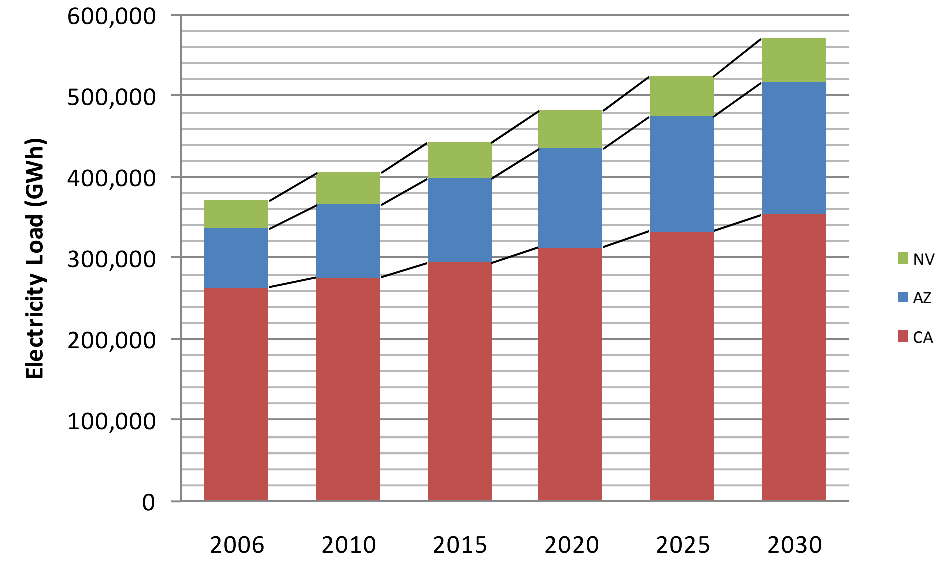
The primary utilities serving the three state region of Arizona, California and Nevada are highlighted in Appendix A. The utilities identified in Appendix A represent 87 percent of electricity sales in this three state region.[iv] According to forecasts compiled from these utilities and various state regulatory commissions, Arizona, California and Nevada will experience the following average annual growth rates in energy sales between 2007 and 2016, compared to actual growth rates experienced between 2000 and 2006 (Table 2). While growth rates in California and Nevada are expected to decrease, the overall demand for energy is still expected to grow substantially (Figure 2).

Table 2

Historic & Forecasted Average Annual Sales Growth			
	AZ	**CA**	**NV**
2000-2006	3.5%	1.7%	4.0%
2007-2016	4.0%	1.2%	2.7%

In terms of annual electricity sales this would mean that the three state region is forecasted to grow from 370,000 GWh in 2006 to nearly 570,000 GWh in 2030 (Figure 2). This implies that per capita consumption in the region will increase from about 8,200 kWh to nearly 9,300 kWh by 2030.

Figure 2



Source: Energy Strategies adapted from state regulatory agency and utility forecasts

Energy efficiency is the most effective way to combat climate change and affect forecasted increases in energy use. A recent analysis, sponsored in part by National Grid and undertaken by McKinsey & Company, illustrated that energy efficiency initiatives are among the most economic options for reducing GHG emissions.[v]

Each of the states and utilities represented in Figure 2 has demand side management (DSM) and energy efficiency programs which are captured within their energy forecasts. These programs are integral to helping utilities meet the rising demand for energy. In fact, in California's long-term planning process the first priority is given to energy efficiency resources.[vi]

Energy efficiency is factored into the forecast in Figure 2. It is possible, however, that energy efficiency measures may have a greater impact on demand than these forecasts predict, or that growth in the region may be less than forecasted. This report tests these possibilities by evaluating a 15 percent decrease in forecasted energy use is realized in 2020 and continues on through 2030. The result is a decrease in forecasted energy sales of 85,000 GWh in 2030 compared to Figure 2. This scenario demonstrates that even with greater than expected improvements in energy efficiency and/or slower than forecasted growth there is still a significant demand for new energy resources.

3.3 WESTERN STATES RPS BASED RENEWABLE ENERGY DEMAND

Figure 3

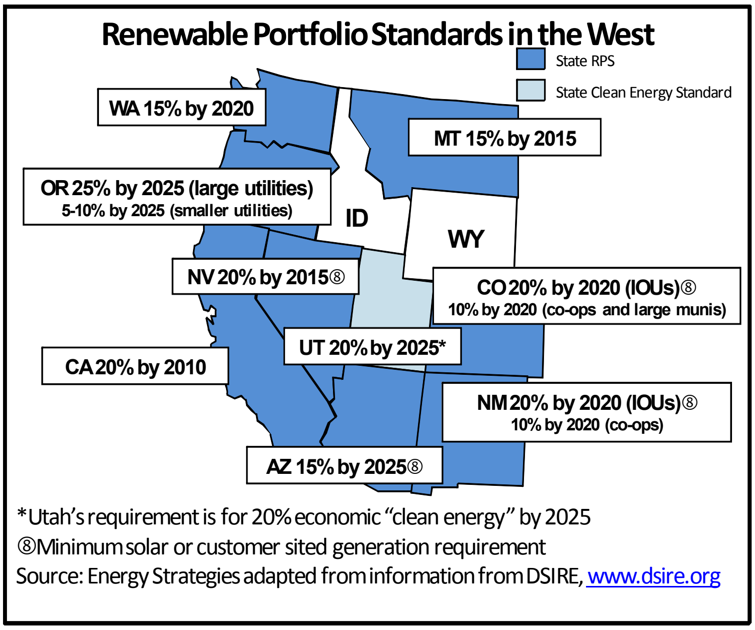


Figure 3[vii] identifies states in the West that have established state level RPSs.

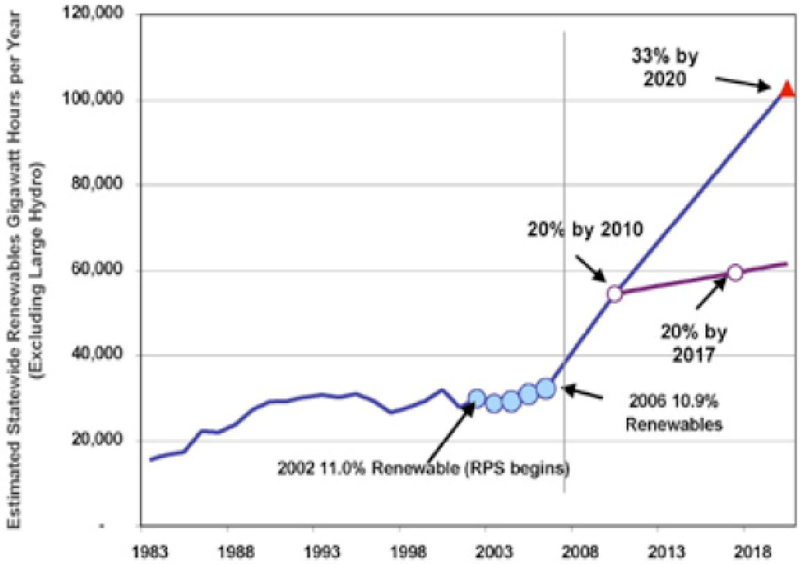
California has led the way with a requirement that 20 percent of electricity sales come from renewable energy sources by 2010. This equates to more than 55,000 GWh of renewable energy per year by 2010, nearly 30,000 GWh more than is currently produced in California. California also has a more aggressive goal of 33 percent by 2020 which was recognized in the *Energy Action Plan II* published in 2005.[viii] While this goal is not legislated, the *2008 Energy Action Plan Update* indicated that the regulators "*are committed to working together to evaluate the potential for making 33 percent of the power delivered in California renewable by 2020.*"[ix] Furthermore, in June 2008, a privately backed citizens' initiative to target a 50 percent RPS by 2025 was certified and will be on the ballot for voters to accept or reject in November 2008.

California's more aggressive 33 percent goal combined with other mandated RPS requirements and the forecasted regional sales growth will require renewable energy sales for the US portion of the WECC region of close to 150,000 GWh by 2020. The incremental renewable energy required, after accounting for existing renewable resources, will exceed 116,000 GWh (Table 3). At the 33 percent goal, California would comprise 70 percent of the US WECC-wide RPS need in 2020. The forecasted need does not include Idaho, Utah and Wyoming, states that have not yet established mandatory standards. Utah has, however, established a "clean energy goal" of 20 percent by 2025, requiring utilities to acquire cost-effective clean energy to meet the goal. Incorporating Utah's clean energy goal increases the renewable energy required in the WECC region by almost 9,000 GWh in 2025.

California's renewable energy demands drive renewable development in the West. Figure 4 compares California's installed renewable resources to the state's renewable energy goals. California needs to add significant amounts of renewable resources regardless of the ultimate level mandated.

Figure 4

Progress Toward California's Renewable Energy Goals



Source: 2007 *Integrated Energy Policy Report*

Requirements for incremental renewable capacity for the US portion of the WECC region, assuming an average renewable capacity factor[x] of 30 percent, will be nearly 45,000 MW by 2020. Assuming 80 percent of this capacity is wind and 20 percent is utility scale solar, the capital investment necessary to meet the RPS requirements in 2020 ranges from $100 to $130 billion or $8 to $11 billion per year.[3] The DSW will account for nearly 50 percent of the WECC region's 2020 incremental RPS requirement, requiring nearly 55,000 GWh of incremental renewable energy production by 2020 (Table 3). The US as a whole needs to triple renewable energy generation under current RPS requirements, while the US portion of WECC will need to increase renewable energy generation nearly fivefold in order to meet current RPS obligations.

[3] Capital costs range from $3,800/kW to $4,800/kW (2008$) for CSP projects and from $1,900 to $2,400 (2008$) for wind, per the California RETI Analysis Phase 1A Report.

Table 3: Incremental State and Regional Renewable Energy Needs				
Location	**RPS as a Percent of Energy Sales (2020)**	**Renewable Energy Sales Required to Meet RPS (2020 GWh)**	**Existing Renewable Generation (2006 GWh)**	**Incremental Renewable Energy Required (2020 GWh)**
Arizona*	7.0%	6,945	48	6,897
Nevada	20%	8,419	1,209	7,210
So. California	33%	51,282	10,730	40,552
Desert Southwest		66,647	11,988	54,659
California	33%	102,762	21,502	81,261
WECC		146,856	30,620	116,236
U.S. Total		256,383	86,781	169,602

*Excludes distributed generation requirement in AZ.

NOTES: 1. AZ, NV and WECC data for selected utilities only (IOUs and certain large municipals).
2. CA estimates include the entire state, not just IOUs.
3. WECC Estimates include U.S. States only (Mexico and Canada not included in this analysis).
4. WECC Estimates for CO, MT, NM, OR and WA from Energy Strategies analysis of IRPs and other load forecasts.
5. U.S. Total RPS energy need estimate from the Union of Concerned Scientists.
6. Existing renewable generation from EIA's 2006 Electric Power Annual, accounting for 10% line losses.
7. Existing renewable generation is in-state/in-region generation only, i.e. does not account for imports/exports.
8. Estimates do not account for planned generation.

Source: Energy Strategies adapted from state regulatory agency and utility forecasts.

The potential incremental RPS need of 55,000 GWh for the DSW, stated above, is based on electricity consumption forecasts from utilities and state regulatory commissions (Figure 2). Should energy efficiency have a greater impact than assumed within these forecasts and/or should growth be slower than expected, and Arizona, Nevada and California reduce energy consumption 15 percent below these forecasts in 2020, the incremental RPS energy need would be about 45,000 GWh by 2020 for the DSW. This demonstrates that while energy efficiency is an extremely important resource and climate change initiative, it does not fundamentally change the significant need for renewable energy due to electricity sales growth and RPS obligations.

3.4 2020 GHG EMISSION REDUCTION TARGETS

In contrast to the relative certainty of (targeted) RPSs, it is less clear how various GHG reduction measures will be implemented and precisely what they will mean in terms of renewable energy generation. It is very possible, however, that they will create an even greater demand for renewable energy supply than the RPS requirements alone. The two primary measures to drive GHG reductions in the West are the WCI and various forms of proposed federal legislation that would impose a cost on GHG emissions.

In February 2007 the Governors of Arizona, California, New Mexico, Oregon and Washington signed a statement announcing the formation of the Western Regional Climate Action Initiative, a joint effort to reduce GHG emissions[xii] currently known as the WCI. Since the formation by the five founding members 14 other states and provinces from Canada, Mexico and the United States have joined, some as partners and some as observers (Table 4). Partners have committed to reduce GHG emissions while observers have not.

Table 4: Western Climate Initiative Participants[xi]	
Partners	**Observers**
United States	**United States**
Arizona	Alaska
California	Colorado
Montana	Idaho
New Mexico	Kansas
Oregon	Nevada
Utah	Wyoming
Washington	**Canada**
Canada	Ontario
British Columbia	Quebec
Manitoba	Saskatchewan
	Mexico
	Sonora

In August of 2007 the WCI announced a regional GHG reduction goal of 15 percent below 2005 GHG emission levels by 2020. The 2020 goal is based on the aggregation of each WCI partner's GHG emission goal. The following chart summarizes each state/provincial goal (Table 5). Table 6 includes the relative GHG reduction targets based on a 2020 business as usual (BAU) case for each partner.

Table 5: State and Provincial Goals for GHG Reductions[xiii]

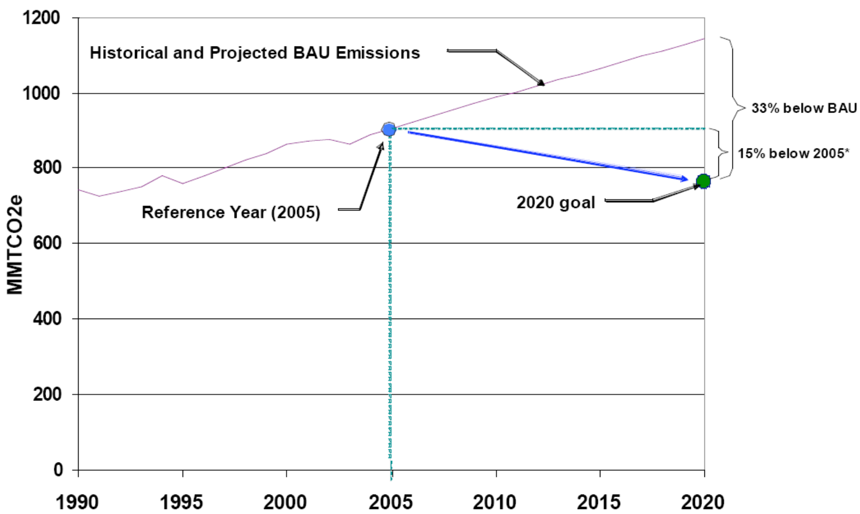
State/Province	Short Term (2010-12)	Medium Term (2020)	Long Term (2040-50)
Arizona	not established	2000 levels by 2020	50% below 2000 by 2040
British Columbia	not established	33% below 2007 by 2020	not established
California	2000 levels by 2010	1990 levels by 2020	80% below 1990 by 2050
Manitoba	6% below 1990	not established	not established
New Mexico	2000 levels by 2012	10% below 2000 by 2020	75% below 2000 by 2050
Oregon	arrest emissions growth	10% below 1990 by 2020	>75% below 1990 by 2050
Utah	2005 levels by 2020		
Washington	not established	1990 levels by 2020	50% below 1990 by 2050

Table 6: 2020 State/Provincial Goals Compared to Historic and Forecasted GHG Emissions (Estimates as of July 2007)[xiv]

	2020 Goal Relative to 1990	2020 Goal Relative to 2000	2020 Goal Relative to 2005[xv]	2020 Goal Relative to 2020 BAU	Absolute Reductions from BAU (MMtCO2e)[xvi]	1990-2020 BAU Growth
Arizona	35%	0%	-11%	-45%	72	144%
British Columbia	-9%	-27%	-30%	-46%	40	69%
California	0%	-10%	-14%	-28%	173	40%
Manitoba	-6%	-16%	-17%	TBD	TBD	TBD
New Mexico	14%	-10%	-14%	-31%	28	65%
Oregon	-10%	-29%	-32%	-44%	40	61%
Utah	TBD	TBD	TBD	TBD	TBD	TBD
Washington	0%	-16%	-11%	-28%	33	40%
Total	**2%**	**-12%**	**-16%**	**-33%**	**383**	**54%**

Figure 5 illustrates the 2020 goal relative to the business-as-usual cases developed by the WCI.

