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P.O. Box 711
Tucson, Arizona 85702

UniSourceEnergy
SERVICES

Arizona Corporation Commission
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April 2, 2012

Docket Control
Arizona Corporation Commission
1200 West Washington
Phoenix, Arizona 85007

Re: Notice of Filing – UNS Electric, Inc.'s 2012 Integrated Resource Plan
Docket No. E-00000A-11-0113

Pursuant to A.A.C. R14-2-703, *et seq.*, UNS Electric, Inc. ("UNS Electric") hereby files its 2012 Integrated Resource Plan. UNS Electric has also prepared supporting analysis for the filing that will be provided electronically to Commission Staff upon the execution of a Protective Agreement.

If you have any questions regarding this filing, please contact Mike Sheehan at (520) 884-3656.

Sincerely,

Jessica Bryne

Jessica Bryne

cc: Barbara Keene, ACC
Compliance Section, ACC

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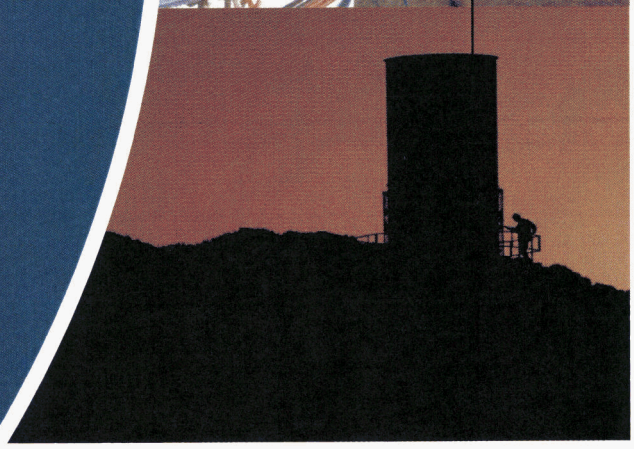
UNS Electric, Inc.



2012
Integrated Resource Plan

April 2, 2012

UniSource Energy Corporation

Acknowledgements

UniSource Electric IRP Team

Mike Sheehan, Director, Resource Planning
Victor Aguirre, Lead Resource Planner
Kevin Battaglia, Lead Resource Planner
Jon Bowman, Lead Resource Planner
David Jacobs, Director, Fuels and Energy Procurement
Denise Richerson-Smith, Director, Energy Efficiency
Carmine Tilghman, Director, Renewable Programs
Debbie Lindeman, Energy Efficiency and Renewable Programs
Ron Belval, Supervisor, Transmission Planning
Erik Bakken, Director, Corporate Environmental Services and Land Management
Jeff Yockey, Manager, Corporate Environmental Services
Mark Mansfield, Senior Director of Tucson Generation
Don Gin, Manager of Remotes and Special Projects

IRP Consultants

Ventyx
Doug Buresh, Senior Vice President of Strategy Analysis, Ventyx
Jean Agras, Vice President - Environmental Markets, Ventyx
www.ventyx.com

Pace Global
Jim McMahon, Vice President, - Consulting Services
Pat Augustine, Director - Consulting Services
Gary W. Vicinus, Executive Vice President, - Consulting Services

Wood Mackenize- Consulting Service

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CHAPTER 1

2012 INTEGRATED RESOURCE PLAN

Introduction

UNS Electric, Inc.'s (UNS Electric) 2012 Integrated Resource Plan (IRP) identifies UNS Electric's future capacity requirements through 2027. The plan describes how UNS Electric plans to meet future demand requirements, while maintaining system reliability, meeting future regulatory requirements, and reducing environmental impacts in a cost-effective manner that leads to just and reasonable rates. Besides providing a snapshot of UNS Electric's current loads and resources, the IRP highlights the near term acquisition goals through the Reference Case plan. The Reference Case portfolio is made up of renewable resources, EE, market purchases and new gas-fired generation. The Reference Case plan puts emphasis on developing a market based resource portfolio that can adapt to future uncertainty.

The Reference Case plan highlights the following goals:

- The Reference Case plan will implement an aggressive EE portfolio that includes a range of cost effective energy conservation programs. The 2012 Reference Case plan includes an EE portfolio that is consistent with the Arizona Energy Efficiency Standard.
- Through a competitive procurement process, the Reference Case Plan will execute a number of renewable purchase power contracts to meet future RES requirements. The Company will also continue to pursue opportunities for shareholder investment in renewable resources. Emphasis will be placed on low-cost, renewable projects that are diversified across a wide-range of developers.
- The Reference Case Plan will develop future transmission infrastructure that maximizes UNS Electric's future load serving capabilities while enhancing access to future renewable and wholesale market resources.
- The Reference Case plan will target new gas-fired resources to meet future intermediate and base load requirements as well as firming capacity for intermittent generation resources. These future resources may be diversified with a combination of firm purchase power agreements, plant acquisitions, and construction of new generating facilities.

The Reference Case Plan

The Reference Case plan assumes the continued use of our existing resources with a focus on future development of EE, demand response, renewables, and natural gas resources. This section presents an overview of the Reference Case plan and provides associated timelines for future resource additions.

Recommended Resource Portfolio Composition

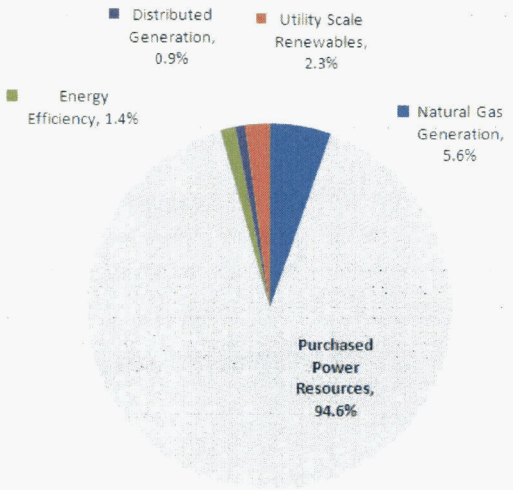
Table 1 below shows the generation mix by resource type under the Reference Case plan. Today, UNS Electric's resource portfolio is dominated by purchase power and natural gas resources. The Reference Case resource plan anticipates potential investments in both zero emission and natural gas-fired resources over the next twenty years. By 2027, it is projected that UNS Electric's resource portfolio will be 71% natural gas and purchase power resources with 18% made up of EE and 11% renewables resources.

Table 1 - Reference Case Portfolio Composition (Percent of Total Resources)

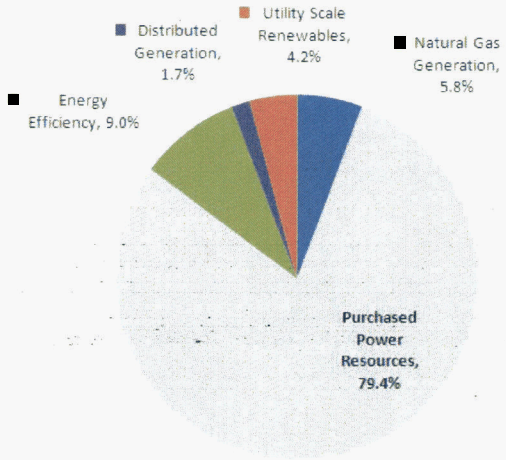
Resource Portfolio % Energy	2012	2017	2022	2027
Natural Gas Generation	5.6%	5.8%	9.5%	16.2%
Purchase Power Resources	94.6%	79.4%	66.4%	54.7%
Energy Efficiency	1.4%	9.0%	15.0%	17.3%
Distributed Generation	0.9%	1.7%	2.6%	3.5%
Demand Response	0.0%	0.0%	0.0%	0.0%
Utility Scale Renewables	2.3%	4.2%	6.4%	8.2%
Total Resources	100.0%	100.0%	100.0%	100.0%
Percent of Net Retail Load	2012	2017	2022	2027
Renewable Resources (Utility Scale and Distributed Generation)	3.5%	7.0%	12%	15%
Energy Efficiency and Demand Response	3%	10%	22%	

Chart 1 below details how the Reference Case Resource plan diversifies UNS Electric's portfolio over the next 15 years.

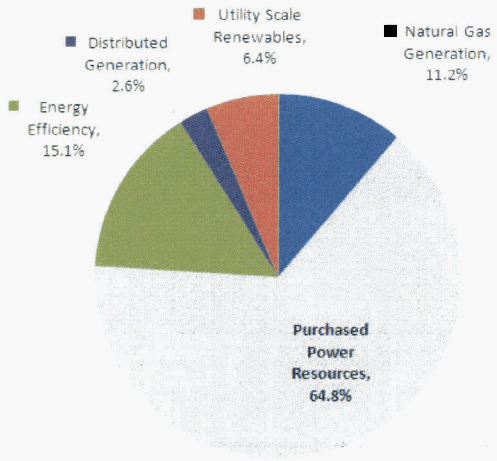
Chart 1 - Reference Case Portfolio Diversification (2012-2027)



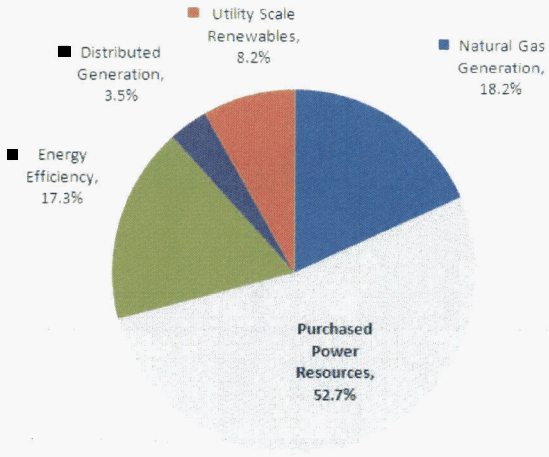
Forecast Year 2012



Forecast Year 2017



Forecast Year 2022



Forecast Year 2030

Energy Efficiency and Demand Response

Energy Efficiency

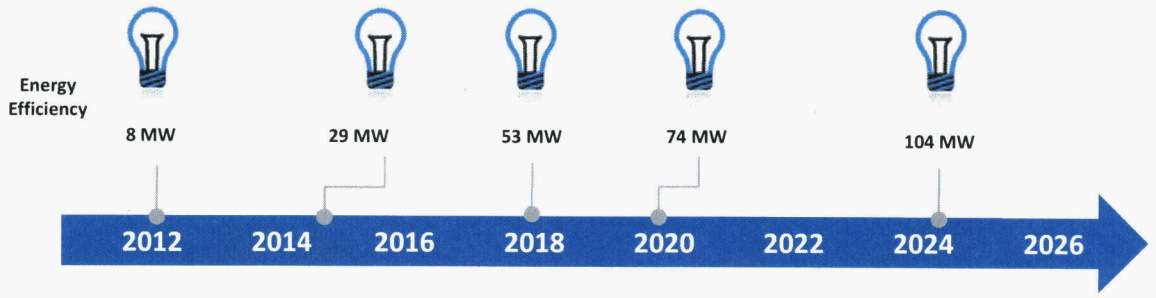
The most cost-effective resource option available to any utility is energy efficiency (EE). Accordingly, UNS Electric proposes to pursue the most cost-effective and reliable energy efficiency programs available. The proposed EE portfolio targets a 22% cumulative energy reduction by 2020. This offset to future retail load growth is expected to reduce UNS Electric's annual energy requirements by 370 GWh in 2020. The EE programs will also reduce UNS Electric's system peak demand by 74 MW by 2020.

Demand Response

Although the Reference Case plan currently doesn't include any demand response (DR) programs, UNS Electric is currently in the process of exploring possible DR opportunities. UNS Electric expects that these efforts will determine the potential benefits of DR for UNS Electric and these programs will be considered in future planning studies.

Figure 1 shows the equivalent capacity reductions to be installed under future EE programs for the Reference Case plan from 2012 through 2027.

Figure 1 - Energy Efficiency Resource Capacity



Utility Scale Renewables and Distributed Generation

Utility Scale Renewables

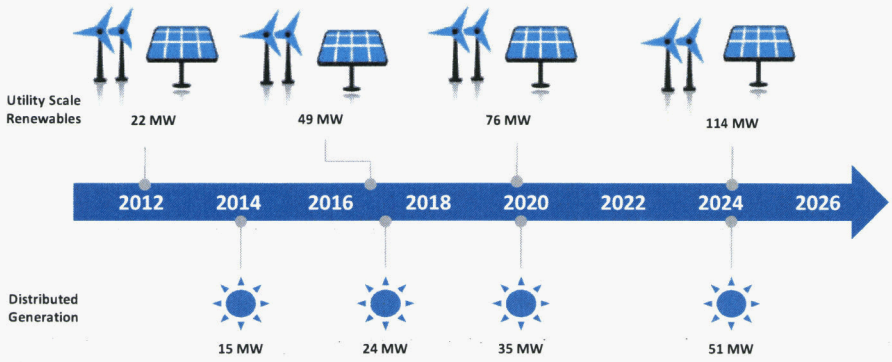
The Reference Case plan also includes a diverse portfolio of renewable resources that complies with the Arizona Renewable Energy Standard (RES). The Reference Case plan meets the renewable energy standard goals, which require UNS Electric to obtain renewable energy which is equivalent to 3.5% of its 2012 retail load requirement, growing to 15% by 2025. By 2020, the Reference Case plan will include over 76 MW of renewable nameplate capacity. These utility scale renewable resources are expected to supply over 151 GWh of energy on an annual basis in 2020.

The 2012 Reference Case plan places emphasis on a diversified renewable resource portfolio. UNS Electric plans to acquire a diverse mix of renewable technologies and short-term REC market purchases when opportunities become available. Finally, as part of this IRP process, UNS Electric's action plan includes plans to conduct a series of on-going RFPs in conjunction with Tucson Electric Power to acquire adequate renewable resource to meet future REST requirements.

Distributed Generation

The Reference Case plan meets the distributed generation requirement based on Arizona's Renewable Energy Standard. The annual distributed generation requirement is 30% of the RES requirement in 2012. By 2020, the Reference Case plan will include 35 MW of distributed generation nameplate capacity. Distributed generation resources are expected to supply at least 461 GWh of energy on an annual basis in 2020. Figure 2 below shows the expected cumulative nameplate capacity to be installed under future utility-scale renewable and distributed generation programs from 2012 through 2027.

Figure 2 - Utility Scale Renewables and Distributed Generation Resource Capacity



Future Generation and Transmission Upgrades

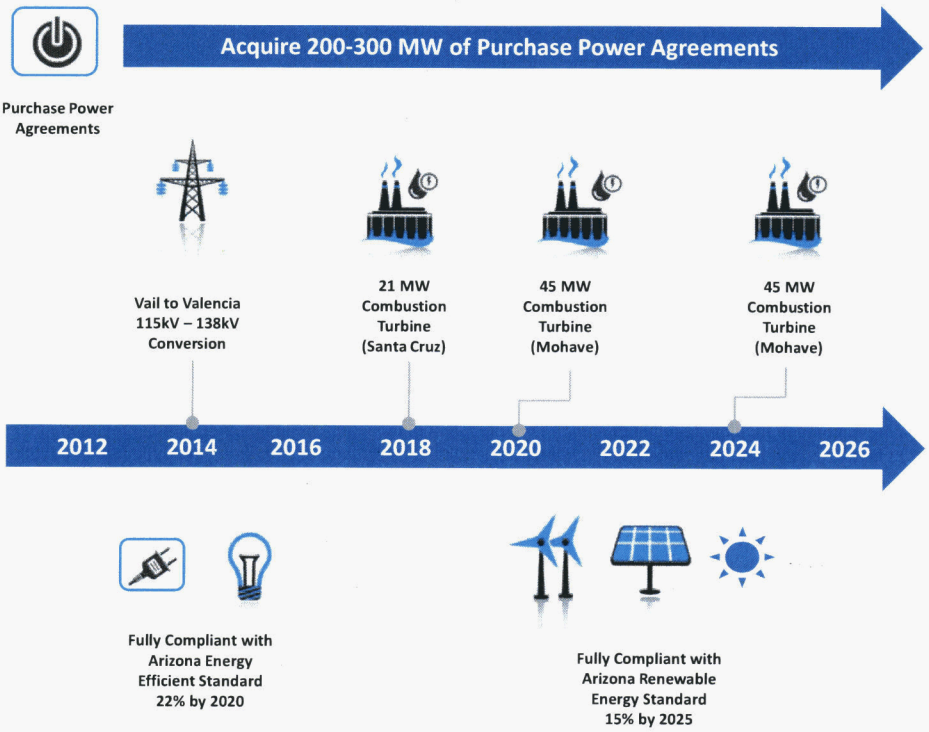
Future Supply-Side Resources

The Reference Case plan also assumes the need for additional market based capacity that ranges from 200 to 300 MW on a summer peaking basis. This market based capacity will be acquired on a continuous basis through UNS Electric's hedging strategy policy. This capacity will be comprised of various purchase power contracts and will be diversified across a wide range of resources and counterparties.

Based on current load growth projections, the Reference Case plan assumes that the Vail to Valencia 115kV to 138kV conversion is completed in 2014 and for purposes of maintaining continuity of service, a new 21 MW combustion turbine (CT) will be sited at the Valencia Power Plant located within the City of Nogales in 2018. In addition, natural gas turbines are also needed to support UNS Electric's renewable resources and two 45 MW gas turbines are shown in 2020 and 2024.

Figure 3 below shows the capacity and the timing associated with UNS Electric's generation and transmission resources.

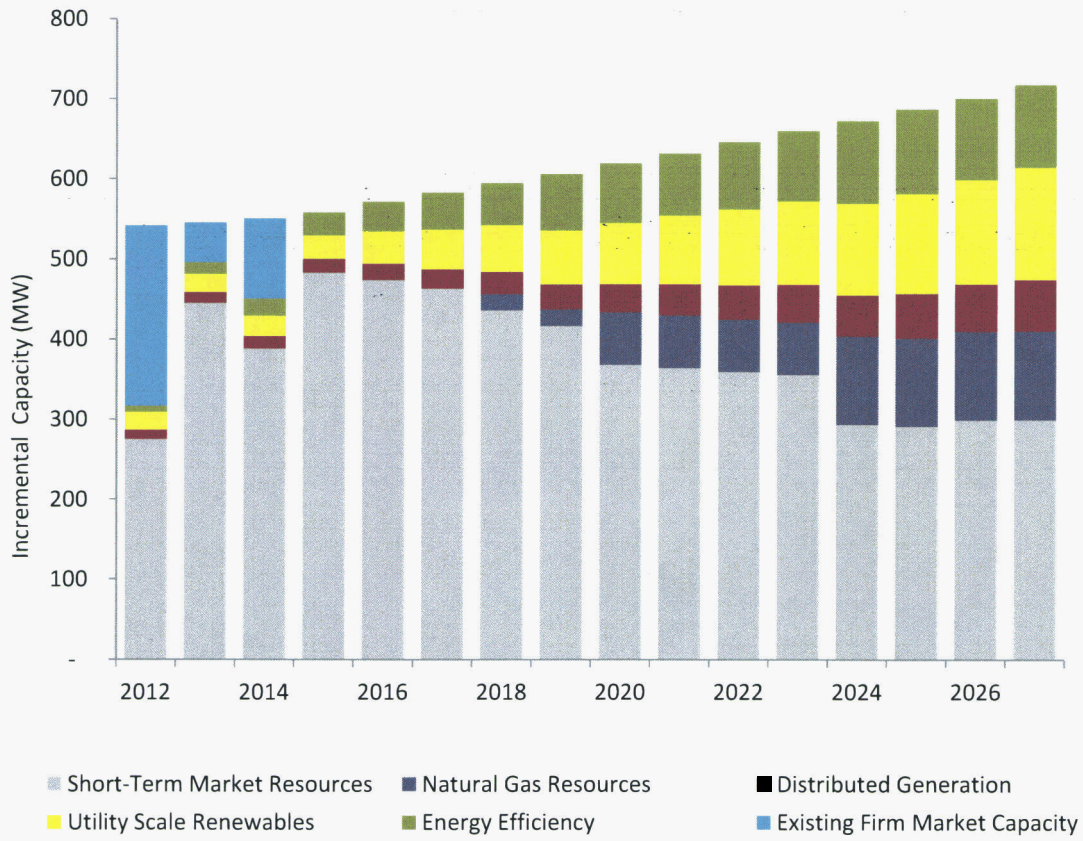
Figure 3 – Local Area Generation and Transmission Resources



Reference Case Resource Plan - Future Capacity Additions

The Reference Case plan identifies the need for approximately 718 MW of new nameplate capacity through 2027. Chart 2 below shows the incremental nameplate capacities installed by year and resource type.

Chart 2 – Reference Case Plan Capacity Additions, Future Nameplate Capacity (MW)



Reference Case Resource Plan - Future Capacity Additions

Table 2 shows the future resource nameplate capacities by year and resource type. This table summarizes the cumulative capacity additions that are expected under the Reference Case plan.