Figure 5



Source: Western Climate Initiative, Statement of Regional Goal, August 22, 2007

The WCI accounts for electricity sector emissions on an in-state consumption basis rather than an in-state generation basis. Electricity consumption related emissions accounted for 38 percent[xvii] and 25 percent[xviii] of the total Arizona and California GHG emissions in 2006, respectively. While Nevada has not adopted a GHG reduction goal (and is therefore excluded from the tables above), for purposes of this Report it has been assumed that Nevada will adopt the WCI GHG reduction goal. Nevada's electricity sector emissions accounted for 40 percent[xix] of statewide GHG emissions in 2006. Assuming that the electricity sector will be expected to reduce GHG emissions to meet each state's goal on a proportionate basis (i.e. to historic level according to each state's goal), states in the DSW would target at least the following GHG emission reductions from the electricity sector by 2020 (Table 7).

Table 7: GHG Emission Reduction Targets by State from 2020 BAU Case				
	Arizona	So. CA	Nevada	DSW Total
2020 Target GHG Reductions from BAU (MMtCO2e)	72	88	28	**188**
Electricity Sector Reductions Necessary to Meet Target (MMtCO2e)	38	11	15	**64**
Projected Average Emission Rates (MtCO2e/MWh)	0.5562	0.4434	0.7071	
Renewable Energy (RE) Required to Meet Electricty Sector GHG Mitigation Target (GWh)				
Case 1: 100% Mitigation from RE	67,785	25,505	21,778	**115,068**
Case 2: 50% Mitigation from RE, 50% from Nuclear and CCS	33,893	12,753	10,889	**57,534**

According to the methodology of this Report, California's goal to reduce GHG emissions to 1990 levels by 2020 will require a 22 million metric ton carbon dioxide equivalent ($MMtCO_2e$) reduction from emissions created as a result of electricity consumed in the state. It should be noted that the electricity sector may be required to reduce emissions beyond its proportionate share. For example, the Climate Change Draft Scoping Plan, recently released by the California Air Resource Board, requires the electricity sector to reduce GHG emissions by much more than 22 $MMtCO_2e$ through both increased deployment of renewables and increased energy efficiency. The same Report expects the implementation of the 33 percent RPS to reduce GHG emissions by about 21.2 $MMtCO_2e$ in 2020. [xx]

The WCI partners are planning to announce a "*regional market-based multi-sector mechanism, such as a load-based cap and trade program, to help achieve the GHG reduction goal*"[xxi] by August 2008. The WCI partners have adopted The Climate Registry's methodology as the accepted GHG accounting methodology. Each WCI partner will be required to provide an update to the other partners every two years on GHG reduction progress to "*ensure that actions are underway at levels consistent with full achievement of the 2020 goal*."[xxii]

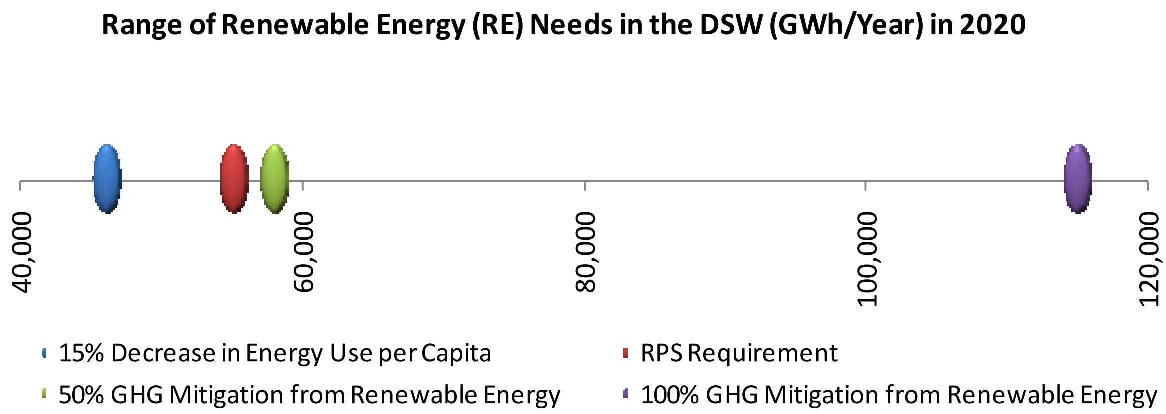
One way for a WCI partner to achieve the GHG reduction goal for emissions from electricity use is to use renewable energy to offset other generation sources. If the WCI used 100 percent renewable energy to meet GHG reduction goals for the electricity sector the DSW would need nearly 115,000 GWh of incremental renewable energy (Figure 6). If other options were used to mitigate GHG reduction goals, e.g. nuclear generation or carbon capture and storage (CCS), and only 50 percent of the GHG target was met by the use of renewable energy the DSW would need nearly 58,000 GWh of incremental renewable energy (Figure 6). If the entire US portion of the WCI used 100 percent renewable energy to offset GHG emissions from electricity use the region would need an estimated 167,000 GWh of additional renewable energy by 2020.

3.5 RANGE OF RENEWABLE ENERGY NEEDS

The above sited factors, i.e. RPS requirements and GHG targets, will be the major factors driving the implementation of renewable energy in the DSW and the West. If the impact of energy efficiency measures is greater than expected and/or growth is slower than expected and the DSW reduces energy use 15 percent below forecasted levels in 2020 (as described in Section 3.2) it would reduce the RPS requirements for that region from 55,000 GWh to about 45,000 GWh, illustrating that even with significant gains in energy efficiency and/or slower than expected growth the need to access new renewable resources remains.

Bringing together the above information on renewable requirements, it is estimated that the DSW will require anywhere from 45,000 GWh (to meet RPS requirements with significant amounts of energy efficiency realized and/or slower than expected growth) to 115,000 GWh (to meet GHG reduction goals in the electricity sector with 100 percent renewable energy) of renewable energy by 2020. It is estimated that the most likely range will be from 45,000 GWh to 58,000 GWh, assuming other options will be available to eliminate at least 50 percent of the electricity sector's GHG emissions (see Figure 6).

Figure 6



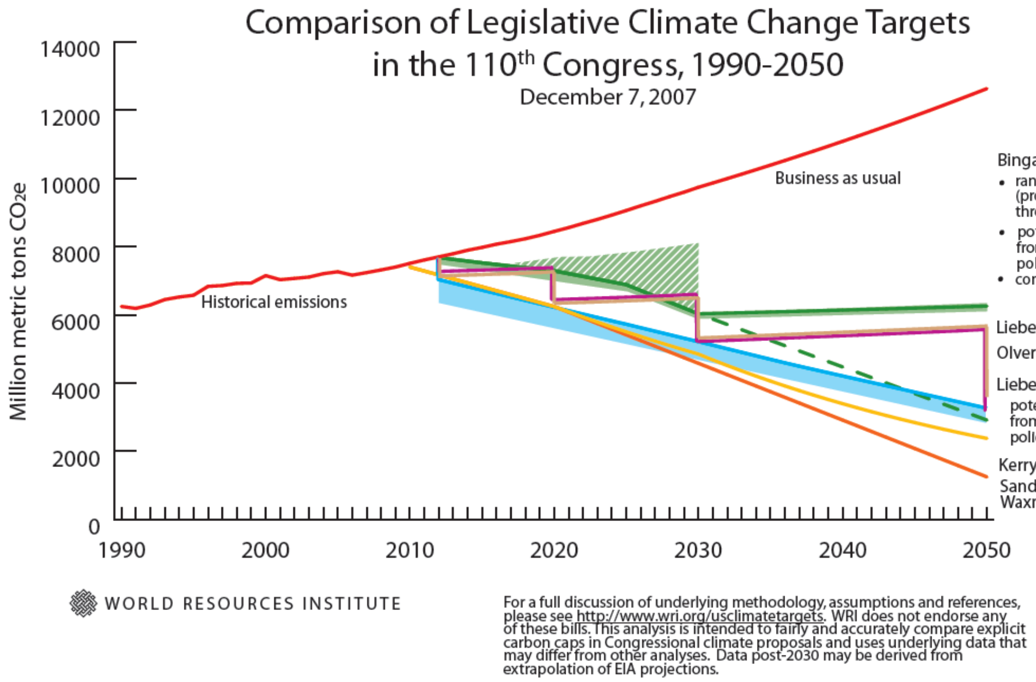
For the US portion of the WECC region, between 84,000 and 167,000 GWh of incremental renewable energy resources will be required by 2020 to satisfy the WCI's GHG reduction goals, illustrating that while RPS goals are significant, GHG reduction goals may require even greater renewable energy development.

(Note: While this report concludes that the incremental RPS demand for the US portion of the WECC region as a whole is 116,000 GWh by 2020, the corresponding estimate from PA Consulting Group is 104,000 GWh.)

3.6 POTENTIAL GHG EMISSION COSTS

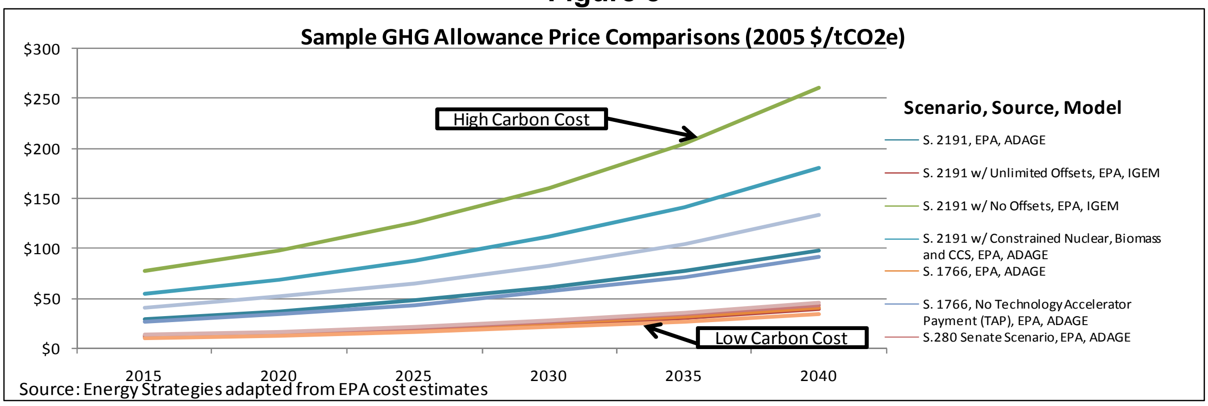
In addition to the regional GHG related activity, there is a "*growing consensus* [at the national level] *that the United States should reduce its GHG emissions by 60 to 80 percent by 2050 to support the global efforts to reduce GHG emissions.*"[xxiii] The leading proposals currently before federal lawmakers recommend a cap-and-trade system to reach GHG reduction goals. Figure 7 shows the potential impact of the leading proposals on future emissions, according to an analysis published by the World Resources Institute in December 2007. The Lieberman-Warner bill, for example, proposes a 70 percent reduction from 2005 levels by 2050. 2005 emissions were just over 7 billion metric tons CO_2e. 34 percent of 2005 emissions were from electricity generation.[xxiv] Lieberman-Warner is not the most stringent proposal on the table, but has received support from multiple parties to the debate. This bill was debated and rejected in the US Senate in June 2008.

Figure 7[xxv]



There is a great deal of uncertainty surrounding the impact of GHG legislation on the cost of carbon emissions. The Environmental Protection Agency (EPA) has published various reports identifying potential costs of GHG allowances under the different legislative scenarios. Figure 8 highlights some of the scenarios evaluated in this analysis. The low end estimates cluster around \$15 (2005\$/tCO_2e) in 2012 growing to \$55 (2005\$/tCO_2e) in 2050, while the high end estimates cluster around \$45 (2005\$/tCO_2e) in 2012 growing to more than \$200 (2005\$/tCO_2e) by 2050, with an extreme case under the Lieberman-Warner bill where prices would reach more than \$400 (2005\$/tCO_2e) by 2050 if no offsets were allowed.[xxvi,xxvii,xxviii]

Figure 8



Although GHG regulations are not currently in place, many utilities in the West include a "cost estimate" for carbon dioxide emissions in their Integrated Resource Plans (IRPs) as they evaluate future resource alternatives. In California, for example, pursuant to California Public Utilities Commission (CPUC) Decision 05-04-024 utilities use a GHG adder (cost) of \$8.00 per ton of CO_2 for energy delivered in 2004, with a five percent per year escalation factor. This equates to \$17.46/ton by 2020. PacifiCorp, in its 2007 IRP, uses a medium case inflation adjusted CO_2 allowance price of \$8/ton (2008\$).[xxix] Other utilities in the West (including, Idaho Power, Avista, Northwestern, Portland General Electric, Puget Sound

Energy, and Seattle City Light)[xxx] use similar figures for the cost of carbon dioxide, although some utilities fail to account for a carbon dioxide price in the planning process. As shown in Figure 8 the national estimates for GHG allowance prices, in most cases, are much higher than the prices assumed by utilities in the West.

This wide range of estimates illustrate that the full legislative and regulatory impact on the cost of producing electricity with fossil fuels is unknown. Therefore, energy resource options that allow for the flexibility to choose from a portfolio of reasonably priced, low or no GHG emitting renewable resources become an increasingly attractive economic option.

3.7 SECTION SUMMARY AND CONCLUSIONS

- The population of the three state region of Arizona, Nevada and California is forecasted to grow by 45 percent between 2000 and 2030. This represents 25 percent of total US population growth for this period.
- Despite improvements in energy efficiency and DSM, population growth and other factors are forecasted to drive an increase in electricity sales for this three state region from 370,000 GWh to 570,000 GWh from 2006 to 2030.
- Led by California, many states in the West have committed to challenging RPS goals that will require incremental development of 116,000 GWh of renewable energy resources by 2020. The equivalent figure for the DSW is 55,000 GWh by 2020.
- In order to test the possibility that greater than forecasted gains in energy efficiency are realized and/or growth is slower than expected this Report has evaluated the RPS requirement if the region's incremental energy need was reduced to 113,000 GWh. The incremental RPS requirement would still be close to 45,000 GWh in 2020.
- To meet these targets, over 9,600 MWh of renewable generation needs to be added every year from 2009 to 2020. Total capital investment in the US portion of WECC is projected to be greater than $100B and annual capital investment is estimated to be between $8 and $11B. To meet the RPS goals of the DSW about 4,500 MWh of renewable generation needs to be added every year from 2009 to 2020. Annual capital investment is estimated to be between $4 and $6 billion to develop these resources in the DSW.
- While less targeted and not yet fully interpreted, GHG reduction goals will likely have an even greater impact on the region than RPS requirements. If 100 percent of the electricity sector's proportionate share of GHG reduction goals were to be met by renewables, the DSW's 2020 need for renewables becomes 115,000 GWh per year and the US portion of the WCI would require 167,000 GWh. Based on the assumption that 50 percent of the electricity sector's proportionate share of GHG reductions is met by nuclear, CCS, or other non-renewable GHG reducing options this will require 58,000 GWh of new renewables by 2020 for the DSW or 84,000 GWh for the broader region.
- As a reference, the current electricity consumption for the City of Los Angeles is 24,000 GWh (according to Los Angeles Department of Water and Power's 2006 electricity sales). Therefore, the forecasted need for additional renewable energy across the West, driven by RPSs alone, is approximately five times current consumption in the city.