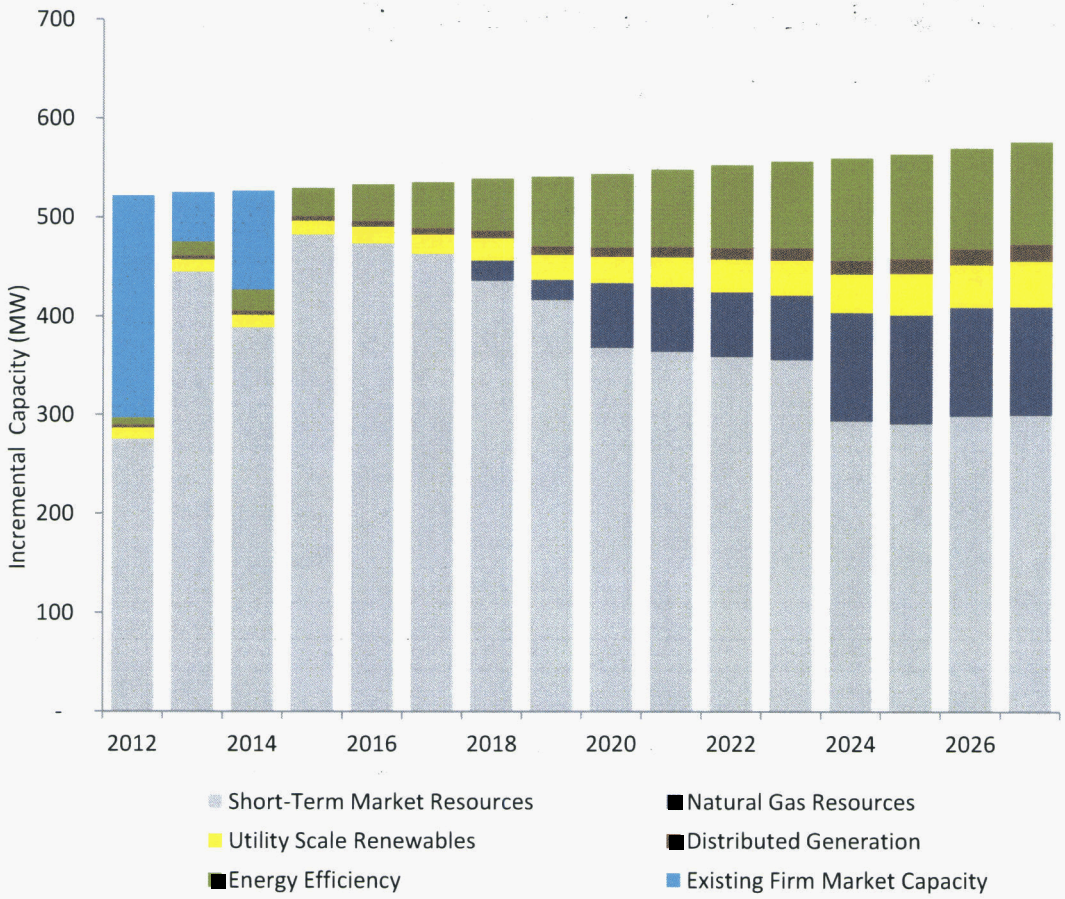
Table 2 – Reference Case Plan Capacity Additions 2010-2027, Future Nameplate Capacity (MW)

Future Resources (Nameplate Capacity MW)	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
Natural Gas Resources	-	-	-	-	-	-	21	21	66	66	66	66	111	111	111	111
Utility Scale Renewables	22	23	25	29	40	49	58	67	76	85	94	104	114	124	130	140
Distributed Generation	12	14	15	17	21	24	28	31	35	39	43	47	51	55	60	64
Energy Efficiency	8	14	22	29	37	46	53	71	74	78	84	88	104	106	102	104
Total Nameplate Capacity	41	50	62	76	98	120	159	190	251	267	287	304	379	396	402	418
Short-Term Market Resources	500	495	489	483	474	463	436	416	368	364	359	356	293	291	299	300
Total Resources	542	545	551	558	571	583	595	606	619	632	646	660	673	687	701	718

Reference Case Resource Plan - Capacity Contribution to System Peak

Chart 2 on page 19 and Table 2 on page 20 referred to installed nameplate capacities for future capacity additions. However, for resource planning purposes, it is important to value resource capacity on its coincidence to system peak. Chart 3 displays the capacity contribution coincident to system peak by resource type. For the 2012 IRP, the resource planning team determined the expected capacity contribution values for the evaluated utility-scale and distributed renewable resources. The expected capacity values were derived from hourly data sources and the capacity contribution for each renewable resource is documented in Chapter 9 of this report. The 718 MW of nameplate capacity shown in Chart 1 is adjusted accordingly and under the Reference Case plan, new resource capacity results in an expected capacity contribution of 577 MW by 2027.

Chart 3 – Reference Case Resource Plan, New Resource Capacity (Coincident to System Peak MW)



Future Load Obligations

The tables on the next two pages provide a data summary on UNS Electric's loads and resources. Table 3 details UNS Electric's projected firm load obligations which include retail and planning reserves.

Table 3 - Firm Load Obligations, System Coincident Peak Demand (MW)

Firm Load Obligations	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
Retail Peak Demand	458	462	465	469	474	478	483	488	492	497	503	508	514	519	525	532
Less Energy Efficiency	8	14	22	29	37	46	53	71	74	78	84	88	104	106	102	104
Less Demand Response	3	4	4	5	5	6	7	8	9	10	11	12	13	15	16	17
Net Peak Demand	447	444	439	435	431	425	423	409	408	409	408	408	397	398	407	411
Reserve Requirements	67	67	66	65	65	64	63	61	61	61	61	61	60	60	61	62
Retail & Reserves	515	511	505	501	496	489	486	470	470	470	469	469	456	458	468	473

Reference Case Resource Plan – System Resource Capacity

Table 4 details UNS Electric's Reference Case resource plan based on a resource's capacity contribution to system peak.

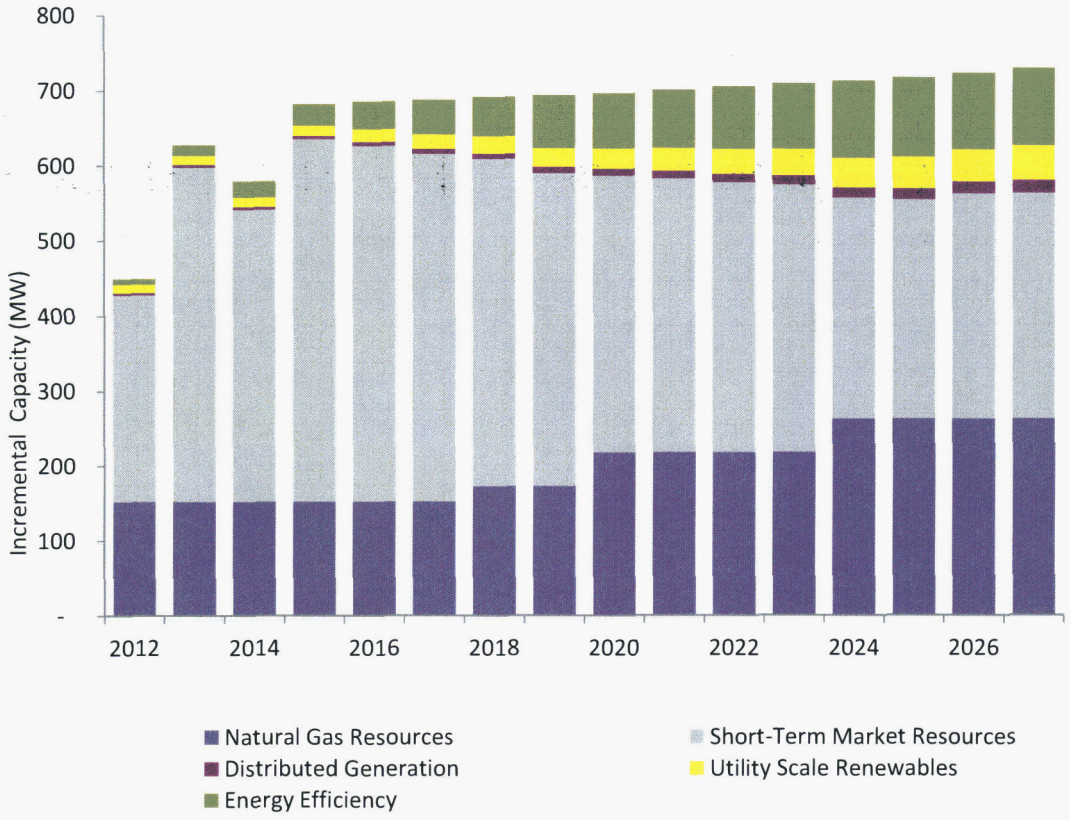
Table 4 – Reference Case Resource Plan- Capacity Resources, System Coincident Peak Demand (MW)

Firm Resource Capacity (MW)	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
Natural Gas Resources	153	153	153	153	153	153	173	173	218	218	218	218	263	263	263	263
Utility Scale Renewables	11	12	13	14	17	19	23	25	27	30	33	35	39	42	43	46
Distributed Generation	3	4	4	5	5	6	7	8	9	10	11	12	13	15	16	17
Total Coincident Peak Capacity	167	168	169	171	175	178	203	206	254	258	262	266	316	320	322	326
Firm Purchases	225	50	100	-	-	-	-	-	-	-	-	-	-	-	-	-
Short-Term Market Resources	123	293	236	330	321	310	283	264	216	212	207	203	141	139	146	147
Total Resources	515	511	505	501	496	489	486	470	470	470	469	469	456	458	468	473

Reference Case Resource Plan – System Coincident Peak Capacity

Chart 4 provides an aggregate summary of UNS Electric's resource capacity including its existing generation resources. In 2012, the resource capacity mix is made up of natural gas and merchant resources. Based on the recommended resource plan, the UNS Electric portfolio is further diversified to include additional capacity resources such as renewables, DG, and EE.

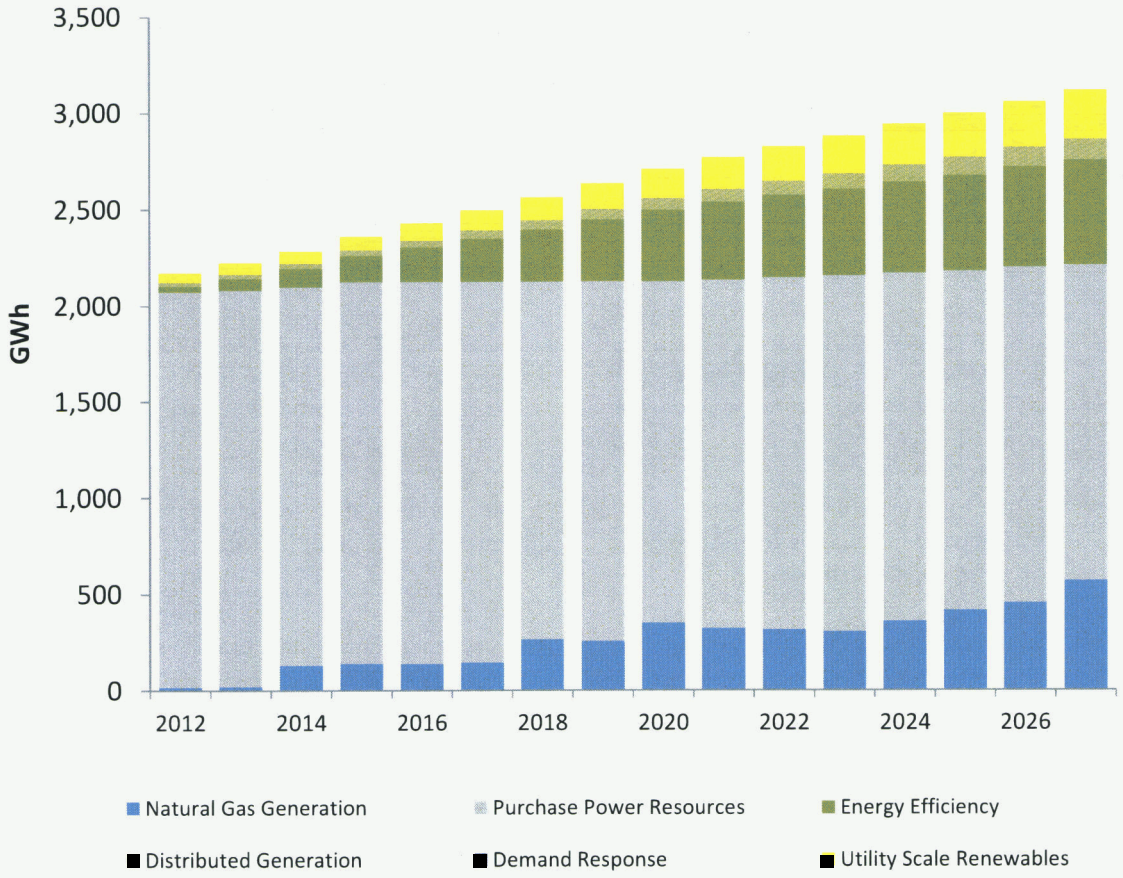
Chart 4 – Reference Case Plan (Total Capacity - Coincident to System Peak MW)



Reference Case Resource Plan – Annual Generation Output

Chart 5 shows the expected energy contribution required to meet UNS Electric's firm load obligations by year and resource type. In 2012, UNS Electric's resource portfolio is comprised of 97% purchase power and natural gas resources. By 2027, it is projected that UNS Electric's resource portfolio will be comprised of 71% natural gas and purchase power resources with 18% made up of EE and 11% renewable resources.

Chart 5 – Reference Case Resource Plan, Expected Annual Generation Output (GWh)



Action Plan

Overview

It is important to note that the Reference Case resource plan was chosen as the portfolio plan that appropriately balances the competing interests for UNS Electric's customers based on the current view of the future. As a result, UNS Electric has developed an action plan required to implement the Reference Case plan. The action plan is based on the resource decisions that must be implemented in the early phases of this strategy. Under this action plan, additional detailed study work will be conducted to fully validate all technical and financial assumptions prior to any implementation decisions. Due to the capital intensive nature of the electric industry as well as the impacts of current and future regulations, UNS Electric plans to file an IRP with the Arizona Corporation Commission (ACC) every two years as required by AAC R14-2-704. To implement the Reference Case plan, UNS Electric identified the following actions that must occur over the next two years prior to the next IRP update:

UNS Electric Requests Acknowledgement of the Following Action Items

- Through approval of future REST implementation plans, UNS Electric will plans to collaborate with Tucson Electric Power to execute a well diversified portfolio of utility-scale renewable projects. UNS Electric will consider locating renewable energy resources within its service territories if the projects make sense from both a reliability and economic standpoint.

- Through approval of future EE implementation plans, UNS Electric will target an aggressive demand-side management (DSM) implementation schedule to achieve the proposed EE goals which cumulatively reduce customer consumption by 22% by 2020. UNS Electric will closely monitor the success of its EE programs and adjust its short-term capacity plans accordingly.

- In order to fill in UNS Electric's capacity shortages and provide support for intermittent generation, UNS Electric will continue with its ongoing hedging practices to acquire firm short-term capacity resources in a timely manner.

- UNS Electric will continue to monitor economic development in both Mohave and Santa Cruz Counties to account for potential high load growth scenarios and adjust it's near term transmission and/or local area generation plans to maintain adequate load serving capability.

- UNS Electric will monitor the market for economically attractive plant acquisition opportunities. A low cost, multi-owner acquisition of an existing combined cycle gas fired plant would enable UNS Electric to firm up its longer-term capacity needs while realizing economies of scale through a multi-owner plant configuration.

CHAPTER 2

INTEGRATED RESOURCE PLANNING METHODOLOGY

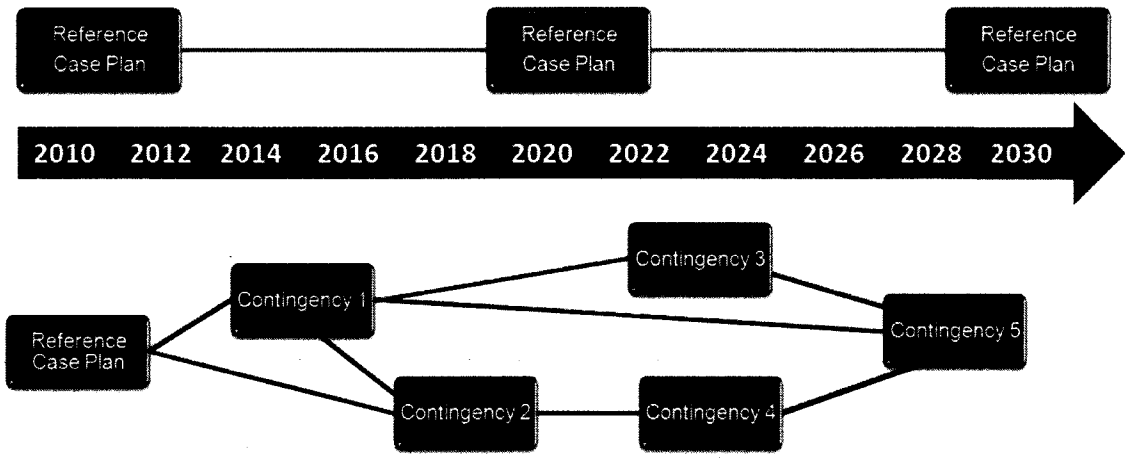
Overview

The purpose of the 2012 IRP is to develop a strategic roadmap for UNS Electric that ensures reliable electric service, meeting renewable and EE mandates while effectively managing costs and future uncertainty. The IRP also serves to inform regulatory staff, customer interest groups, regulators and other interested stakeholders on the assumptions used to develop the company's long-term resource strategy.

The IRP process is a dynamic business function that helps utility planners narrow the choices on long-term resource procurement. The Reference Case plan is not meant to be a static plan; but rather it is expected to evolve as economic, regulatory, and environmental uncertainty reshapes the utility industry.

It is important to realize that the Reference Case plan is considered the current "best view" of future resource possibilities. The Reference Case plan also considers future uncertainties and through the use of scenario analysis a number of contingency plans are also developed. This approach is similar to a project management exercise where utility planners determine the foreseeable critical path decisions along the resource planning timeline. Figure 4 shows this from a conceptual basis.

Figure 4- Resource Planning Contingency Timelines



Methodology for Analyzing Potential Portfolios

The scope of this IRP is to identify a resource portfolio that meets UNS Electric's projected firm load obligations over the next twenty years. This IRP process identifies a series of resource options that can be used to meet system reliability in a cost effective and environmentally responsible manner.

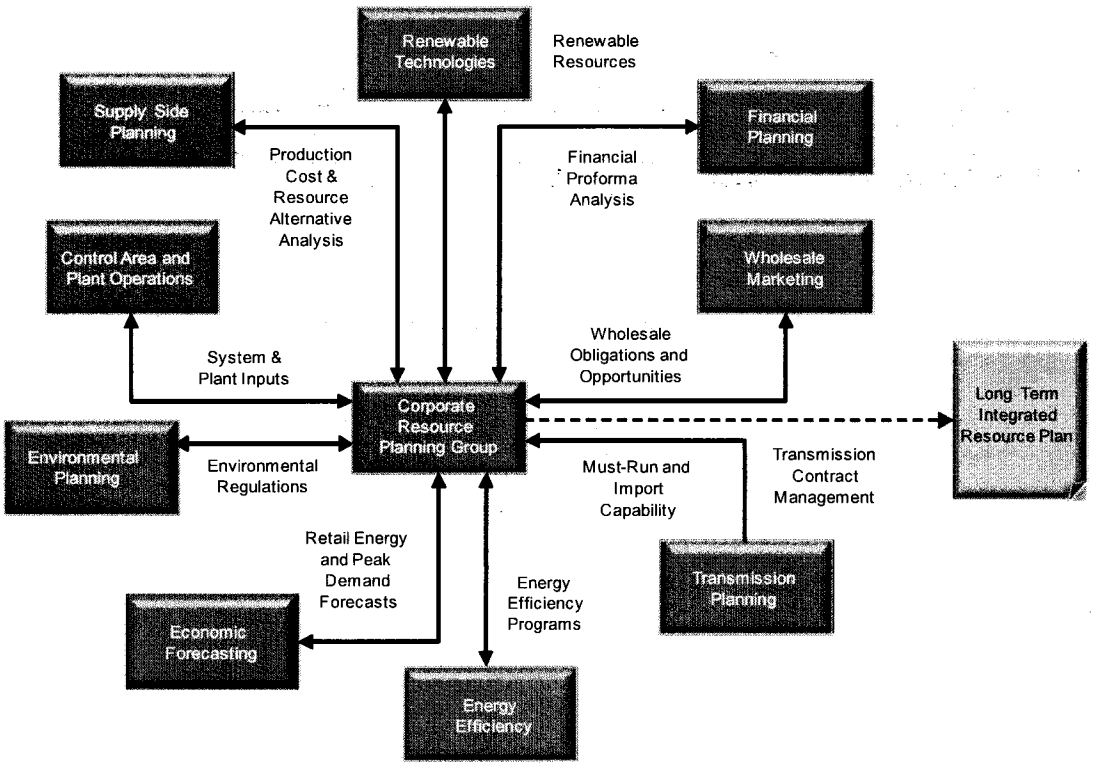
This chapter summarizes UNS Electric's IRP methodology and discusses the following topics related to this integrated planning process.

- Corporate Resource Planning Group
- IRP Process Overview
- Minimum Planning Requirements
- Public Workshops

Corporate Resource Planning Group

The Corporate Resource group is responsible for overseeing the coordination of the resource planning efforts for UNS Electric. This group, shown in Figure 5, is comprised of representatives from different planning areas that provide the assumptions required to perform this analysis. Planning groups such as Financial Planning, Supply-Side Planning, Transmission Planning, EE and Renewable Programs examine the financial and technical tradeoffs between the numerous resource alternatives. The Reference Case plan presented in this report represents the collaborative efforts of several workgroups.