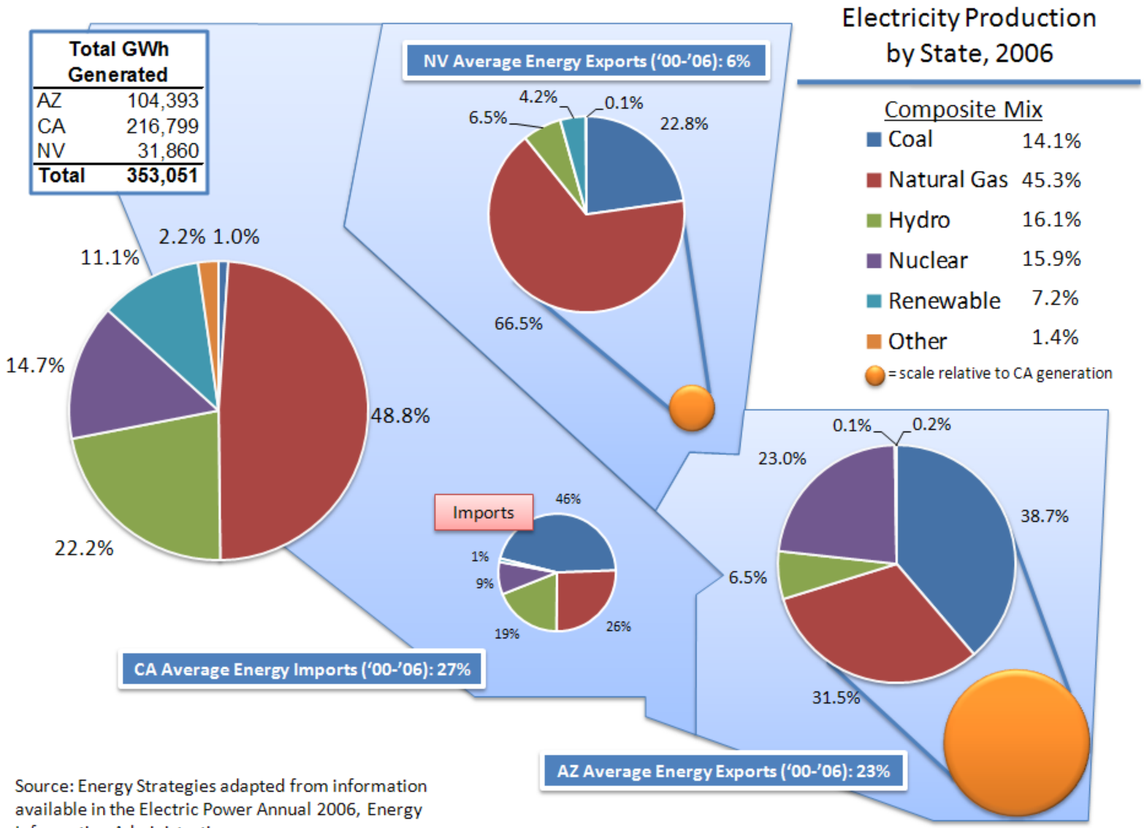
4 POTENTIAL RENEWABLE RESOURCE SOLUTIONS

This section of the Report reviews the scale of potential renewable resource options available to help meet the environmental and energy objectives of the DSW region.

4.1 DSW REGION RENEWABLE RESOURCE AVAILABILITY

The states of Arizona, Nevada and California need significant renewable resources to meet RPS requirements and GHG reduction goals (Section 3 for details). Figure 9 provides the context of each state's current resource mix. Currently only seven percent of the generation within the three state region is from renewable sources, of which nearly 95 percent is produced in California. California currently imports 27 percent of the electricity used in the state, of which only one percent is from renewables. [xxxi]

Figure 9



Source: Energy Strategies adapted from information available in the Electric Power Annual 2006, Energy Information Administration.

Utilities across the DSW are aggressively trying to acquire new renewable resources. The *RPS Procurement Status Report* published in January 2008 by the CPUC, illustrates that California investor owned utilities (IOUs) have a significant number of contracts and plans to meet their growing RPS needs. While the report shows promising progress towards meeting RPS goals the CPUC report also states that:

> *While the RPS procurement process has resulted in dozens of contracts for new renewable capacity, project development continues to lag….The slow pace of project development despite strong solicitations underscores the fact that projects face a number of challenges beyond simply getting a contract with an IOU to coming online. These barriers include, but are not limited to, transmission, permitting challenges and developer inexperience. The CPUC is working with the range of stakeholders, market participants, and public entities that play a role in bringing renewable resources online to ensure that RPS projects remain on track.* [xxxii]

California currently has 220 MW of wind, geothermal, biomass and pumped storage projects under construction.[xxxiii] The Tehachapi Transmission Project (TTP) is a $1.8 billion project sponsored by Southern California Edison to connect the Tehachapi Wind Resource Area (TWRA) to the transmission network. TWRA is viewed as "*California's largest wind resource area.*"[xxxiv] Utilities in California are also investigating long-distance transmission lines to British Columbia, Canada to access potential large scale renewable energy developments.

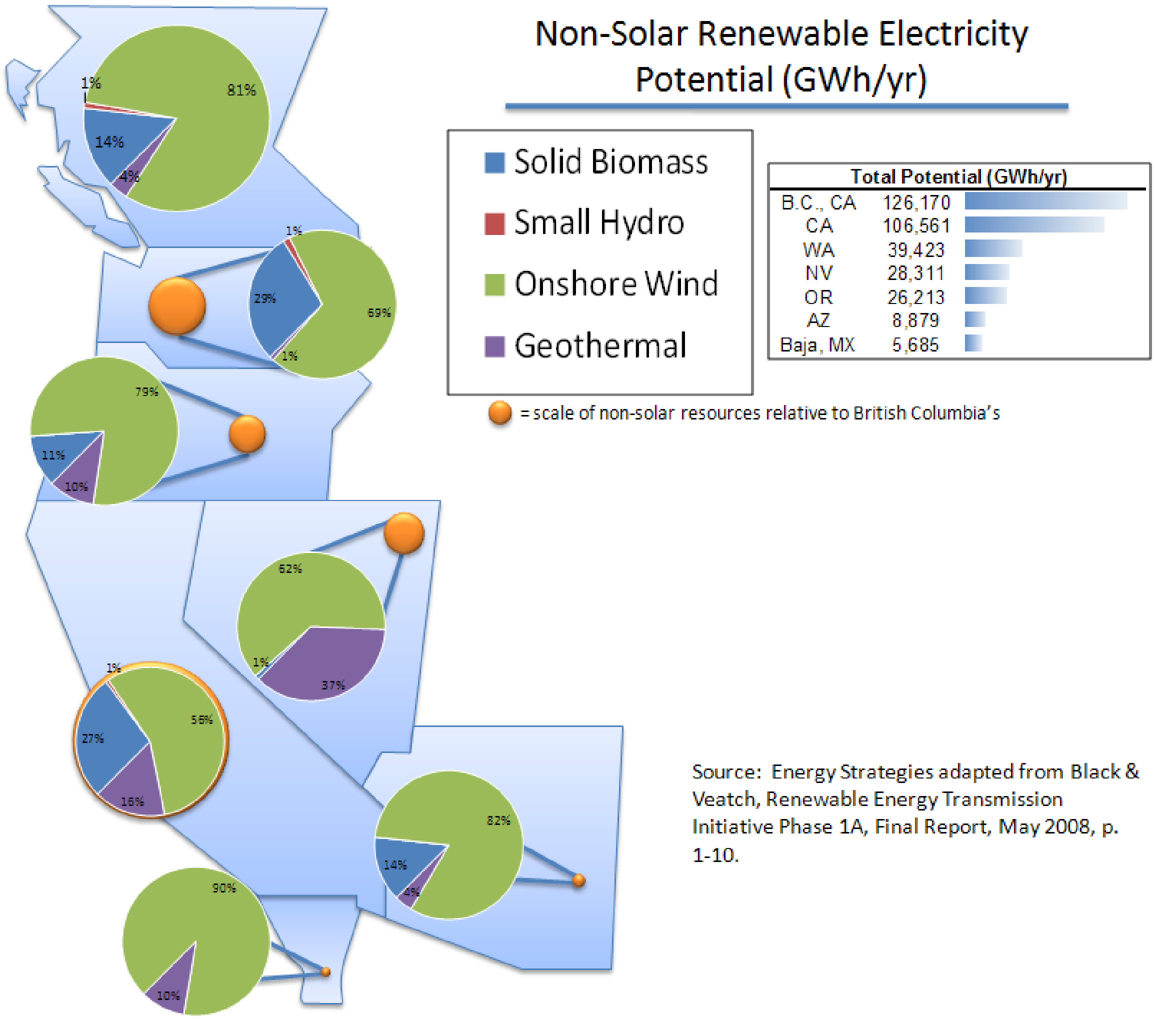
Arizona and Nevada utilities have similarly been pursuing renewable energy resources. Arizona Public Service (APS) is part of a consortium that recently issued a Request for Proposals seeking 250 MW of CSP capacity.[xxxv] APS also recently signed a power purchase contract for the output of a 280 MW CSP facility.[xxxvi] Nevada Power has a power purchase agreement to purchase 64 MW from a solar thermal project. There are a number of small scale geothermal projects being developed in Nevada with an estimated 500 MW currently securing a PPA, final permits or under construction.[xxxvii]

The DSW states are mostly pursuing in-state renewable resources but it may be necessary for utilities and policymakers to look outside the DSW region to acquire the scale of renewable resources required to meet RPS and GHG reduction objectives cost effectively. The recently published, California RETI Phase 1A Final Report[xxxviii] is an excellent step towards a better understanding of the potential renewable resources available to serve the California market. Phase 1A evaluated the renewable energy potential of Arizona, Nevada, California, Oregon, Washington, British Columbia, Canada and Baja, Mexico. Future RETI steps include the prioritization of renewable energy regions and development of transmission plans to access those regions. Figure 10 and 11 below illustrate the estimated renewable resource potential available in the RETI study region for the resources that have been recommended for further consideration in Phase 1B of the RETI process. Figure 10 focuses on non-solar renewable technologies and Figure 11 on estimated CSP resources available in each state.

In addition to the resources captured in these two figures there is an order of magnitude larger amount of potential solar photovoltaic (PV) energy identified in the RETI report. Solar PV is unique among renewable energy resources in that small scale distributed PV systems have similar economics to large scale PV systems. With its relatively higher costs, deployment will mostly be on a distributed basis and of a scale that should not materially impact the analysis within this Report. It should be noted, however, that federal legislation was proposed in July of 2008, by Senator Bernie Sanders and others, which would promote the creation of 10 million solar PV systems by 2018.[xxxix] If PV systems were ever implemented on this scale this would have an impact on the underlying assumptions of this Report. With the significantly lower costs of wind energy, however, (for those states that have access to resources of the quality found in Wyoming), the more likely policy approach would be to implement solar PV systems in such a way that does not discourage development of cost effective utility scale wind energy resources.

Both the RETI Phase 1A Report's review of potential resources and this Report's review of Wyoming's wind resources are derived from various NREL databases. NREL essentially uses "desk-top" screening criteria in identifying land suitable for development. In practice, a more vigorous screening would be required to explore the limits of potential developable land. For instance, for wind and solar resources NREL's exclusions include urban areas, national parks, wetlands and land with a slope greater than 20 percent and 1 percent, respectively. Factors NREL has not addressed include cost, transmission availability, resource accessibility and other environmental considerations. Phase 1B of the RETI analysis "*will use a more detailed set of screening criteria*" in evaluating developable resources.[xl]

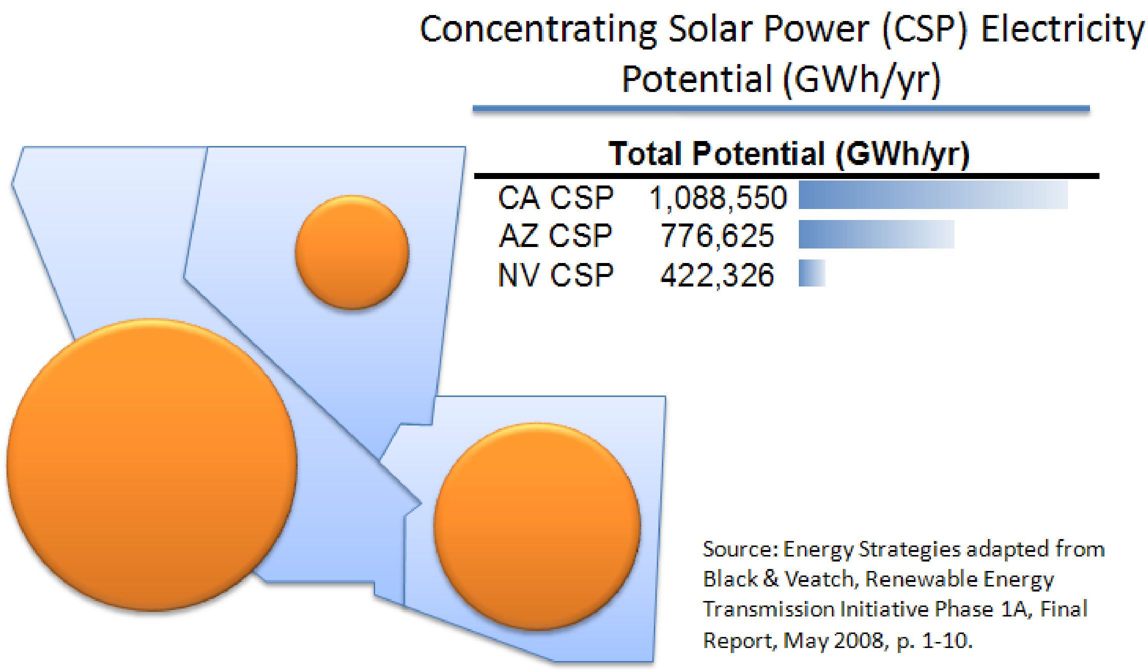
Figure 10



Total Potential (GWh/yr)	
B.C., CA	126,170
CA	106,561
WA	39,423
NV	28,311
OR	26,213
AZ	8,879
Baja, MX	5,685

Source: Energy Strategies adapted from Black & Veatch, Renewable Energy Transmission Initiative Phase 1A, Final Report, May 2008, p. 1-10.