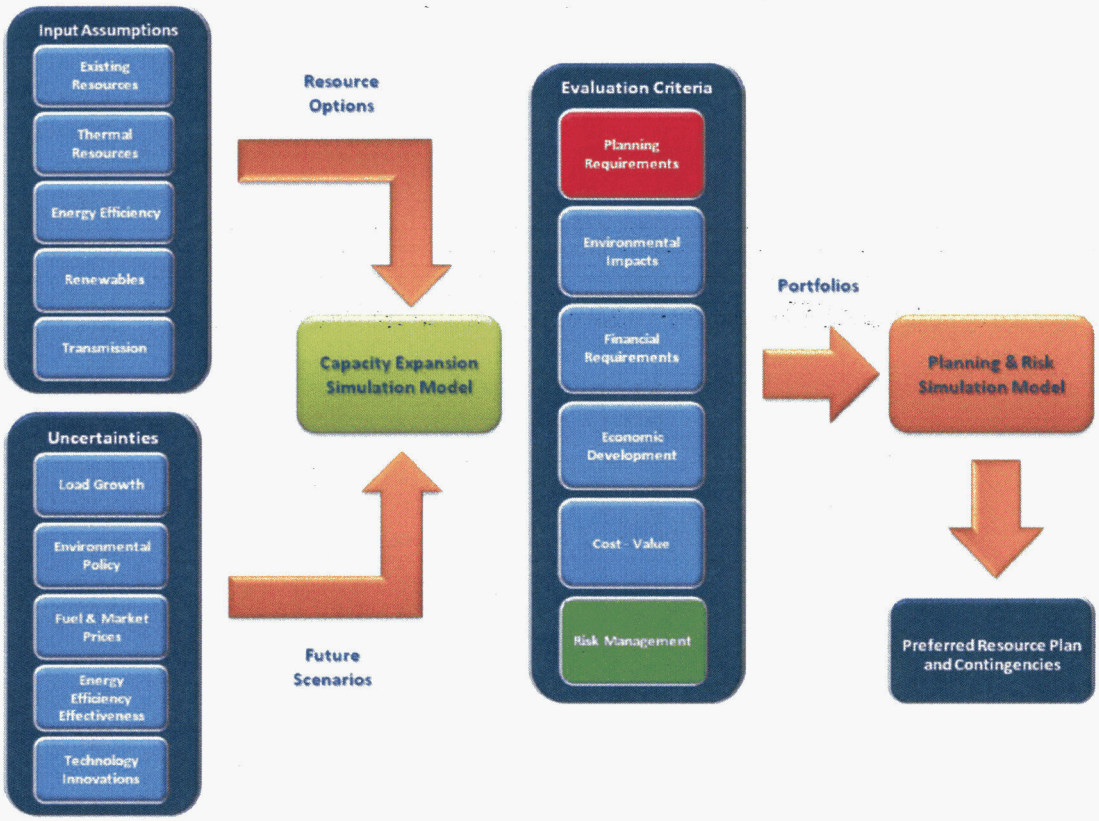
Figure 5 - Corporate Resource Planning Group



IRP Process Overview

The section provides a narrative of the data requirements, evaluation criteria and computer simulation models that were used in developing the 2012 resource plan. An overview of the resource planning process is shown in Figure 6 - IRP Process Overview.

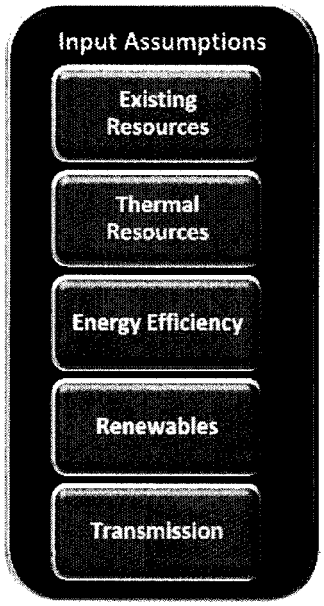
Figure 6 - IRP Process Overview



Input Assumptions

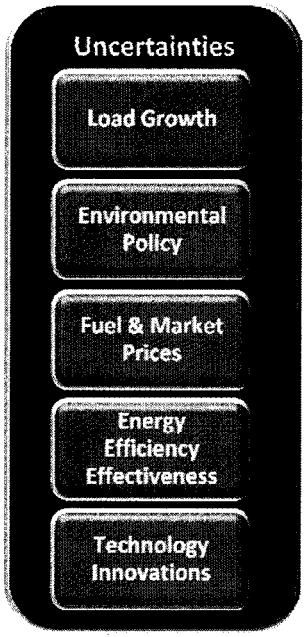
One of the first steps in developing an IRP is to define the input assumptions for the Reference Case. The details related to future generation and transmission resources are covered in detail throughout this report.

- Future Supply-Side and Demand–Side Resources are summarized in Chapter 6.
- Future transmission resources are summarized in Chapter 7.
- Chapter 8 provides an overview on UNS Electric's EE programs and modeling assumptions.
- Chapter 9 has an in-depth write-up on UNS Electric's renewable resources.
- Chapter 11 has details on UNS Electric's conventional generation modeling assumptions.



Forecast and Scenario Development

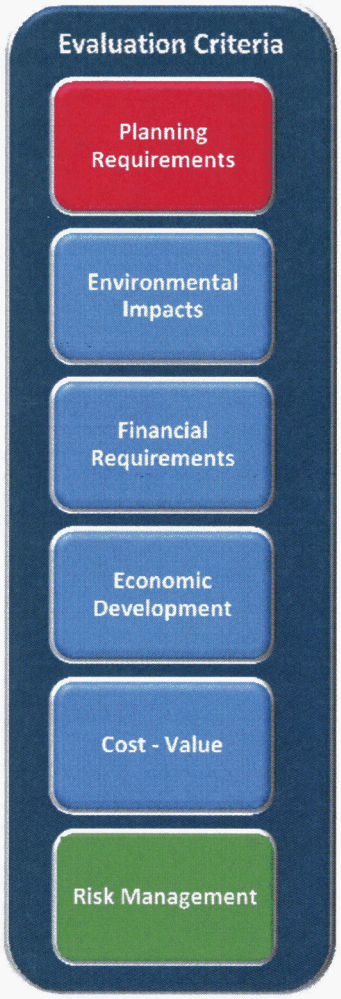
In developing its fifteen year market forecast, the resource planning team relied on PACE Global to provide a comprehensive set of correlated market, fuel, and emission price forecasts. These forward price projections for wholesale power, coal, natural gas and emission prices were based on a comprehensive set of market fundamentals for the WECC Region. As a general planning rule, UNS Electric compares its input assumptions against multiple third party sources to validate the range of potential forecast values for developing its Reference Case and sensitivities. The data related to these forecast assumptions are summarized in Chapter 12.



Minimum Resource Planning Requirements

In addition to the market input assumptions UNS Electric has some minimum resource planning criteria that are required under all resource portfolios. In all planning scenarios, UNS Electric assumed compliance with the following criteria:

- Maintain 15% Planning Reserve Margin
- Maintain Adequate Load Serving Capacity
- Meet the Arizona Energy Efficiency Standards (EE Standard)
- Meet the Arizona Renewable Energy Standards (RES)



Planning Reserve Margin

A planning reserve margin of 15% is used in the resource planning process to compensate for uncertainty surrounding future load forecast changes and resource contingencies such as a generation or transmission forced outages. The planning reserve margin is calculated as the amount of firm peak resource capacity in excess of projected retail demand as a percentage of total demand. For purposes of the reserve margin calculation in the IRP, UNS Electric defines system peak demand as the forecasted retail peak demand minus EE and DR programs. It is assumed that these demand-side resources will meet the reserve criteria of SRSG, WECC and NERC.

Maintain Adequate Load Serving Capacity

UNS Electric load serving requirement is defined around UNS Electric's ability to adequately serve its retail load obligations within the UniSource service territories. UNS Electric's load serving capability is defined as the sum of local area generation capacity plus transmission import capacity at system peak. Adequate capacity to meet UNS Electric's load serving capability is one of four mandatory planning requirements in all potential resource portfolios.

Energy Efficiency Standard Compliance

For resource planning purposes, UNS Electric has assumed that it maintains compliance with Arizona Energy Efficiency Standard (EE Standard) which targets a cumulative reduction of 22% by 2020.

Renewable Energy Standard Compliance

The Renewable Energy Standard sets forth the annual renewable energy requirements for UNS Electric. For resource planning purposes, UNS Electric has assumed that it maintains compliance with the RES targets throughout the 15 year planning horizon.

IRP Public Workshops

In developing the 2012 IRP, UNS Electric conducted a public workshop to inform and solicit feedback from a variety of stakeholders. The 2012 IRP workshop was held at the Doubletree Hotel in Tucson, Arizona on November 4, 2011. The Resource Planning group distributed an announcement through e-mail in early October, 2011 and posted the announcement on TEP's website. The Resource Planning team offered direct invitations to their industry counterparts. Invitees were encouraged to convey the invitations and workshop details to any interested party. The goal of the workshop was to provide a public forum where participants could ask questions and provide input into the resource planning process. UNS Electric's resource planning group presented a wide range of resource planning topics.

In addition to members of the general public, workshop attendees included stakeholders from various organizations:

American Solar
Arizona Corporation Commission (ACC)
Arizona Public Service Company (APS)
CalPortland
Capital Power Corporation
Conservation Services Group
Entegra Power Group LLC
Fennemore Craig Attorneys
Freeport McMoRan
H.J. Krzysik Architect
Salt River Project
Sierra Club
Sierra Southwest Energy
Southwest Energy Efficiency Project (SWEEP)
Southwest Energy Solutions
Southwestern Power
SWCA Environmental Consultants
Trico Electric Cooperative
University of Arizona
URS Corporation
Western Resource Advocates

These presentations are currently available on the TEP website in a PDF file format. The UNS Electric resource planning website address is listed below:

http:// https://www.tep.com/Projects/Planning/

CHAPTER 3

LOAD FORECAST

Introduction

In the IRP process, it is crucial to first estimate the load obligations that existing and future resources will be required to meet for both short and long term planning horizons. As a first step in the development the current resource plan, a long term load forecast was produced. This chapter will provide an overview of the anticipated long term load obligations at UNS Electric, a discussion of the methodology and data sources used in the forecasting process, and a summary of the tools used to deal with the inherent uncertainty currently surrounding a number of key forecast inputs.

The sections in this chapter include:

- **Company Overview:** UNS Electric geographical service territory, customer base, and energy consumption by rate class.
- **Reference Case Forecast:** An overview of the reference case forecast of energy and peak demand used in the planning process along with an outline of alternate forecast scenarios that were considered in the planning process.
- **Summary:** Compilation of results from this analysis

Company Overview

Geographical Location and Customer Base

UNS Electric currently provides electricity to approximately 90,000 customers in two geographically distinct areas. In northwest Arizona, UNS Electric provides service to the majority of Mohave County. This segment of the service territory includes approximately 72,000 customers located primarily in the Kingman and Lake Havasu City areas. In addition to Mohave County, UNS Electric also provides service to the majority of Santa Cruz County in southern Arizona. This southern service territory includes approximately 18,000 customers located primarily in the Nogales area.

The two regions are very different both in terms of population and geography. For instance, Mohave County is estimated to have a current population of approximately 200,000 and has experienced rapid growth over the last decade, while Santa Cruz County is estimated to have a current population of approximately 40,000, and has grown at a more modest rate in recent years. In addition to the varying population dynamics, the geography and weather of the two service areas is also distinctly different. For example, Lake Havasu City sits at an elevation of approximately 735 feet, while Nogales is located in mountainous terrain and sits at 3,823 feet. The differences in population dynamics, topography, and weather result in distinct patterns of demand, consumption, and customer growth within each region that must be taken into account during the planning process.

While the economic climate has slowed population growth dramatically in recent years, UNS Electric's service areas are still expected to experience significant growth after the recessionary environment in Arizona subsides. This anticipated growth will likely require the acquisition of additional resources in order to provide service to an increasing customer base.

Map 1 - Service Area of UniSource Electric

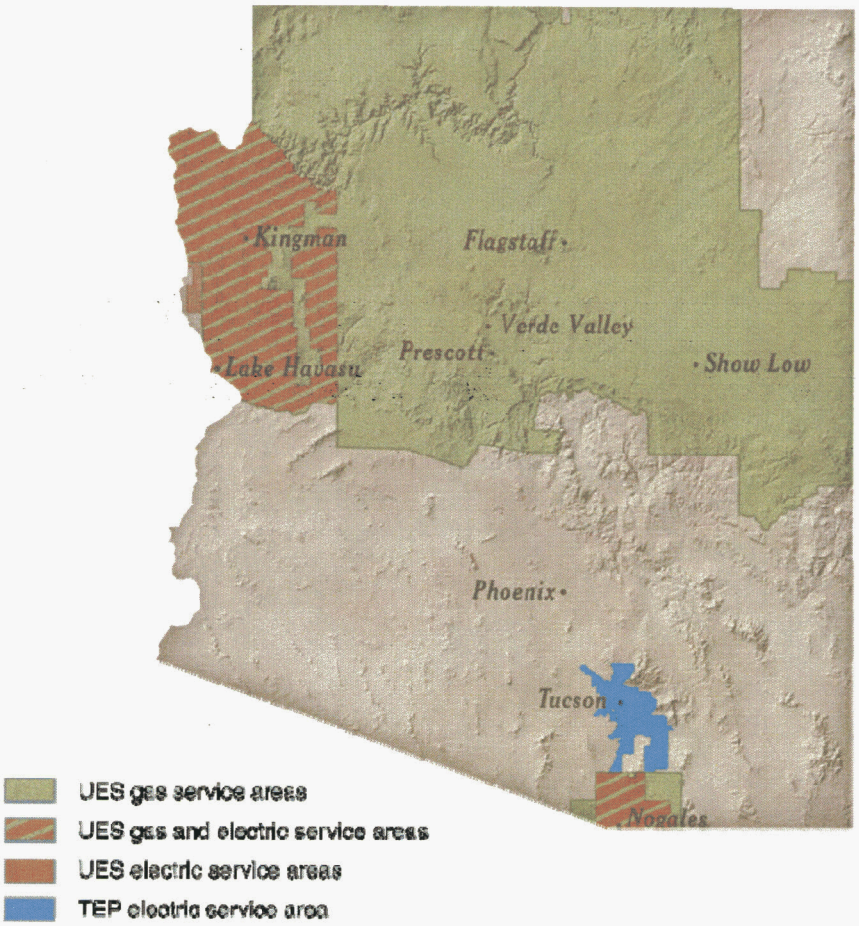
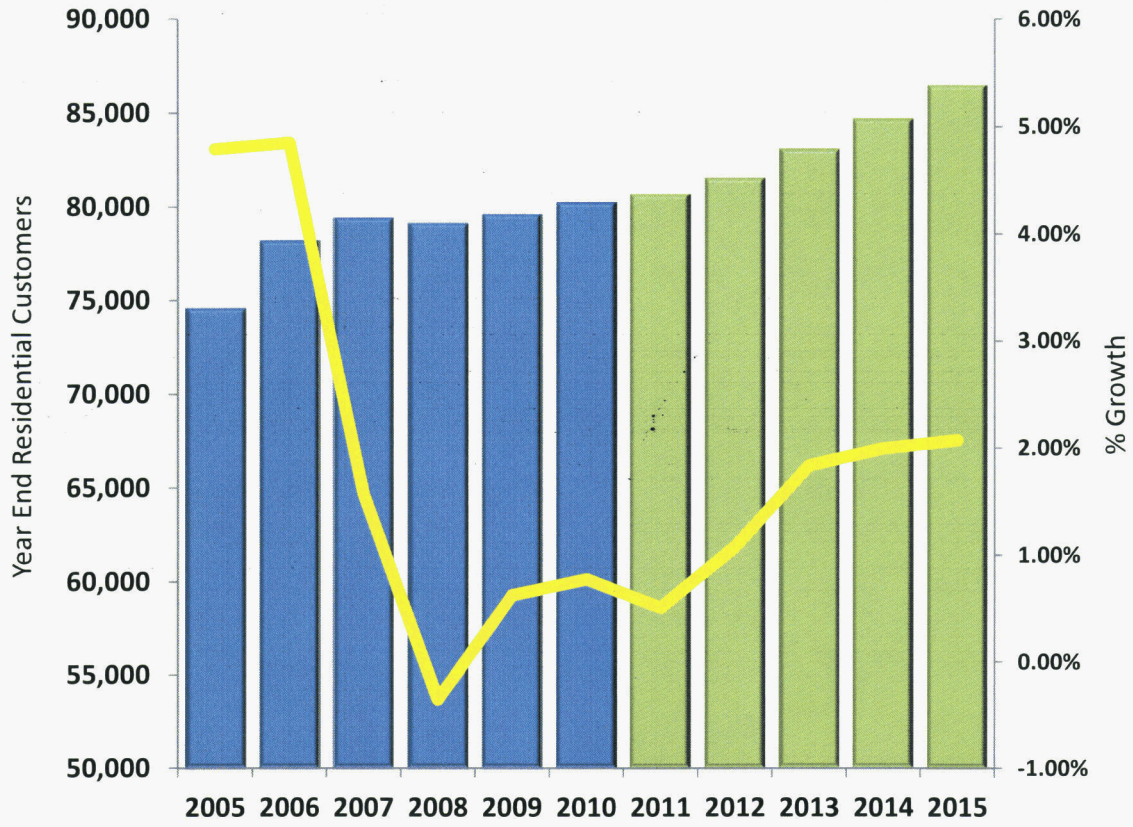


Chart 6 summarizes the historical and projected UNS Electric residential customer growth from 2005-2015.

Chart 6 - UNS Electric Customer Growth 2005-2015

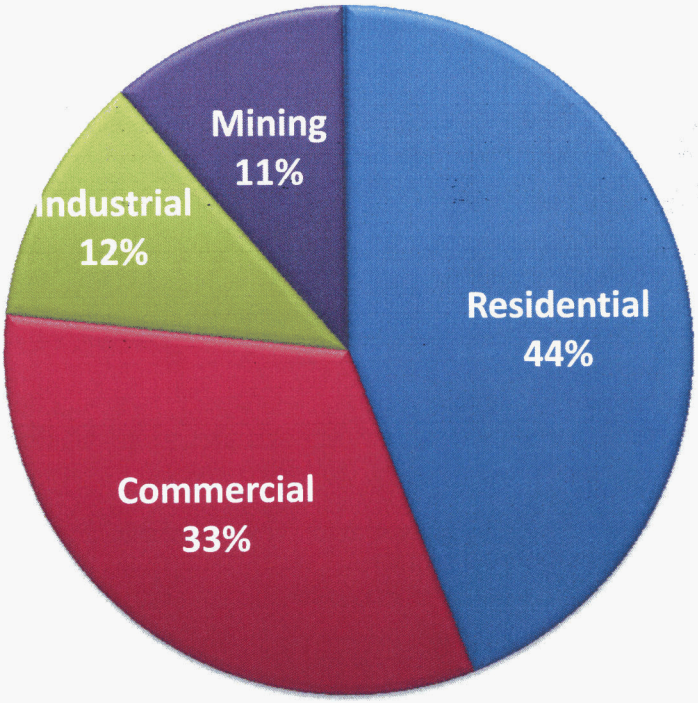


While the economic climate has slowed population growth dramatically in recent years, UNS Electric's service area is still expected to experience significant growth after the recessionary environment in Arizona subsides. This anticipated growth will likely require the acquisition of additional resources in order to provide service to a larger number of customers.

Retail Sales by Rate Class

In 2010, UNS Electric experienced peak demand of approximately 450 MW while generating approximately 1,800 GWh of retail sales. Approximately 77% of 2010 retail sales were generated by the residential and commercial rate classes, with approximately 23% generated by the industrial and mining rate classes.

Chart 7 - 2010 Retail Sales % by Rate Class



Reference Case Forecast

Methodology

The load forecast used in the UNS Electric IRP process was produced using a "bottom up" approach. A separate monthly energy forecast was prepared for each of the major rate classes (residential, commercial, industrial, and mining). Widely varying customer usage patterns and weather in Mohave and Santa Cruz counties, as well as significant differences between customers and weather in the Kingman area and the Lake Havasu City area within the Mohave service territory also require that the forecasts be further segmented into three distinct geographical areas. As the factors impacting usage in each of the rate classes and geographical areas vary significantly, the methodology used to produce the individual forecasts also varies. However, the individual methodologies fall into two broad categories:

1) For the residential and commercial classes, forecasts are produced using statistical models. Inputs may include factors such as historical usage, weather (e.g. heating and cooling degree days), demographic forecasts (e.g. population growth), and economic conditions (e.g. GSP and disposable income).

2) For the industrial and mining classes, forecasts are produced for each individual customer on a case by case basis. Inputs include historical usage patterns, information from the customers themselves (e.g. timing and scope of expanded operations), and internal company resources working closely with the mining and industrial customers.

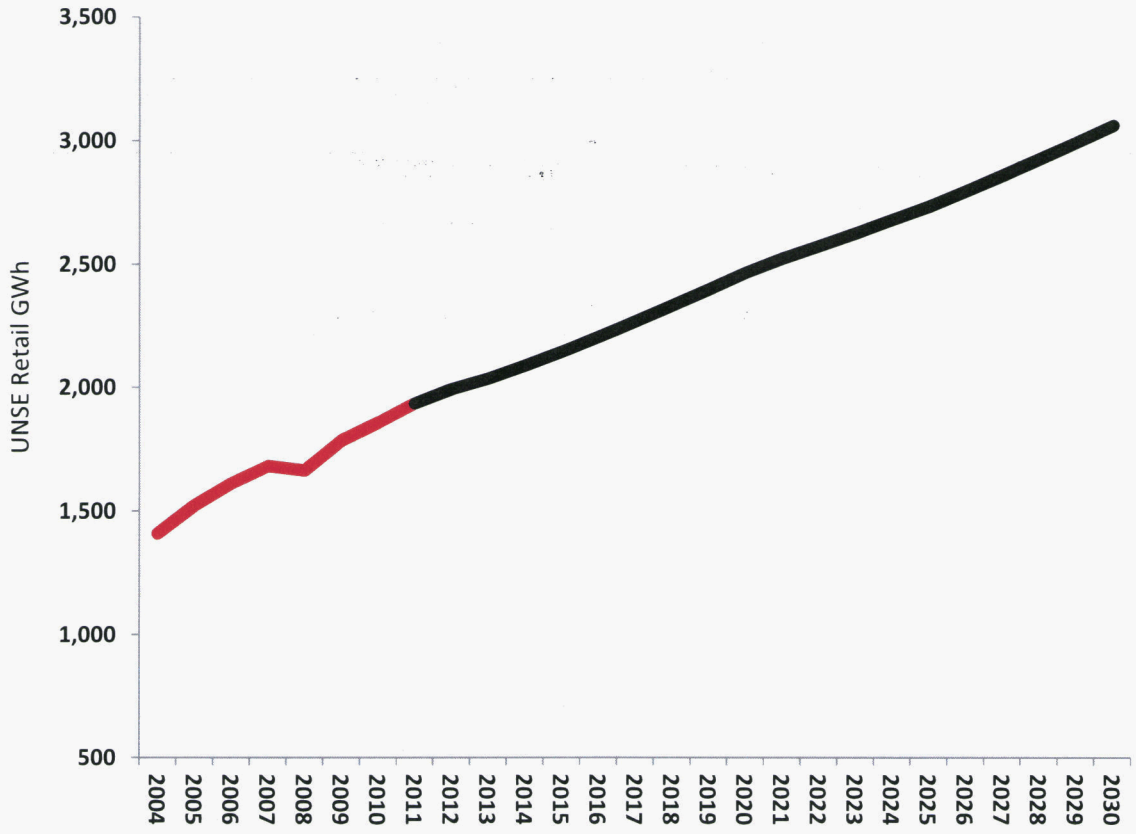
After the individual monthly forecasts are produced, they are aggregated (along with any remaining miscellaneous consumption falling outside the major categories) to produce a monthly energy forecast for the company.