Figure 11



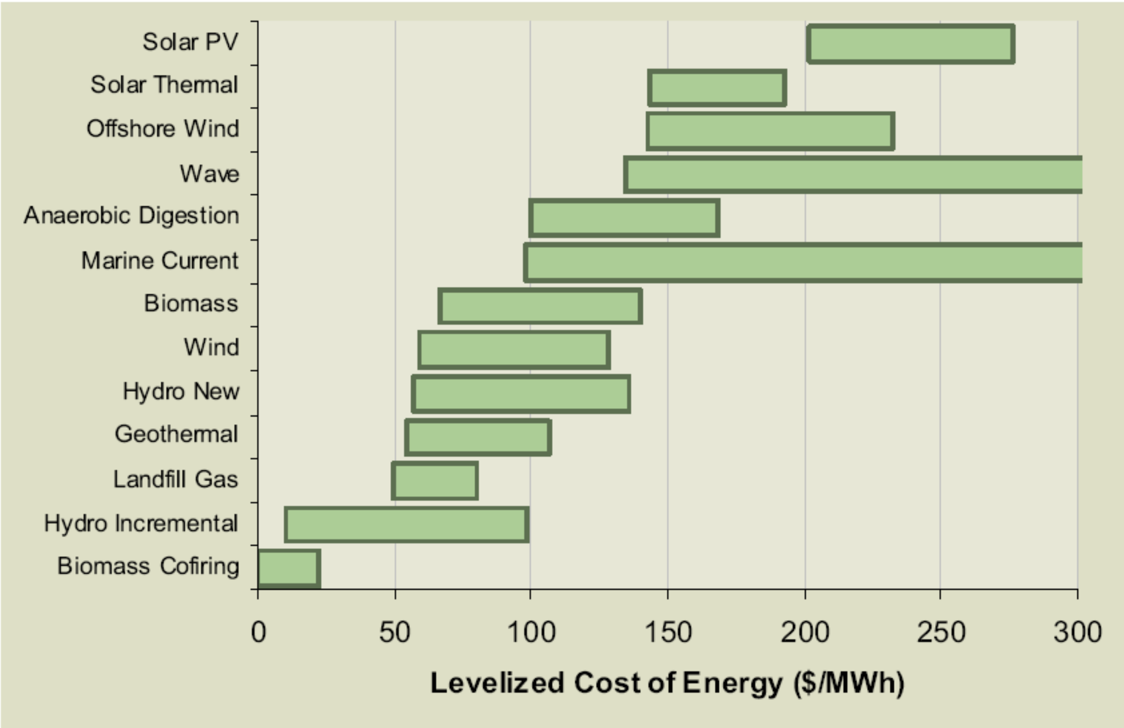
Total Potential (GWh/yr)	
CA CSP	1,088,550
AZ CSP	776,625
NV CSP	422,326

Source: Energy Strategies adapted from Black & Veatch, Renewable Energy Transmission Initiative Phase 1A, Final Report, May 2008, p. 1-10.

The RETI Phase 1A Report tabulated potential renewable resources in the study region and found that wind and solar have the largest scale. The McKinsey report (*Reducing US GHG Emissions: How Much at What Cost?*) also identified wind and solar as the primary renewable resources to help reduce GHG emissions. Wind and solar are the two resources that have the potential to make a major impact on the needs of California. Each has its own unique development issues, transmission needs, availability and costs. Figure 12 from the RETI Phase 1A Report illustrates, that the cost of CSP, or solar thermal, resources are significantly higher than other renewable resources evaluated in the RETI report. Appendix B, also from the RETI report, provides additional detail on the underlying cost assumptions used to develop Figure 12.

It is important to note, however, that while wind has become a relatively mature technology, with relatively predictable costs, CSP is a relatively young technology. Therefore, estimated CSP costs may not be as certain as estimated wind costs. As CSP technology evolves and economies-of-scale are realized these advances may lead to reductions in CSP costs over the next 10 to 20 years.

Figure 12[xli]

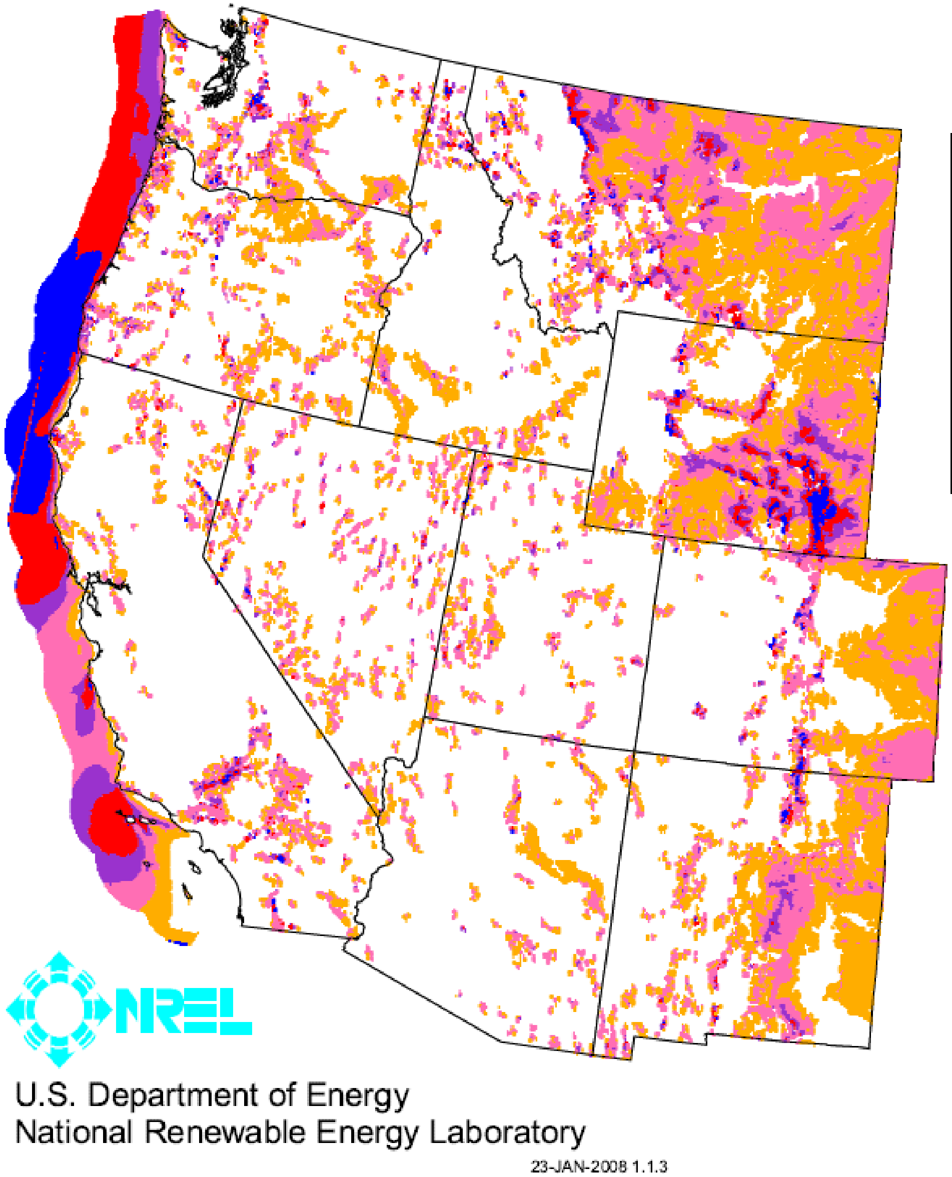


In order to meet renewable resource objectives, policymakers will need to consider numerous factors including relative costs, location, quality, scale and other environmental factors. Policymakers have recognized the potential of remote renewable resources in the West and that significant transmission investment is necessary to deliver those resources to market. However, the original scope of the RETI analysis did not include the wind resources of Wyoming and other intermountain states, principally because large scale transmission to deliver those resources to markets does not yet exist.

4.2 WYOMING WIND RESOURCE POTENTIAL

NREL assessed the quality of renewable resources available in the United States and the map below (Figure 13) highlights the concentration of Class 6 and Class 7 onshore wind resources in Wyoming. Wyoming's concentration of high quality wind is well suited to support the development of a large scale transmission solution.

Figure 13



Wind Power Classification

Wind Power Class	Resource Potential	Wind Power Density at 50 m W/m^2	Wind Speed[a] at 50 m m/s	Wind Speed[a] at 50 m mph
3	Fair	300 - 400	6.4 - 7.0	14.3 - 15.7
4	Good	400 - 500	7.0 - 7.5	15.7 - 16.8
5	Excellent	500 - 600	7.5 - 8.0	16.8 - 17.9
6	Outstanding	600 - 800	8.0 - 8.8	17.9 - 19.7
7	Superb	800 - 1600	8.8 - 11.1	19.7 - 24.8

[a] Wind speeds are based on a Weibull k value of 2.0

The American Wind Energy Association (AWEA) ranks Wyoming 7th in the US for potential wind capacity (Table 8) and 2nd among all Western states for wind energy potential. While ranked only 7th in total wind potential, Wyoming's concentration of Class 6 and Class 7 wind is better than any other region in the country. In fact, NREL's data shows that southeastern Wyoming has over 50 percent of the onshore Class 6 and 7 wind in the continental US. According to NREL, this high quality wind region is:

> *An area of high wind energy (which) extends across southern Wyoming from the Utah border on the west to the Nebraska border on the east. This zone of high wind energy can be attributed to a major gap, about 150 km (90 mi) wide, in the north-south barrier of the Rocky Mountains. Prevailing westerly and southwesterly winds blow with little resistance through this gap across the relatively high plains and uplands of southern Wyoming.*[xlii]

California, on the other hand, ranks 2nd in installed wind capacity (Table 8) but only ranks 17th in wind energy potential and has already utilized more than one-third of the potential wind capacity. As more of the in-state potential capacity in California is utilized the remaining sites become lower in quality and hence, higher in cost. Furthermore, with its higher population density and pattern of private land ownership, locating future wind farms in California may not always be viewed as appropriate and thus may be difficult to permit.

.

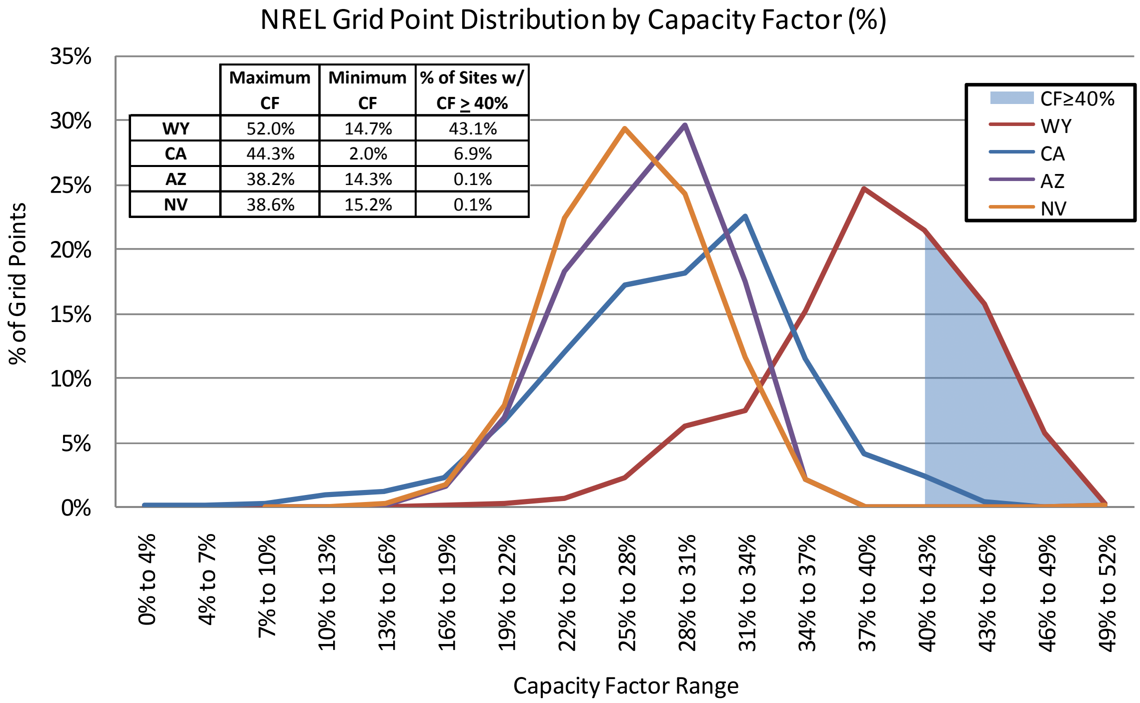
Table 8: Wind Potential by State

State	Wind Energy Potential Ranking	Wind Energy Potential: Average Power Output (MW)	Wind Energy Potential: Annual GWh (000's)	Installed Capacity Ranking	Installed Wind Capacity (MW)
North Dakota	1	138,400	1,210	14	179
Texas	2	136,000	1,190	1	3,150
Kansas	3	121,900	1,070	10	364
South Dakota	4	117,200	1,030	22	44
Montana	5	116,000	1,020	15	146
Nebraska	6	99,100	868	18	73
Wyoming	7	85,000	747	12	288
Oklahoma	8	82,700	725	6	535
Minnesota	9	75,000	201	4	895
Iowa	10	62,900	551	3	936
Colorado	11	54,900	481	11	291
New Mexico	12	49,700	435	7	497
Idaho	13	8,290	73	17	75
California	17	6,770	59	2	2,361
Nevada	21	5,740	50	35	0
Utah	26	2,770	24	32	1
Arizona	30	1,090	10	35	0

Source: Energy Strategies: adapted from AWEA Wind Energy Projects, Updated Mar 31, 2007

Wind resource information made available by NREL[xliii] provides high quality data on wind resources in the West. While this database is not an exhaustive inventory of the best wind sites in the Western US, it highlights the richness of Wyoming's wind resources. Figure 14 illustrates and compares the distribution of the NREL grid points by capacity factor in Wyoming, California, Arizona and Nevada, demonstrating that Wyoming's wind sites have significantly higher capacity factors. Over 43 percent of Wyoming grid points have a capacity factor of 40 percent or more, while only seven percent of California's and less than one percent of Arizona and Nevada's have a capacity factor of 40 percent or more.

Figure 14



Source: Energy Strategies, adapted from NREL 3Tier Wind Mesomodel Dataset

The RETI analysis utilized the NREL's WinDS wind resource database to identify potential wind resources. This Report uses the same database to identify potential Wyoming wind resource capacity. This identifies a potential Wyoming wind resource of more than 250,000 MW (Class 4 or higher) or more than 50,000 MW (Class 6 and 7 – located in southeastern Wyoming). Figure 15 below illustrates this against the types and quantity of non-solar resources (GWh) potentially available per the RETI analysis.

Wyoming wind Class 4 and above has three times more potential wind capacity than the entire RETI analysis study region and two and a half times as much as all of the non-solar renewable resources identified in the RETI analysis. Wyoming's highest quality (and lowest cost) Class 6 and 7 wind energy potential (GWh) [4] is nearly three times greater than the wind energy potential of Arizona, Nevada and California combined.

[4] NREL data provides MW of wind energy potential in Wyoming. The capacity of Wyoming's wind was converted into GWh using typically capacity factors for each wind Class (4-7).

Figure 15

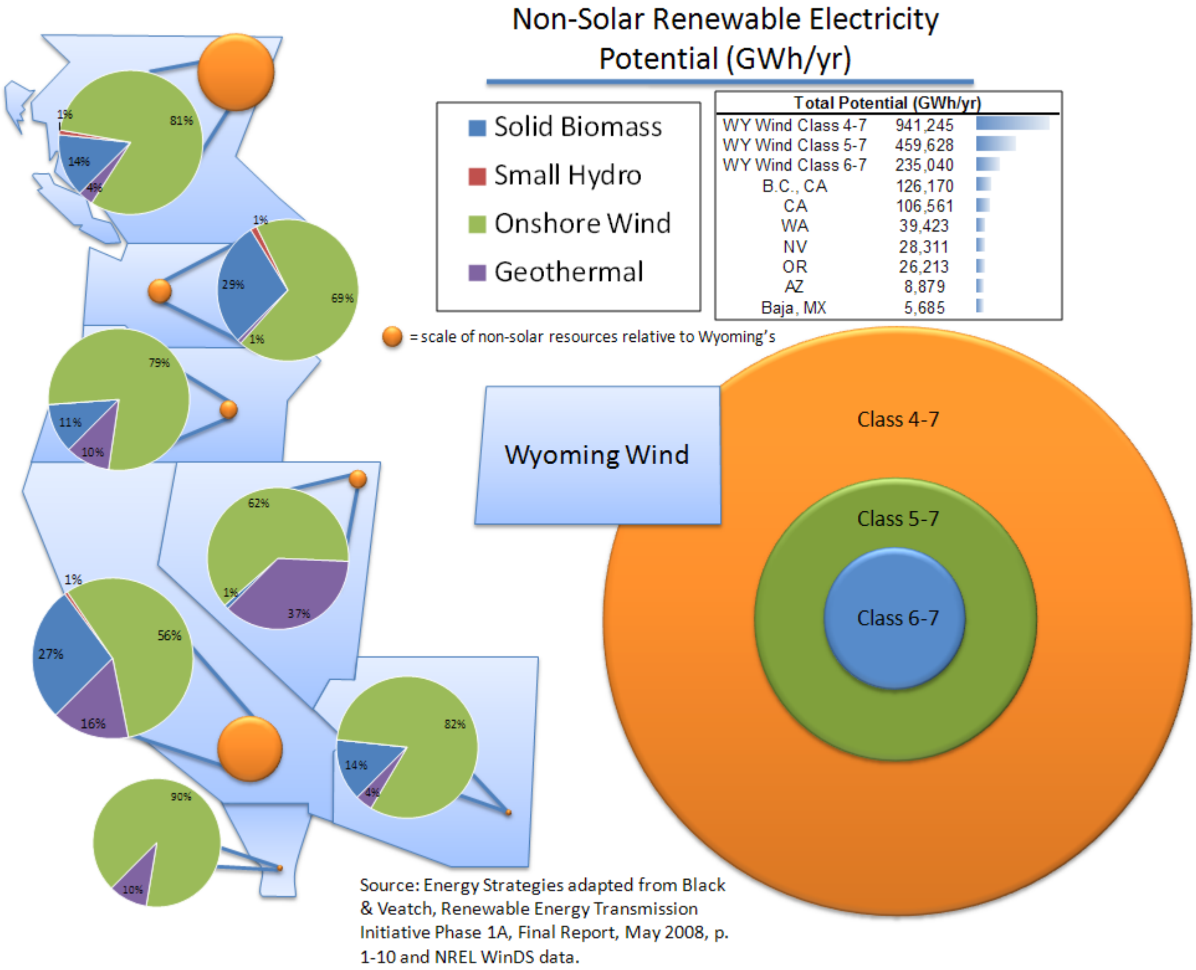
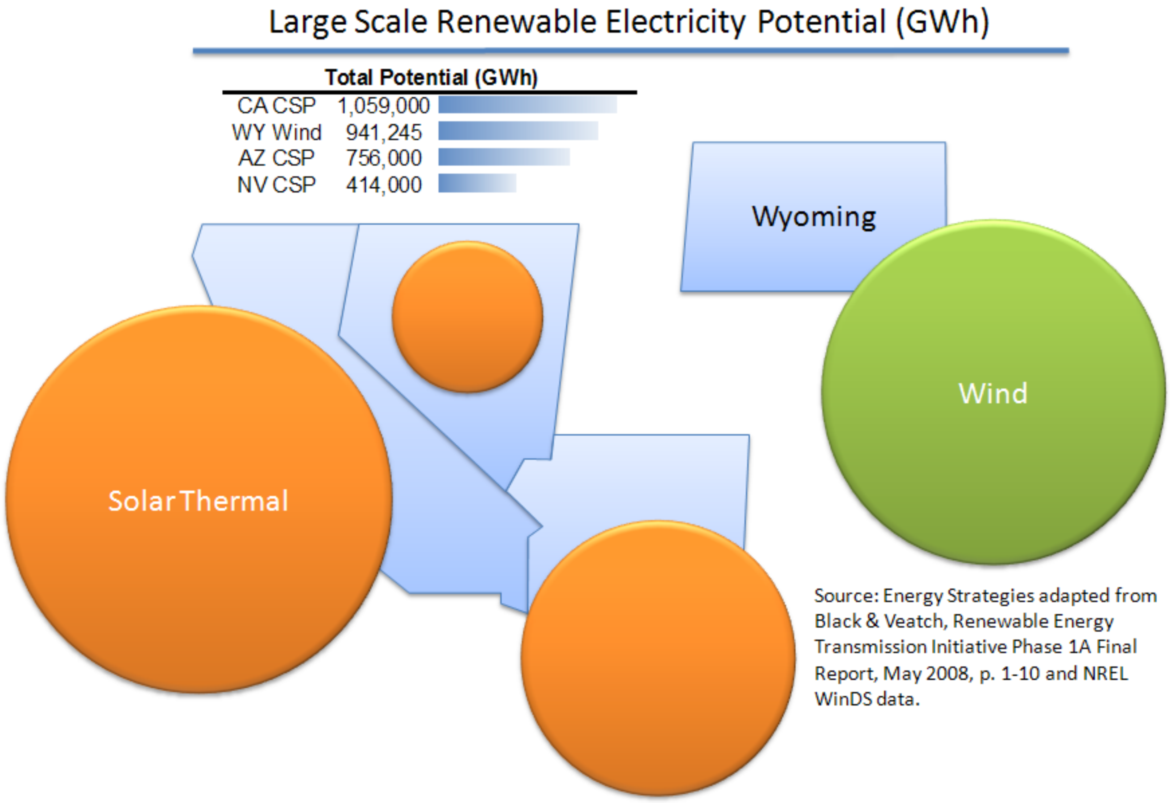


Figure 16 compares the identified CSP potential from the RETI report to the potential Wyoming wind resource from Figure 15. This illustrates that Wyoming wind and DSW solar resources are the only renewable resources that have the scale to make a significant impact on the renewable energy needs of the West.

Figure 16



4.3 SECTION SUMMARY AND CONCLUSIONS

- A significant amount of new renewable development is underway in the DSW. At this time, however, this is mostly focused on in-state resources.
- The West has significant renewable resources. However, the only resources that have the scale to address the large scale renewable needs are Wyoming wind and DSW solar.
- The NREL data shows that Arizona, Nevada and California's potential CSP resources are 2,229,000 GWh/year. CSP potential in Arizona, Nevada and California is so vast it could theoretically meet 19 times the 2020 RPS need for the US portion of the WECC region.
- NREL data shows that over 50 percent of the best quality (Class 6 and 7) wind capacity in the continental US is located in Wyoming. This Class 6 and 7 wind resource has an energy potential of 235,000 GWh/year. Wyoming's Class 4 and above wind resource has a potential of 944,000 GWh/year.
- Wyoming wind has two and a half times more energy potential than all the non-solar resources within the RETI analysis study area and could meet eight times the RPS need in the US portion of WECC in 2020.

5 TRANSMISSION SOLUTIONS

This section describes the need for transmission investment in the West. It also evaluates transmission solutions and costs, focusing on the proposed TWE project. Finally it considers the implications of adding significant amounts of renewable generation on grid operations.

5.1 BACKGROUND

National Grid has suggested that, by international standards, the nation's transmission system is underinvested. Numerous explanations have been offered, with most quoting lack of long term planning at a regional level, difficulty with cost allocation on multi-state projects and permitting issues. Furthermore, there are additional risks associated with long-distance transmission projects that are not as pronounced in shorter distance projects. These risks include increased permitting and political risks and a longer lead time for development.

A significant amount of long-distance, large scale transmission was built in the West in the 1970s and 1980s. Since then, several regional studies have recognized the need to develop new transmission. In 2001, the WGA sponsored a report that concluded that significant transmission investment was required. In 2004 regional Governors sponsored RMATS and in 2006 the WGA sponsored the CDEAC effort. All of these reports support the conclusion that significant investment in transmission is required.

With the exception of the CDEAC report, the findings in these reports were mostly based on accessing the most cost effective conventional thermal generation resources. Resources such as wind and solar are location constrained, meaning that transmission is an even greater barrier to renewable development. A substantial expansion of the transmission system in the West is essential if the region's GHG reduction goals are to be met.

California has led the way in recent transmission expansion and is poised to spend $1.8B on transmission upgrades in the Tehachapi area to interconnect 4,200 MW of wind. The California Energy Commission (CEC) has estimated that required in-state transmission system upgrades alone, to meet the 2020 33 percent RPS target, at $6.4B.[xliv]

5.2 TRANSMISSION SOLUTIONS AND COSTS

The primary consideration in evaluating new interstate transmission is whether the economic or other benefits of providing access to a remote resource can offset the substantial capital costs, as well as the operating losses, of a long-distance transmission line.

To achieve the best possible unit ($/MWh) delivery costs, TWE's designers favored HVDC technology (the breakeven point between HVDC and AC technologies is usually around 400 miles of point to point interconnection). The designers also favored a 3,000 MW design, which is the largest single element of transmission infrastructure that can be added to the WECC system without modification to the WECC reliability criteria. The criteria are based on the regional system's ability to withstand an unexpected outage. In general, introduction of an element larger than the current single largest system element would require substantial system upgrades that could be very costly.

For this Report, therefore, a "reference" transmission solution of a 3,000 MW, 500 kV, two-terminal, bi-pole HVDC transmission line from southeast Wyoming to southern Nevada is used – as adopted by TWE. TWE's northern terminal will be in southeast Wyoming, near the planned Aeolus substation. The southern terminal will be the Marketplace Hub south of Las Vegas, from where Southern California, Arizona and Nevada markets can be reached (see Appendix C for a representative map). This reference transmission solution is used to provide indicative costs of transmission necessary to deliver Wyoming wind resources to the DSW and compare the costs with the other resource alternatives evaluated.

It should be noted that while HVDC has cost and other significant operational benefits, it is essentially a "point to point" technology with intermediate drop off or pick up points either not cost effective or operationally restrictive. In the case of TWE, however, the project is planned to be developed, or 'co-developed', in parallel with, and in the same corridor as, PacifiCorp's Gateway South project, providing the combined benefits of both long-distance point to point and intermediate distance transmission capacity out of Wyoming.

Estimated TWE capital costs take into account "development" costs (design, right-of-way acquisition, environmental permitting, regulatory approvals, etc.) and "construction" costs (equipment, materials and labor). Details of the cost estimate for TWE are available in a separate Conceptual Technical Report developed by Black & Veatch for the project.[xlv] At this stage, estimates are intended for conceptual purposes only.

Table 9: TWE Cost Summary

Name	Market	Description	WY Export (MW)	Total Project Cost ($MM)
TransWest Express (TWE)	So. CA, AZ, NV	Wyoming-LV Marketplace HVDC 500 kV	3,000	$3,080

5.3 TWE ENERGY TRANSMISSION COSTS

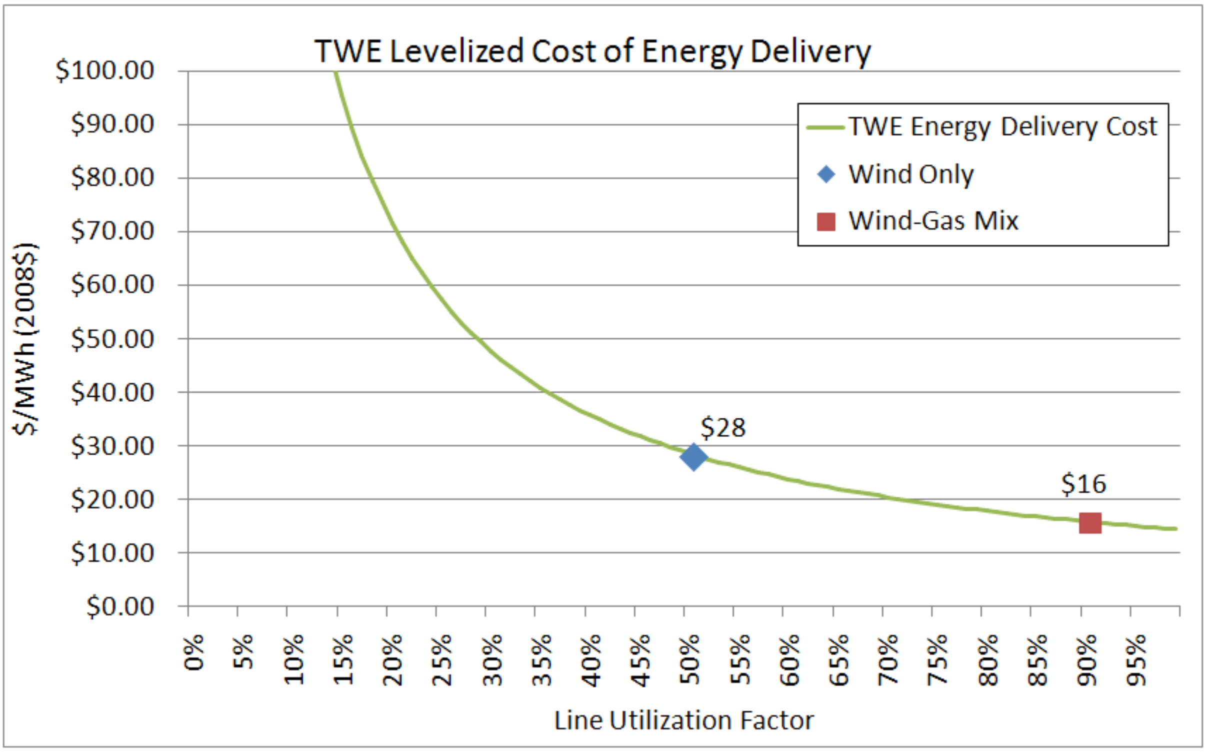
In order to determine a total cost to deliver energy ($/MWh) "financing" costs (based on a typical utility finance structure); "operational losses" (see below) and "operational costs" (maintenance and operations) were added to the TWE capital costs listed above. The line utilization factor is an important additional factor that affects per unit energy delivery costs. Figure 17 below illustrates how the delivery cost is inversely related to the utilization of the line. At full utilization the delivery cost is estimated to be $15/MWh. At an (unlikely) 20 percent utilization the delivery cost approaches $100/MWh. This is, therefore, a key variable in determining transmission costs.

Wind generation is an intermittent resource and cannot, on its own, fully use the capacity of a dedicated line. Conversely, a wind and natural gas fired generation mix might use over 90 percent of the line capacity. Line utilization is, therefore, largely a function of the type of generation mix. TWE has used two "bookend" scenarios and these produce transmission cost estimates of $16/MWh and $28/MWh.