After the monthly energy forecast for the company was produced, the anticipated monthly energy consumption was used as an input for another statistical model used to estimates the peak demand for each month based on the historical relationship between consumption and demand in the month in question. Annual peak demand was then calculated by simply taking the maximum monthly peak demand for each year in the forecast period.

Reference Case Retail Energy Forecast

As illustrated in Chart 8, after a period of relatively rapid growth from 2004 – 2007, UNS Electric's retail energy sales fell significantly in 2008 before rebounding in 2009 due to mining and large industrial expansion. As illustrated in Chart 8, total energy sales are expected to continue to increase at roughly the same rate for the foreseeable future. Chart 8 excludes the effects of distributed generation and EE.

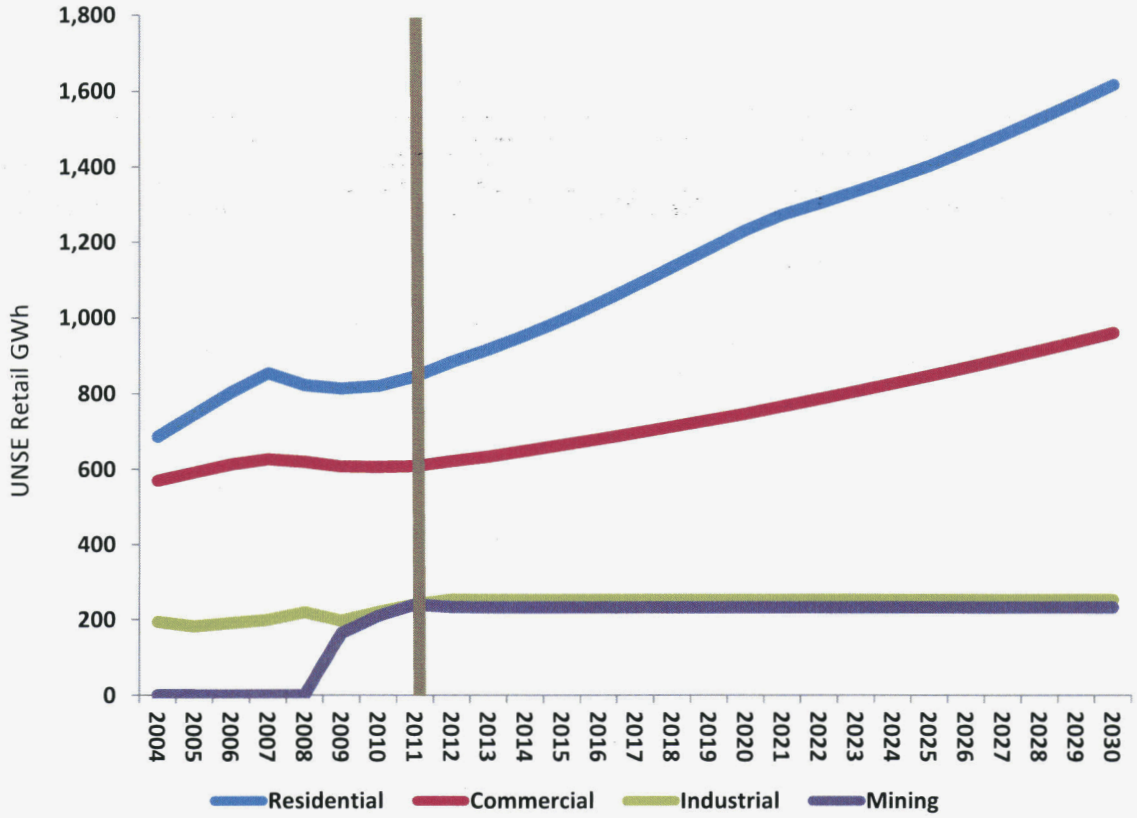
Chart 8 - Reference Case Retail Energy Sales



Reference Case Retail Energy Forecast by Rate Class

As illustrated in Chart 9, the reference case forecast assumes significant, steady energy sales growth at UNS Electric throughout the planning period. However, the growth rates vary significantly by rate class. The energy sales trends for each major rate class are detailed in Chart 9. Chart 9 excludes the effects of distributed generation and EE.

Chart 9 - Reference Case Retail Energy Sales by Rate Class



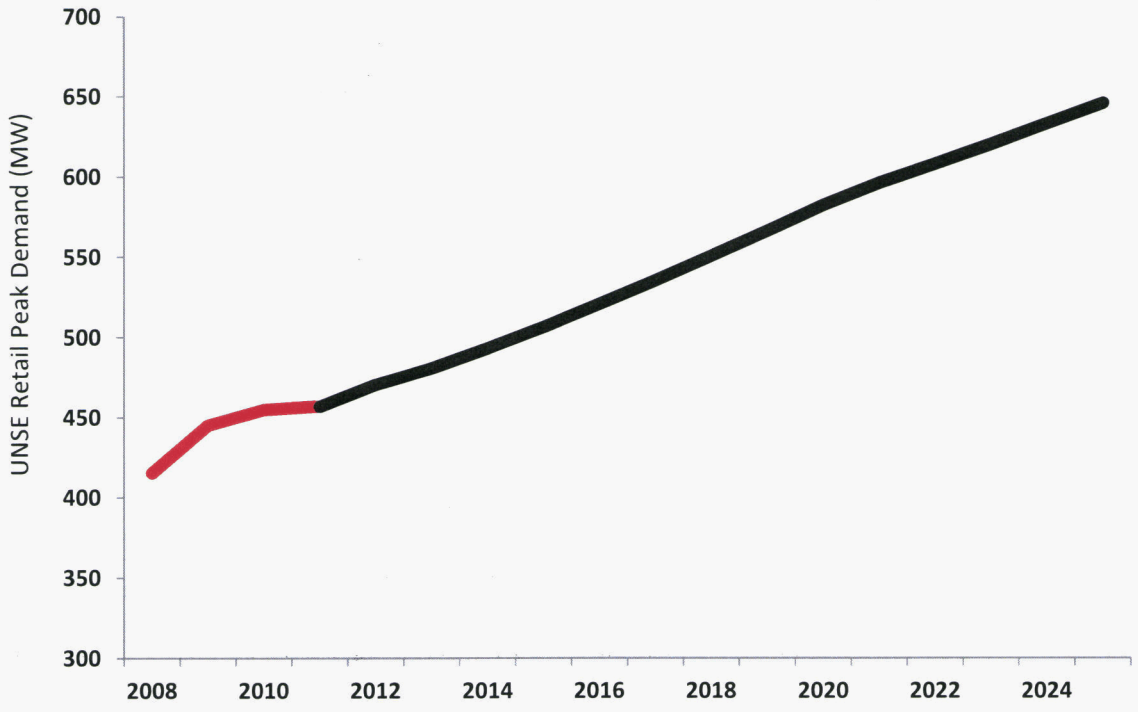
After experiencing consistent year over year growth throughout the recent past, both residential and commercial energy sales fell from 2008-2010, but are expected to resume growth in the near term and for the foreseeable future. Industrial and mining sales are assumed to remain flat for the entirety of the planning period.

Reference Case Peak Demand Forecast

As illustrated in Chart 10, UNS Electric's peak demand increased sharply (to approximately 450 MW) in 2009 with the expanded operations of a large mining customer. After remaining relatively stable from 2009-2011 UNS Electric's peak demand is expected to increase steadily for the foreseeable future.

Note that, all references to peak demand are "coincidental" peak system demand (i.e. the highest demand seen simultaneously in the Mohave and Santa Cruz service areas). Due to geography, the two service areas typically experience individual service area peaks at different times with the Santa Cruz peak typically occurring in June and the Mohave peak typically occurring in July or August. Because Mohave County generates much higher demand (and energy sales), the UNS Electric coincidental system peak also typically occurs in July or August.

Chart 10 - Reference Case Peak Demand



Data Sources Used in Forecasting Process

As outlined above, the reference case forecast requires a broad range of inputs (demographic, economic, weather, etc.) For internal forecasting processes, UNS Electric utilizes a number of sources for these data:

- IHS Global Insight
- The University of Arizona Forecasting Project
- Arizona Department of Commerce
- U.S. Census Bureau
- NOAA
- Weather Underground

Risks to Reference Case Forecast and Alternate Load Growth Scenarios

The production of the reference case load forecast for this year's IRP was completed in an environment of perhaps unprecedented uncertainty. There are numerous factors that may require significant changes to the underlying load growth assumptions in future iterations of the forecast.

While an exhaustive list would be impossible to produce, some of the key risks to the current forecast include:

- Strength and timing of the economic recovery
- Possible structural changes to customer behavior (i.e. do post recession customers have consumption patterns different from those seen pre-recession?)
- Volatility in industrial metal prices and associated shifts in mining consumption
- Efficacy of EE programs (i.e. what percentage of load growth can be offset by DSM)
- Technological innovations (e.g. plug in hybrid vehicle penetration)
- Volatility in demographic assumptions (e.g. much higher or lower population growth than currently assumed)

CHAPTER 4

EXISTING RESOURCE CAPACITY

UNS Electric's Existing Resource Portfolio

This section provides an overview of UNS Electric existing resource portfolio and provides the baseline for USNE's IRP planning process.