The lower cost estimate assumes that a mix of wind and natural gas generation is developed which will result in a 91 percent line utilization factor. The higher cost estimate assumes that Wyoming Class 5 wind is the sole generation source and that this resource will have a 43 percent average annual capacity factor (net of a very small percentage of curtailment that may be necessary during peak wind hours). In order to more economically utilize the transmission line the nameplate wind generation capacity exceeds the nameplate transmission line capacity by 33 percent, giving a line utilization factor of 51 percent.

Figure 17 illustrates the range of delivery costs. The actual generation mix will likely result in a line utilization factor and, consequently, costs somewhere in between these two bookend scenarios.

Figure 17



Furthermore, line losses need to be factored in as they represent a cost of transmitting energy. Line losses are a function of the diameter of conductor bundle and, therefore, designers balance the lower losses and the additional capital costs of a larger conductor bundle to achieve an optimum design. Line losses are also a function of the level of power flow through the line. Details on the estimated line losses and assumptions are available in the Conceptual Technical Report. For the costs used in this Report the assumption is that line losses will amount to a total of ten percent for the entire 900 mile length. This is a conservative simplifying assumption, particularly in lieu of the line utilization factor (51 percent) used for the all Wyoming wind case.

Factoring in losses the scenario used for Wyoming wind, of 4,000 MW of nameplate installed units, in this analysis would deliver 13,500 GWh of renewable energy to the DSW. [5]

5.4 TRANSMISSION GRID OPERATIONS

As the major grid system incidents in California and the Northwest in 1996 and the Northeast in 1965, 1977 and 2003 remind us, the transmission grid is a complex, interconnected and sometimes fragile system. For all of its positive characteristics, the intermittency of wind and the performance of wind generators during stressed periods present some of the most difficult challenges in integrating the significant levels required to meet policy goals.

[5] It is possible that TWE could deliver more wind energy. This scenario assumes 4,000 MW of Wyoming wind with an average 43 percent capacity factor (net of a very small percentage of curtailment that may be necessary during peak wind hours) is delivered on TWE. TWE is rated as 3,000 MW. However, to more economically utilize the transmission line the authors have assumed that under a scenario where TWE transmitted only wind energy, 4,000 MW of wind generation would be built in Wyoming to feed into TWE and increase the line utilization factor.

Current reserve margins and unit ramp rate standards were largely developed in an environment where generation resources were non-intermittent and designed to meet foreseeable fluctuations in demand or an unanticipated failure of a large generator or transmission link. The introduction of wind, a relatively volatile class of resource, at large scales, increases this potential imbalance and requires a system that can accommodate these greater fluctuations. As the potential imbalance increases, system operators will need to rely more on the highly reliable and fast acting generating units (e.g. hydroelectric, natural gas units, etc.).

Numerous studies have been conducted to study wind integration issues at various levels of penetration in different regions of Europe and North America.[xlvi, xlvii] These studies suggest an exponential relationship between the level of penetration and the cost of integration. A report recently released by the Department of Energy concluded that the wind energy could provide for 20 percent of the US's electricity needs by 2030, but that "*significant changes in transmission, manufacturing and markets would be required*."[xlviii] While the level of penetration seems to be the most studied factor, there are additional factors that impact the cost of integration. They include the overall size of the balancing area and the capacity and utilization of interconnections with neighboring regions. Mitigating factors such as geographical diversity of numerous wind resources are not yet fully understood due to the lack of site specific data. As better wind data becomes available analysis of the diversity effect can be better understood.

To account for wind integration costs, $3.25/MWh was added to the delivered wind energy costs within this analysis. This value was recently cited in a Northern Arizona University wind integration study commissioned by APS. The ultimate extent of overall wind penetration, the correlated overall system costs, and the method of allocating these costs will ultimately influence the appropriate integration costs associated with delivering Wyoming wind energy.

5.5 SECTION SUMMARY AND CONCLUSIONS

- The West's transmission system is underinvested and the limitations of the region's transmission system have been recognized by policymakers for years.
- Remote renewable energy resources, especially the highest quality wind, need large scale transmission to reach energy markets.
- TWE is a proposed 3,000 MW, $3B, 500 kV, HDVC transmission line that will run from wind rich southeast Wyoming to southern Nevada. It will help the DSW access large quantities of renewable energy.
- The TWE project has the potential to deliver energy from Wyoming to the DSW with prices in the range of $16/MWh (wind and natural gas) to $28/MWh (all wind).
- A project like TWE could deliver up to 13,500 GWh of Wyoming wind to the DSW, under one all wind scenario.
- Integrating high concentrations of wind into the grid system is a challenge and the cost of integration may increase significantly with increased levels of integration. This Report does not attempt to identify the overall integration costs for the deployment of resources beyond the scale of TWE.

6 ECONOMIC AND OTHER OBJECTIVES

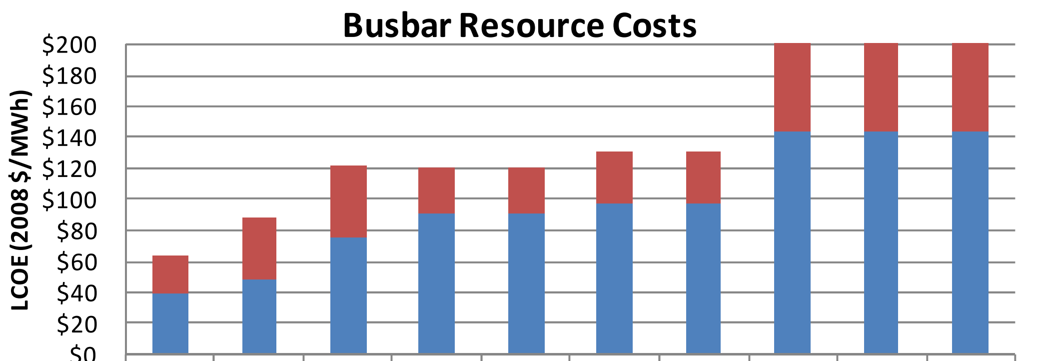
This section examines the costs, in dollars, as well as water and land use, of various renewable resource options available to the DSW.

6.1 SUMMARY OF RESOURCE COSTS

Figure 18 is an assessment of the busbar costs of several resource alternatives available to meet the load growth and renewable energy needs of the DSW. In order to assess how these resources can compete in the DSW markets, Figure 19 takes these same costs and, for Wyoming wind and natural gas generation, adds the cost of transmission from Wyoming to the Marketplace substation. It includes the cost of transmission line losses from Wyoming and wind integration (for all wind resources) to compare delivered costs on a LCOE per MWh basis for multiple alternatives. This analysis has utilized transmission costs derived from the TWE cost estimates described in Section 5.[6]

The results of the analysis (Figure 18 and Figure 19) modeled a range of capital costs, GHG costs and natural gas prices, as well as capacity factors for renewable resources (see Appendix D, E, F and H). One key assumption for renewable resources is that the Production Tax Credit (PTC) for wind and the Investment Tax Credit (ITC) for solar will be extended throughout the period evaluated. One key assumption for natural gas generation prices is a delivered gas price of \$8.63/MMBtu in California in 2015 rising to \$14.73/MMBtu in 2030 (Appendix F). A range of plus or minus 20 percent of these natural gas prices was used in order to help account for some of the volatility in natural gas prices (Appendix G). Another key assumption for natural gas generation is an \$8/ton (2008\$) cost of carbon dioxide emissions. Other GHG costs modeled were the EPA's estimates of costs under the Lieberman-Warner and Bingamen-Specter bills (see Appendix H for details).

Figure 18

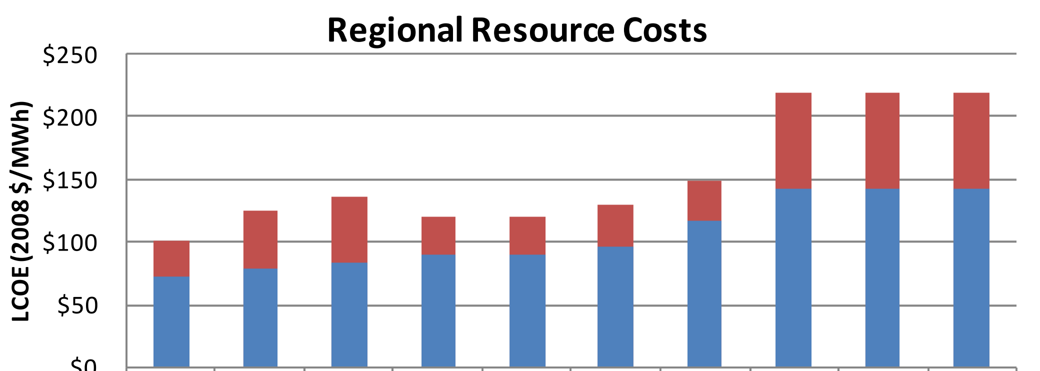


	WY Wind (45-50%)	WY Wind (35-44%)	CA Wind	AZ Gas	NV Gas	CA Gas	WY Gas	CA Solar (CSP)	AZ Solar (CSP)	NV Solar (CSP)
High	\$64	\$88	\$121	\$121	\$121	\$130	\$131	\$220	\$220	\$220
Low	\$40	\$48	\$75	\$90	\$90	\$97	\$97	\$143	\$143	\$143

Source: Energy Strategies, see Appendix D for background assumptions.

[6] The cost estimates for Wyoming wind delivered to the DSW assume the same "overbuild" assumption from Section 5, i.e. that 4,000 MW of nameplate wind capacity is built to more economically utilize the 3,000 MW TWE transmission line.

Figure 19



	WY Wind (45-50%)	CA Wind (30-35%)	WY Wind (35-44%)	AZ Gas	NV Gas	CA Gas	WY Gas	CA Solar (CSP)	AZ Solar (CSP)	NV Solar (CSP)
High	$101	$124	$136	$121	$121	$130	$150	$220	$220	$220
Low	$72	$78	$84	$90	$90	$97	$116	$143	$143	$143

Source: Energy Strategies, see Appendix D for background assumptions.

Several conclusions can be reached:

- The best quality Wyoming wind is the most economic renewable resource available to California and the DSW (other than some biomass, hydro and geothermal resources, not shown here because of their limited scale);
- The best California wind is within the cost range of delivered Wyoming wind (the issue is that California lacks an abundance of high class wind, as noted in Section 4);
- Wind, whether in California or Wyoming, has a significant cost advantage over CSP as an energy product;
- The best California and Wyoming wind is competitive with natural gas fired generation as an energy product, under nearly every scenario evaluated.

Possibly the more significant of these conclusions is that wind generation is competitive with natural gas fired generation in nearly every scenario evaluated. It should be noted, however, that this is on an energy basis. In developing a future resource mix broader issues, such as capacity value (where both natural gas fired generation and CSP have an advantage) and grid integration issues (Section 5.4) have to be considered, both of which are beyond the scope of this Report. It should also be noted that there are scenarios where natural gas fired generation would be less expensive than wind generation, such as if capital costs for wind resources climbed higher while natural gas prices dropped significantly. Notwithstanding that observation, the natural gas price assumptions used in this analysis have been demonstrated in the last few months to be conservative. If gas prices maintain (or continue escalating at) current rates, wind will become even more economically attractive. This highlights one significant benefit of wind and solar energy - their isolation from the volatility of fuel prices (see Appendix G for more information on volatility in natural gas prices).

These findings, therefore, support the view that wind powered generation technology has matured to the point that Wyoming wind could be developed as an economic energy solution regardless of RPS levels. It should be added that in 2008 National Grid commissioned the PA Consulting Group to conduct an independent evaluation of the comparative economics of various resource options for the DSW. This analysis was prepared using a simulated production cost model, which accounted for capacity values, and reached similar conclusions to this analysis.[xlix]

6.2 BACKING UP INTERMITTENT ENERGY SOURCES

As both CSP and wind are intermittent resources, it may be necessary to "back up" a portion of wind and CSP with a firm resource, such as natural gas fired generation (although some types of CSP include thermal storage, which serves as a back-up system within the CSP plant). Furthermore, solar resources typically produce the most energy in the summer, while Wyoming wind often produces the most energy during the winter. CSP energy production tends to peak when the DSW needs the most energy, in the peak hours of hot summer days, when the wind may be least reliable. There may, therefore, be an opportunity for CSP and wind resources to supplement each other to provide for both the energy and capacity needs of the system. Similarly, it is possible that California's (coastal) wind could provide support for Wyoming's wind. At this time, however, the West has not completed a comprehensive technical and economic assessment of backing up one renewable resource with another renewable resource and such analysis is beyond the scope of this Report.

Wyoming is a major producer of natural gas and it would be feasible to site new natural gas fired generation in Wyoming for the purpose of backing up the state's wind resources. The economic issues include increased line utilization and the lower cost of natural gas at the wellhead, these advantages are offset by transmission line losses and the lower efficiency of natural gas fired generation at higher altitudes. As intermittent renewables continue to provide a greater percentage of the DSW's energy needs, the need for additional natural gas (or other, non intermittent) resources to "back-up" these renewables will become a key factor that will affect the incremental costs of additional wind resources. Analysis of these issues is beyond the scope of this Report but further analysis is required.

6.3 LAND AND WATER USE CONSIDERATIONS

The energy demands outlined in Section 3 demonstrate that energy resource development needs are significant. Due to the large scale of these needs, it is appropriate that the additional "costs" of land and water use are recognized.

The best wind generation sites are typically on elevated or exposed uplands and require approximately 5 acres per MW of capacity. In practice, however, only two percent of this is required for siting the wind turbines with the balance of 98 percent remaining available for wildlife habitat, ranching or agriculture.[l] At an effective 0.1 acres per MW, wind generation is a highly efficient use of land. CSP generation requires approximately 8 acres per MW of capacity, none of which can exceed a slope greater than one percent. CSP is therefore a relatively inefficient use of land.

Conventional thermal generation requires significant water use for cooling purposes. CSP plants have a similar need for water cooling, supply of which is made more challenging by the fact that they may be installed in a desert location that lacks water. There is an alternative to conventional cooling for thermal and solar resources often referred to as "dry" cooling. Dry cooling consumes less than ten percent of the water of a conventional system, but at a significant increase in cost. A significant advantage of wind generation, therefore, is that its water usage is zero.

The land and water use requirements for wind, CSP, and combined cycle natural gas generation technologies are described below (Figure 20 and 21). For CSP and natural gas water consumption with both wet and dry cooling technologies is shown.

Figure 20[li]

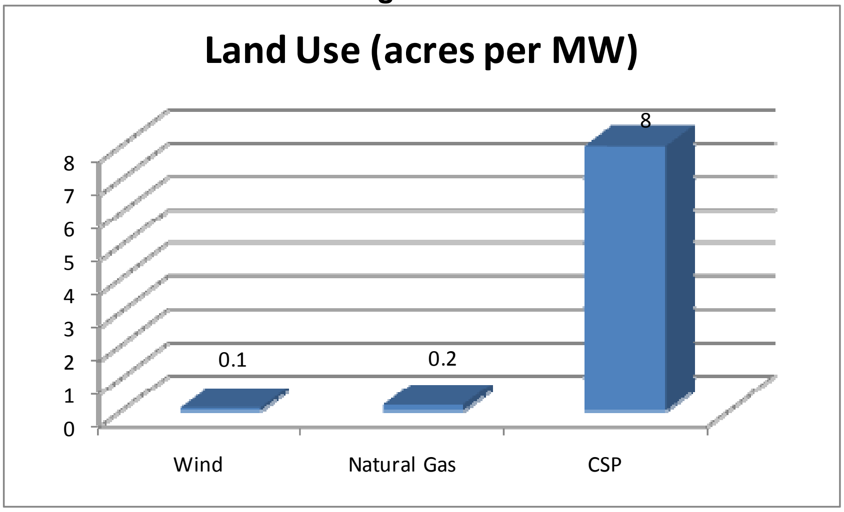
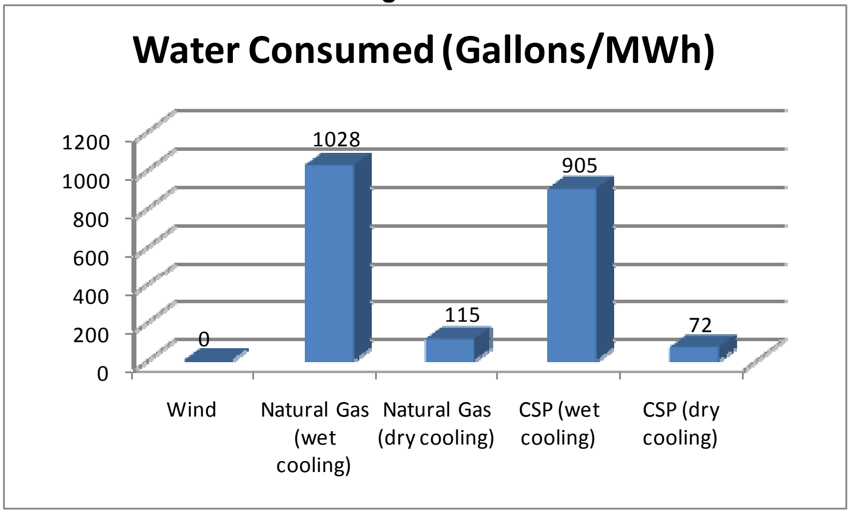


Figure 21[lii]



6.4 SECTION SUMMARY AND CONCLUSIONS

- The delivered cost of Wyoming wind energy is comparable to or lower than California wind energy and significantly less expensive than other large scale renewable resources located in the DSW region.
- Class 6 and 7 Wyoming wind is the lowest cost renewable energy solution for the DSW, with a delivered cost range of $72 to $101 per MWh (2008$).
- The best California wind is comparable in cost to Wyoming wind delivered to the DSW, at $78 to $124 per MWh (2008$) but is limited in scale.
- CSP costs are estimated to be more expensive with forecasted costs of $143 to $220 per MWh (2008$).
- Assuming the extension of the PTC, under nearly every scenario evaluated high quality wind is competitive with natural gas fired generation on an energy basis.
- Wind and solar are intermittent resources that may need to be "backed-up" with a firm resource. More analysis is required to understand integration costs stemming from the large-scale deployment of wind. It is also possible that wind and solar could act as "back-up" resources for one another, but this is similarly beyond the scope of this Report.
- Wind's efficient use of land and water makes it an attractive resource to build in large scale.

7 SUMMARY AND CONCLUSIONS

The 'need' section of the Report, Section 3, examined the impact of Western states RPS and GHG policy goals, in the context of forecasted population and electricity sales growth. RPS and electricity sales growth requirements alone will create a need for an increase of 116,000 GWh of renewable energy supplies across the West by 2020. The need is most acute in the DSW, where RPS and electricity sales growth requirements are forecasted to create a need for an increase of 55,000 GWh by 2020, or nearly half of the total requirement for the US portion of the WECC region.

As aggressive as these RPS goals are, they could yet be on the low end of 2020 requirements to meet GHG reduction targets depending on how policymakers and the market work out how best to measure, allocate and achieve GHG reduction targets. Section 3 analyzes the impact of the WCI and possible federal GHG legislation on the electricity sector. While it is still not entirely clear how the regional GHG reductions goals of the WCI will affect the electricity sector, the Report concludes that these measures will stimulate demand for new renewable energy resources between 84,000 and 167,000 GWh for the US portion of the WECC region or between 58,000 and 115,000 GWh for the DSW region. Regional GHG reduction measures, therefore, have the potential to stimulate even greater demand for new renewable infrastructure than RPS requirements.

Federal GHG legislation is a distinct possibility in the near future. While the design of any such legislation is uncertain, the growing consensus that the US should reduce GHG emissions through a market mechanism has already sent a price signal to the electricity sector. If a federal program is implemented it will become an additional driver for meeting the aforementioned challenging levels of renewable energy deployment.

The good news is that the West is blessed with adequate renewable energy resources that can meet this energy gap. Section 4 of the Report concluded that two resources stand out as having the scale to meet this level of additional demand – solar in the DSW and wind in southeast Wyoming. The West is extremely fortunate to have these two excellent renewable energy resources within its footprint – in fact NREL estimates show that potential solar power is so vast it could theoretically provide for all the energy needs of the region. Additionally, southeast Wyoming contains over 50 percent of the best (Class 6 and 7) wind sites in the entire continental US. Estimates suggest that CSP in the DSW and Wyoming wind could, in theory, meet 19 times and 8 times the 2020 RPS need of the US portion of the WECC region, respectively.

The most significant barrier to developing wind resources is lack of transmission, which is one reason why DSW utilities have initially focused on the deployment of CSP resources. Section 5 of the Report examines the cost of building a 900 mile long, interstate transmission line between Wyoming and the load centers of the DSW, based upon National Grid's data from TWE. The conclusion is that, provided this is done in scale (3,000 MW being the largest rating allowed by WECC without significant system-wide upgrades), the delivery costs can be in the range of $16 to $28/MWh (2008$). Wind and solar are intermittent resources, however, and Section 5 also discusses broader transmission issues, such as the integration of wind into the grid system.

Section 6 of the Report adds TWE forecasted delivery costs to forecasted generation costs in order to draw a comparison between various renewable and conventional generation resources. The conclusion is that the best quality Wyoming wind can be delivered at lower costs than California wind. Furthermore, Wyoming wind can be delivered at significantly lower costs than local CSP and, assuming the PTC is extended throughout the study period, is competitive with natural gas fired generation on an energy basis. Section 6 also looks at

additional "cost" factors and concludes that wind generation uses land and water resources very efficiently.
Policymakers and the industry should focus their attention on Wyoming's wind resources as a key resource for the DSW. Wyoming wind has the potential to help the DSW region meet RPS and GHG reduction goals without imposing a cost premium on customers. It was beyond the scope of this Report, however, to look at several key issues that will influence any final policy or investment decision. Solar and natural gas fired generation resources are a better capacity product than wind resources. Additional production cost and economic analysis is required to fully understand the system wide impacts and mitigation costs of integrating large amounts of wind energy into the system. This further analysis should also examine the diversity effect of renewable resources including the potential for solar, California (coastal) wind, and Wyoming wind to back each other up.

The potential clean energy delivered on TWE can make a significant impact on the region's RPS and GHG reduction goals. Figure 22 illustrates TWE's potential impact on regional RPS goals and Figure 23 illustrates TWE's impact on the region's potential need for renewables as driven by GHG reduction initiatives. TWE has the potential to meet 25 percent of the incremental renewable energy goals for the DSW in 2020 or 11 percent of the DSW's GHG goals for emissions associated with electricity use. This highlights that while TWE's impact can be significant, it is only one of multiple large scale solutions that will be necessary to meet the needs of the region.

Figure 22[7]

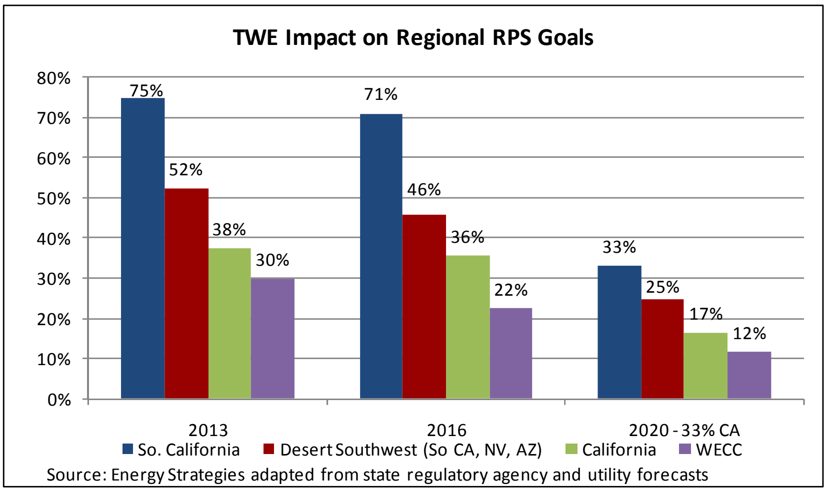
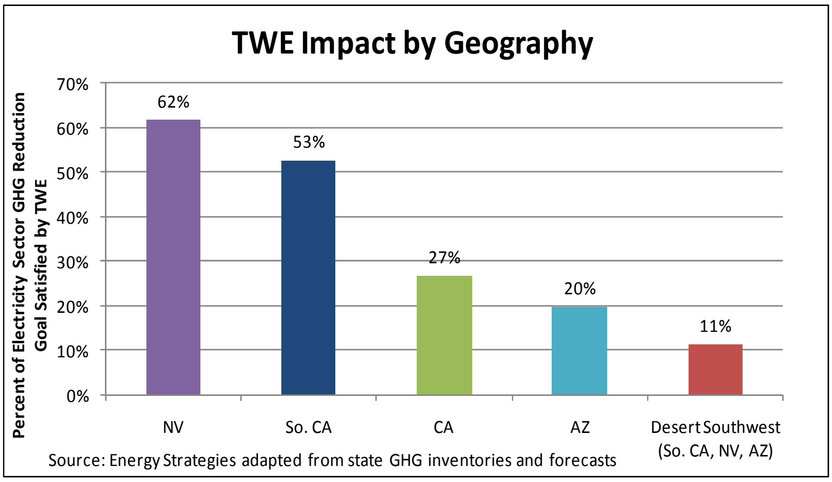


Figure 23



[7] Data in Figure 21 and 22 is generated using the assumption that TWE will transmit 100 percent renewable energy to the geography in question. Furthermore it is assumed that 4,000 MW of wind, with an average capacity factor of 43 percent (net of a very small percentage curtailment that may be necessary during peak wind hours). This represents a 51 percent line utilization factor.

APPENDIX A – MAJOR DSW ELECTRIC UTILITIES

Major Load Serving Entities by State and Associated 2006 Energy Sales				
State	**Utility Name**	**Ownership**	**2006 Sales (MWh)**	**% of 2006 State Sales**
AZ	Arizona Public Service Co	Investor Owned	27,970,397	38%
AZ	Salt River Project	Political Subdivision	26,249,636	36%
AZ	Tucson Electric Power Co	Investor Owned	9,201,419	13%
CA	Southern California Edison Co	Investor Owned	88,728,720	34%
CA	Pacific Gas & Electric Co	Investor Owned	84,785,198	32%
CA	Los Angeles Dept of Water and Power	Municipal	24,313,734	9%
CA	San Diego Gas & Electric Co	Investor Owned	20,236,492	8%
CA	Sacramento Municipal Utility Dist	Municipal	10,799,230	4%
NV	Sierra Pacific Resources (SP and NP)	Investor Owned	30,540,830	89%
Source: Energy Strategies adapted from FERC Form 1 data.				

APPENDIX B – RETI PHASE 1A TECHNOLOGY COST SUMMARY

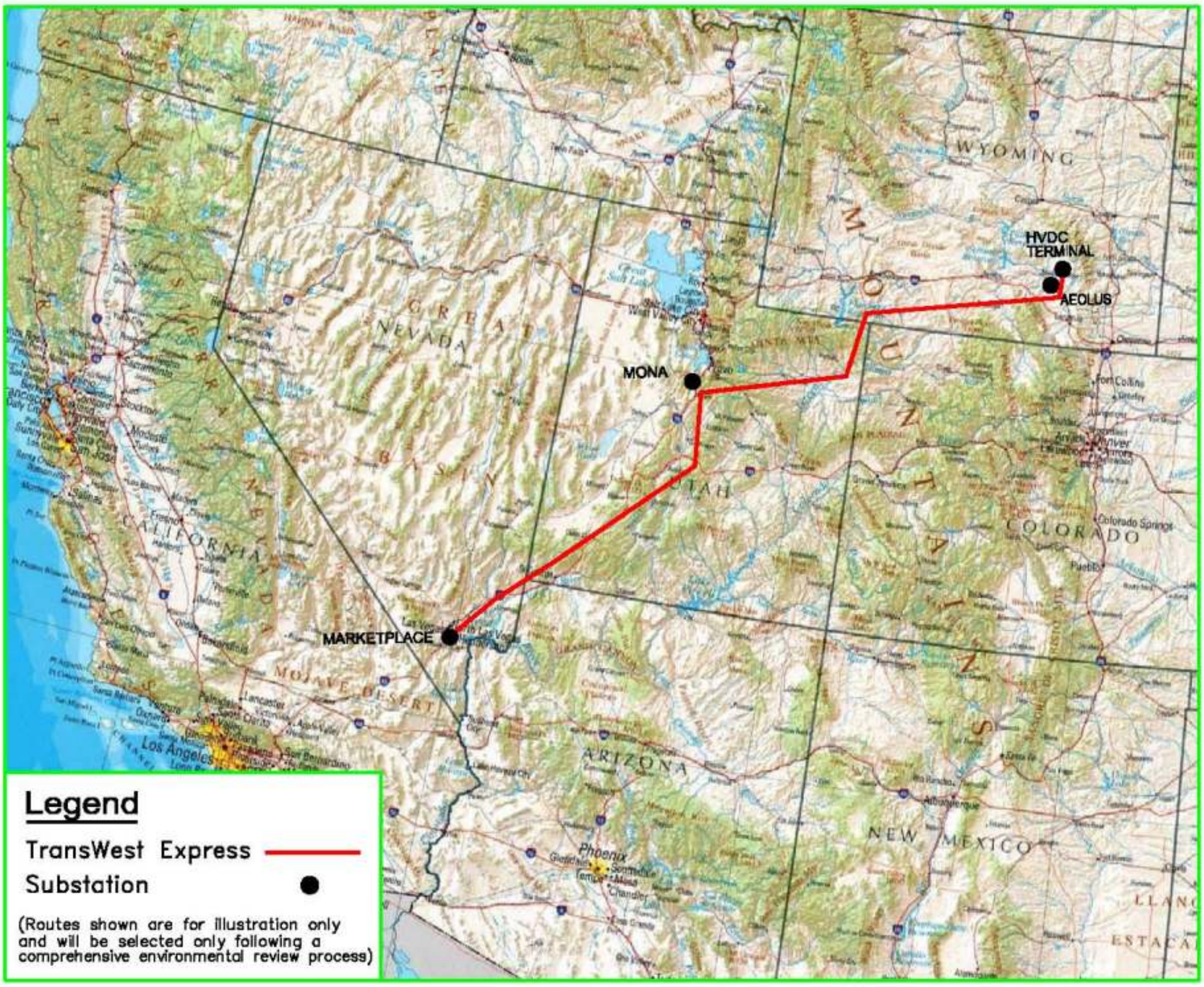
Table 1-1. Renewable Technologies Performance and Cost Summary.

	Net Plant Capacity, MW	Net Plant Heat Rate, Btu/kWh	Capacity Factor	Capital Cost, $/kW	Fixed O&M, $/kW-yr	Variable O&M, $/MWh	Fuel Cost, $/MBtu	Levelized Cost, $/MWh
Solid Biomass	35	14k to 17.5k	80	3000 to 4500	83	11	0 to 3	67 to 140
Cofired Biomass	35	10000	85	300 to 500	5 to 15		-0.5 to 1	-1 to 22
An. Digestion	0.15	13000	80	4000 to 6000		17	1 to 3	100 to 168
Landfill Gas	5	13500	80	1200 to 2000		17	1 to 2	50 to 80
Solar Thermal	200		26 to 29	3800 to 4800	66			143 to 192
Solar Photovoltaic	20		25 to 30	6500 to 7500	35			201 to 276
New Hydroelectric	<50		40 to 60	2500 to 4000	5 to 25	5 to 6		57 to 136
Inc. Hydroelectric	1 to 600		40 to 60	600 to 3000	5 to 25	3.5 to 6		10 to 98
Wind	100		25 to 40	1900 to 2400	50			59 to 128
Offshore Wind	200		35 to 45	5000 to 6000	75-100			142 to 232
Geothermal	30		70 to 90	3000 to 5000		25 to 30		54 to 107
Marine Current	100		25 to 45	2200 to 4725	90 to 255			97 to 410
Wave	100		25 to 45	2800 to 5200	150 to 270	11		135 to 445

Notes:
Levelized cost is the levelized cost of generation only. Includes applicable incentives, subsidies, etc.
Break-outs for fixed and variable are arbitrary and not consistent across technologies. When no value is shown for one O&M category, it is assumed that the other O&M category includes all O&M costs.

Source: Black & Veatch, Renewable Energy Transmission Initiative Phase 1A Final Report, May 2008, Table 1-1.

APPENDIX C – REPRESENTATIVE TWE MAP



APPENDIX D – PLANT ASSUMPTIONS

Plant Assumptions									
					Base Case			Capital Cost Sensitivity	
Location	Resource	Plant Size (MW)	Capacity Factor	Heat Rate (Btu/kWh)	Fixed O&M and Other Fixed ($2008/kW-yr)	Variable O&M and Other Variable ($2008/MWh)	Installed Cost* ($2008/kW)	Low Installed Cost ($2008/kW)	High Installed Cost ($2008/kW)
Arizona	CCCT	520	60%	6,920	$ 13.77	$ 2.53	$ 1,040	$ 884	$ 1,196
	Solar - Parabolic Trough	100	25-30%	0	$ 63.42	$ -	$ 4,590	$ 3,902	$ 5,279
Nevada	Solar - Parabolic Trough	100	25-30%	0	$ 63.42	$ -	$ 4,590	$ 3,902	$ 5,279
	CCCT	520	60%	6920	$ 13.77	$ 2.53	$ 1,040	$ 884	$ 1,196
Wyoming	CCCT	448	60%	7,164	$ 10.90	$ 3.64	$ 1,040	$ 884	$ 1,196
	Wind	100	35-50%	0	$ 66.30	$ -	$ 2,229	$ 1,895	$ 2,563
California	CCCT	500	60%	6,990	$ 10.06	$ 4.51	$ 1,040	$ 884	$ 1,196
	Solar - Parabolic Trough	100	25-30%	0	$ 63.42	$ -	$ 4,590	$ 3,902	$ 5,279
	Wind	100	30-35%	0	$ 66.30	$ -	$ 2,534	$ 2,154	$ 2,914

* Installed costs include all capital costs and interest during construction, carrying costs, etc.

Appendix E illustrates the more detailed economics of each resource assumption used in this analysis including: land/water use, transmission costs on TWE, cost of line losses, cost of wind integration, energy cost and sensitivity assumptions.

APPENDIX E – OVERVIEW OF ECONOMIC ANALYSIS RESULTS

Comparison of Resource Alternatives															
				Levelized Cost of Energy (2008$/MWh)											
				Base Case					GHG Allowance Sensitivity			Capital Cost Sensitivity		Fuel Price Sensitivity	
Resource Type	Location	Water Consumed (Gallons/ MWh)[1]	Land (Acres/MW)[1,2]	Transmission[4]	Losses	Wind Integration[5]	Energy	Total Base Case	No Carbon Price	S.1766 EPA, ADAGE	S.2191 EPA, ADAGE	-15%	15%	-20%	20%
Wind[3]	CA @ 30%	0	0.1	$ -	$ -	$ 3.25	$ 106.17	$ 109.42	$ -	$ -	$ -	$ 94.50	$ 124.33	$ -	$ -
	CA @ 35%	0	0.1	$ -	$ -	$ 3.25	$ 87.75	$ 91.00	$ -	$ -	$ -	$ 78.22	$ 103.78	$ -	$ -
	WY @ 35%	0	0.1	$ 34.11	$ 8.94	$ 3.25	$ 77.22	$ 123.52	$ -	$ -	$ -	$ 111.22	$ 135.83	$ -	$ -
	WY @ 40%	0	0.1	$ 29.85	$ 7.57	$ 3.25	$ 64.83	$ 105.50	$ -	$ -	$ -	$ 94.73	$ 116.27	$ -	$ -
	WY @ 45%	0	0.1	$ 26.53	$ 6.49	$ 3.25	$ 55.20	$ 91.47	$ -	$ -	$ -	$ 81.90	$ 101.05	$ -	$ -
	WY @ 50%	0	0.1	$ 23.88	$ 5.64	$ 3.25	$ 47.49	$ 80.26	$ -	$ -	$ -	$ 71.65	$ 88.87	$ -	$ -
Solar (Parabolic Trough)	AZ @ 25%	905 / 72	8.0	$ -	$ -	$ -	$ 195.90	$ 195.90	$ -	$ -	$ -	$ 171.60	$ 220.21	$ -	$ -
	AZ @ 30%	905 / 72	8.0	$ -	$ -	$ -	$ 163.25	$ 163.25	$ -	$ -	$ -	$ 143.00	$ 183.51	$ -	$ -
	CA @ 25%	905 / 72	8.0	$ -	$ -	$ -	$ 195.90	$ 195.90	$ -	$ -	$ -	$ 171.60	$ 220.21	$ -	$ -
	CA @ 30%	905 / 72	8.0	$ -	$ -	$ -	$ 163.25	$ 163.25	$ -	$ -	$ -	$ 143.00	$ 183.51	$ -	$ -
	NV @ 25%	905 / 72	8.0	$ -	$ -	$ -	$ 195.90	$ 195.90	$ -	$ -	$ -	$ 171.60	$ 220.21	$ -	$ -
	NV @ 30%	905 / 72	8.0	$ -	$ -	$ -	$ 163.25	$ 163.25	$ -	$ -	$ -	$ 143.00	$ 183.51	$ -	$ -
Gas (CC)	Arizona	1028 / 115	0.2	$ -	$ -	$ -	$ 105.05	$ 105.05	$ 100.92	$ 108.98	$ 120.78	$ 101.95	$ 108.16	$ 90.32	$ 119.78
	California	1028 / 115	0.2	$ -	$ -	$ -	$ 113.43	$ 113.43	$ 109.26	$ 117.40	$ 129.32	$ 110.70	$ 116.17	$ 96.87	$ 130.00
	Nevada	1028 / 115	0.2	$ -	$ -	$ -	$ 105.05	$ 105.05	$ 100.92	$ 108.98	$ 120.78	$ 101.95	$ 108.16	$ 90.32	$ 119.78
	Wyoming	1028 / 115	0.2	$ 19.10	$ 11.26	$ -	$ 101.36	$ 131.72	$ 126.96	$ 136.24	$ 149.81	$ 128.27	$ 135.17	$ 116.37	$ 147.07

1. Wet cooling data shown first followed by dry cooling data (if applicable). Land and water use data from CEC's 2007 Environmental Performance Report of California's Electrical Generation System, Table 9 and Figure 13. CSP water use from Solar Thermal Parabolic Trough Electric Power Plants for Electric Utilities in California prepared by Solargenix Energy, November 2005, P.48.

2. Land estimates for wind represent the actual area occupied by the turbines, 2% of the total (Source: NREL). The area required for an entire wind farm (5.4 acres/MW) can serve a dual purpose, e.g. farming.

3. Capital Cost, permitting and O&M expenses are assumed to be the same for wind resources in that state, but they will likely be vary based on the wind resource.

4. Transmission costs from Wyoming do not include the cost of wheeling the power from the Marketplace substation. Likewise, AZ, CA and NV resources do not include local transmission, which will be necessary to move the resources to load. Transmission costs for wind are for 4,000 MW of installed wind capacity and for WY gas assume 75% line utilization.

5. Wind integration costs from "Arizona Public Service Wind Integration Cost Impact Study," 4% penetration case, prepared by Northern Arizona University. September 2007.

* Renewable cost estimates are based on the assumption the PTC and ITC are renewed.

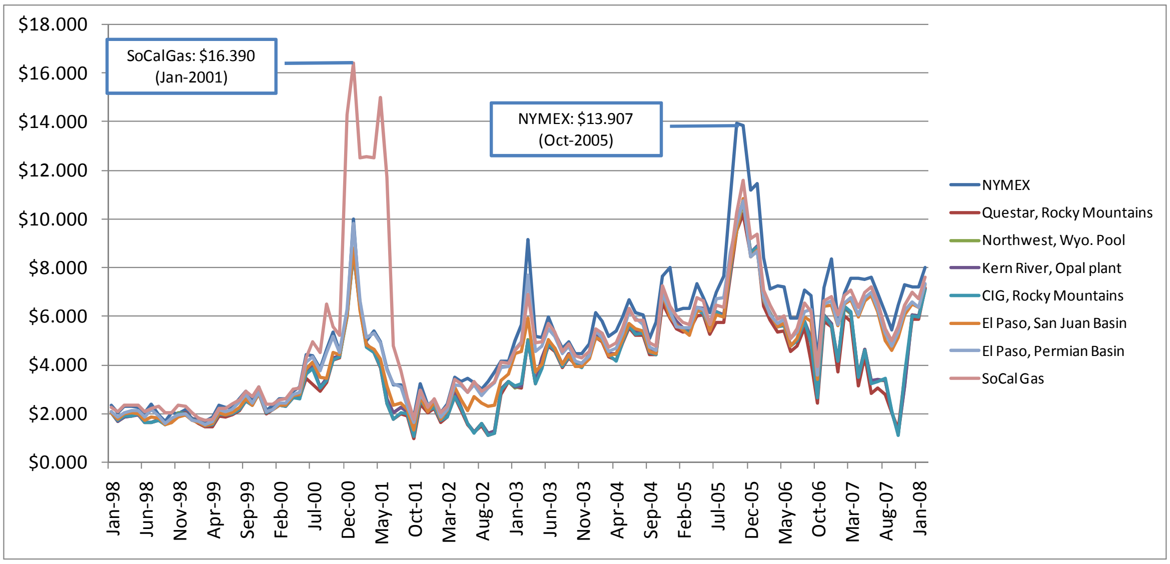
APPENDIX F – NATURAL GAS PRICE ASSUMPTIONS

	Gas ($/MMBtu)		
	AZ & NV	CA	WY
2015	$8.23	$8.63	$7.68
2016	$8.48	$8.72	$8.40
2017	$8.87	$8.80	$9.06
2018	$8.90	$9.38	$9.67
2019	$9.48	$9.98	$10.29
2020	$10.11	$10.16	$10.56
2021	$10.42	$10.34	$10.77
2022	$10.80	$10.86	$10.97
2023	$11.16	$11.39	$11.18
2024	$11.58	$11.81	$11.38
2025	$11.93	$12.23	$11.59
2026	$12.34	$12.67	$11.79
2027	$12.75	$13.15	$11.99
2028	$13.79	$13.68	$12.05
2029	$13.63	$14.21	$12.12
2030	$14.09	$14.73	$12.18

Appendix F illustrates the fuel prices used in the analysis in Appendix E. Price sensitivities were evaluated by taking plus and minus 20 percent of the values in Appendix F.

APPENDIX G – NATURAL GAS PRICE VOLATILITY

The figure below illustrates the historic pricing of natural gas dating back to January 1998.

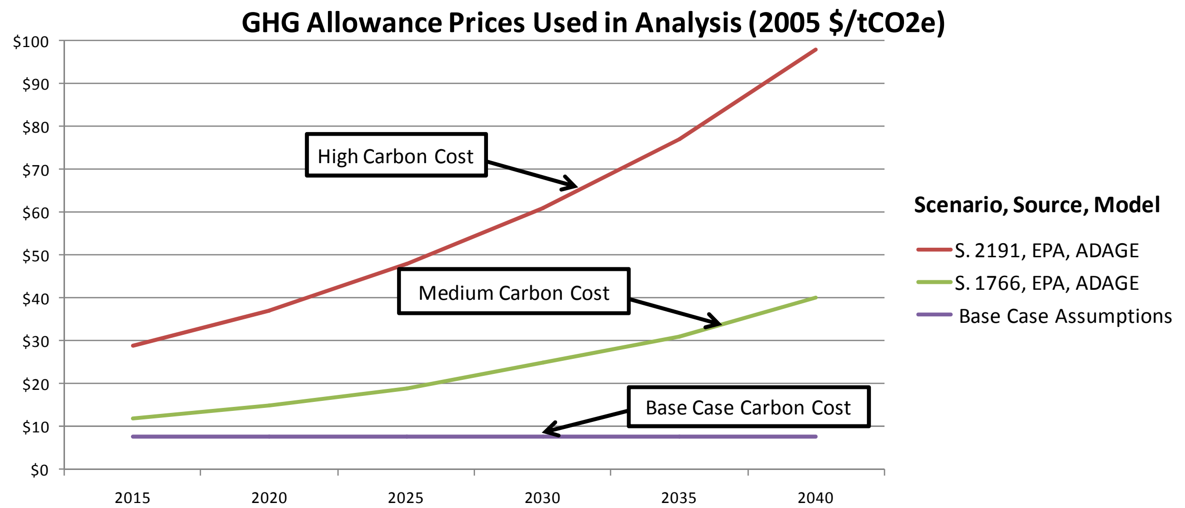


To capture some of the uncertainty illustrated in this graph, the resource cost sensitivity table (Appendix E) incorporates plus or minus 20 percent of the Appendix F values to help identify the potential range of LCOE uncertainty associated with fossil fuels.

APPENDIX H – GHG COST SENSITIVITIES

The future cost of GHG emissions is uncertain but critically important to evaluate in any resource cost comparison. With federal legislation pending, estimates of future GHG allowance prices range from about $10/ton in 2015 to over $425/ton in 2050. Figure 17 below illustrates the cost curves that were used in the GHG price sensitivity estimates in Appendix E. S.2191 is the proposed Lieberman-Warner bill. S.1766 is the proposed Bingaman-Specter bill. The base case assumes a constant GHG price of about $8/ton of CO_2e, similar to the costs used by many Western utilities in their IRPs. The cost curves for the Lieberman-Warner and Bingamen-Specter bills were developed by the EPA.

Current coal technologies emit approximately one metric ton of carbon dioxide per MWh of energy produced. Under the high GHG cost case, if no technology improvements are made, one MWh of coal energy in 2040 could potentially cost $100 more than it does today solely due to the potential cost of GHG allowances. Natural gas plants emit approximately half as much CO_2 as coal plants and therefore the cost of GHG emissions per MWh would be about half this figure.



Source: Energy Strategies adapted from EPA cost estimates

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[ii] Table 6: Interim Projections: Total Population for Regions, Divisions, and States: 2000 to 2030, U.S. Census Bureau, released April 21, 2005.
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