- Existing Conventional Resources
- Renewable Resources
- Market Resources

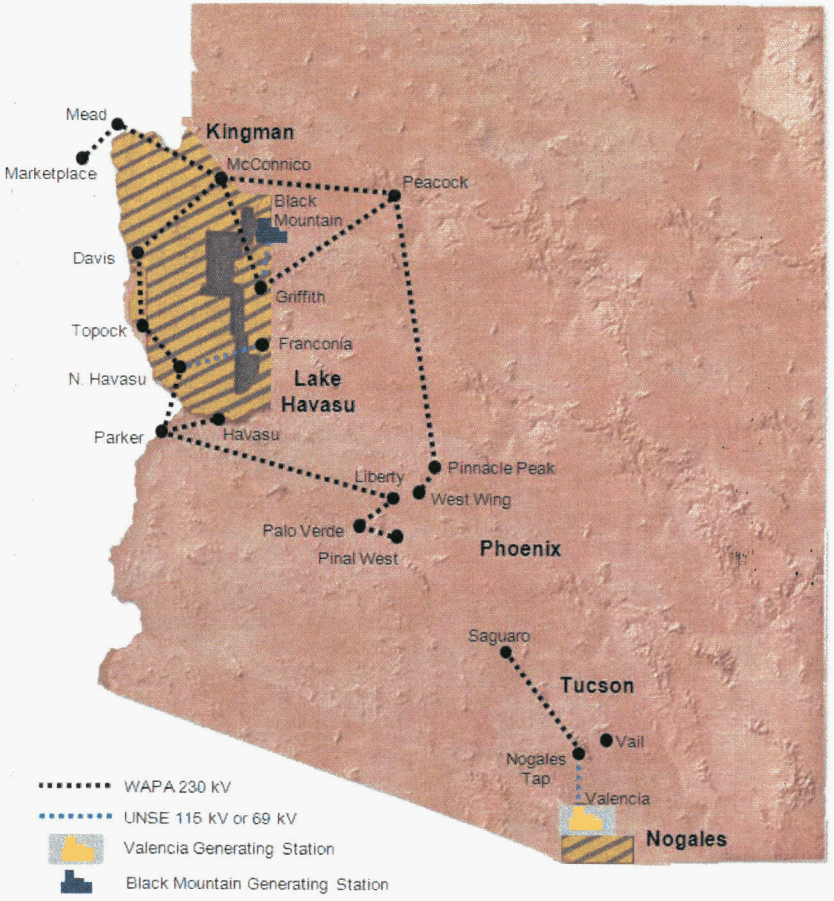
UNS Electric's existing resource capacity that is currently owned or operated through a purchase power agreement is 153 MW. In addition, the Company also relies on the wholesale market for the balance of its resource needs. Table 5 provides a summary of UNS Electric's existing resources.

Table 5 - UNS Electric Existing Resource Portfolio

Generating Station	Unit	Fuel Type	Technology	Commercial Year	Operating Agent	UNS Electric's Share %	Planning Capacity
Black Mountain	1	Gas	Turbine	2008	UNS Electric	100	45
Black Mountain	2	Gas	Turbine	2008	UNS Electric	100	45
Valencia	1	Gas	Turbine	1989	UNS Electric	100	14
Valencia	2	Gas	Turbine	1989	UNS Electric	100	14
Valencia	3	Gas	Turbine	1989	UNS Electric	100	14
Valencia	4	Gas	Turbine	2008	UNS Electric	100	21
Total Resource Capacity							**153**

Existing Resource Overview

Map 2 - UNS Electric Generation and Transmission Resources



Black Mountain Generating Station

Station Overview

The Black Mountain Generating Station (BMGS) is located in Kingman, Arizona and provides UNS Electric with 90 MW of CT capacity.

Primary Fuel Supply

The Company purchases natural gas for Black Mountain on the spot market.

Black Mountain Generating Station

Black Mountain Emission Controls

Black Mountain Generating Station is a natural gas-fired CT with dry LNB and SCR for NOx control. As a greenfield site, a Prevention of Significant Deterioration (PSD) permit was obtained prior to construction. A PSD permit requires that BACT be applied for control of SO2 and NOx, and the facility must comply with the Acid Rain program limits for SO2 and NOx.

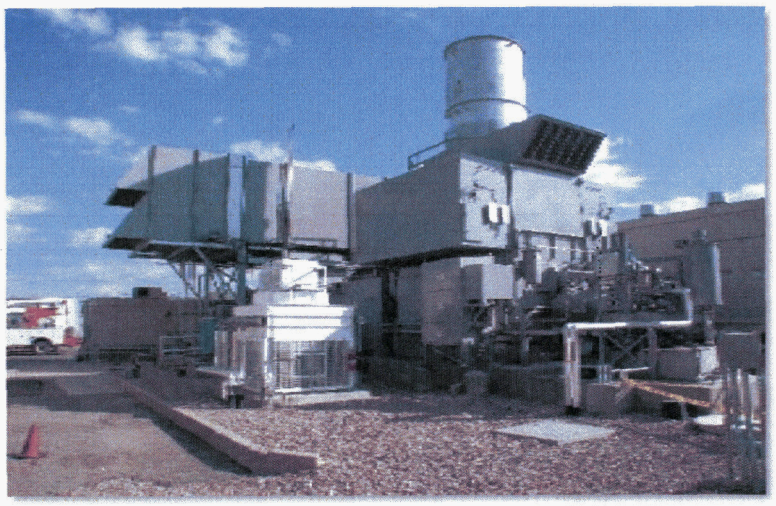
Black Mountain (2010)	SO2	NOx	CO2	PM	Hg	Water (Acre Feet)
Air Emissions, Pounds	1,600	65,800	93,874,000	5,856	0.201	40
Air Emissions, lbs/MWh	0.018	0.753	1,074.062	0.067	2.30E-06	150

Valencia Generating Station

Station Overview

The Valencia Generating Station (VGS) is located in Nogales, Arizona and provides UNS Electric with 63 MW of CT capacity.

Valencia Generating Station



Primary Fuel Supply

The Company purchases natural gas for Valencia on the spot market.

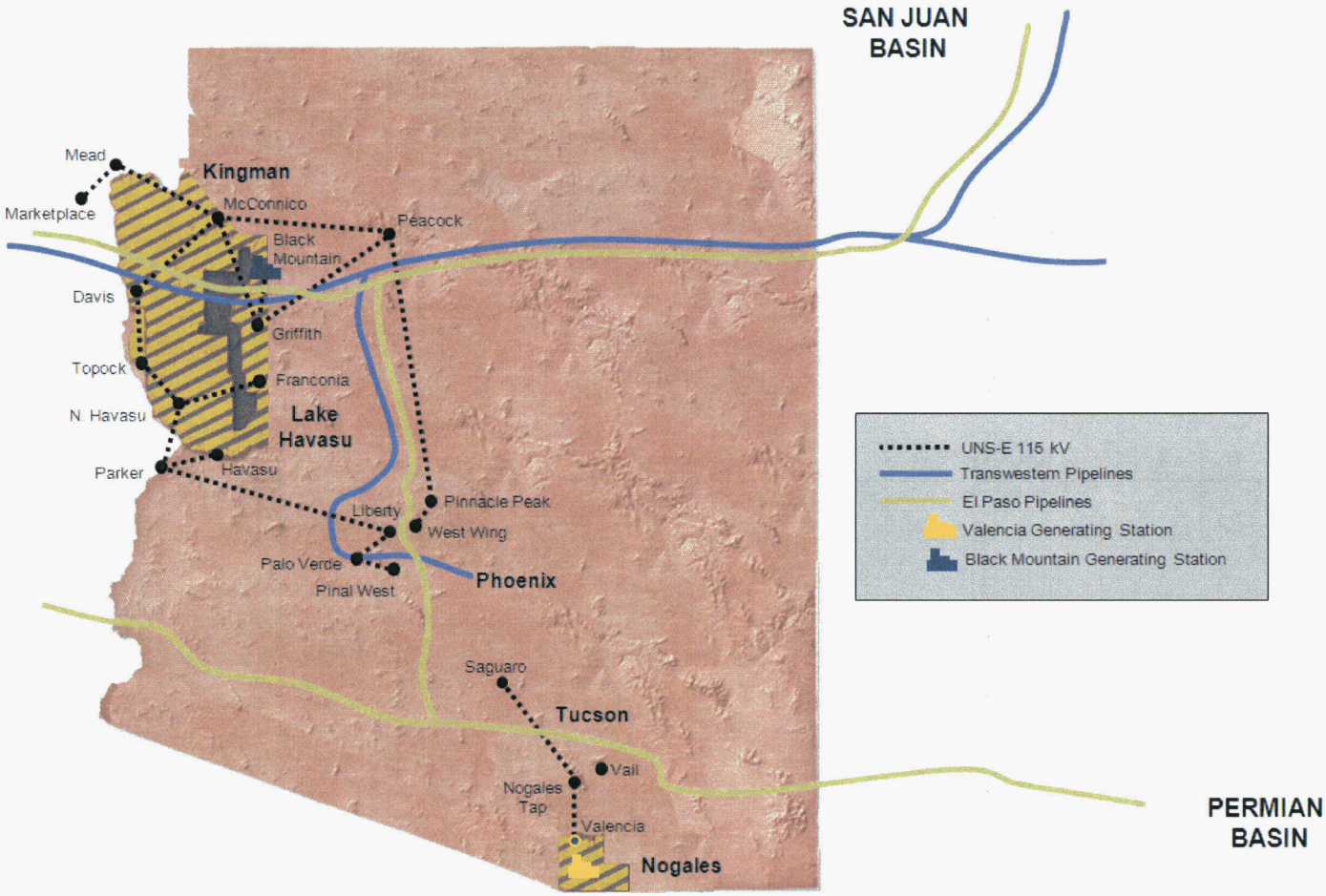
Environmental Controls

Valencia Power Plant (VPP) CT Units 1-4 burn natural gas and diesel fuel, and each unit is equipped with water spray injection for control of NOx. Plant wide voluntary emission limits of 250 tons per year for SO2 and NOx were incorporated into the Title V permit in order to maintain below "major source" thresholds. Each of the units is required to meet NSPS for NOx and SO2. However, each of these units is less than 25MW capacity; therefore, they are not subject to Acid Rain provisions.

Valencia (2010)	SO2	NOx	CO2	PM	Hg	Water (Acre Feet)
Air Emissions, Pounds	33	1,928	1,667,800	2,324	0.079	11
Air Emissions, lbs/MWh	0.001	0.084	72.976	0.102	3.47E-06	150

UNS Electric Generation and Primary Natural Gas Sources

Map 3 - Map of UNS Electric Generation and Primary Natural Gas Sources



CHAPTER 5

Load and Resource Adequacy

A significant consideration in the development of a long-range plan is the extent to which current and proposed resources meet the load requirements. UniSource Energy strives to maximize the value of service to our customers while maintaining a safe, reliable, and efficient balance of resources. In order to derive an adequate and integrated balance of resources, an accounting of loads and resources must be maintained. This assessment of the existing resources and market purchases, in part, predetermine the need or resource adequacy for the future. In this chapter, we will present an assessment of generation resources, culminating with a preview of the generation required in order to maintain a flexible, conscientious and adequate balance of resources.

Load and Resource Assessment

The mix of existing resources for UniSource Electric Services (UNSE) at Mohave and Santa Cruz counties consists solely of gas-fired CTs. The UNS Electric CTs, which are detailed in Chapter 3, account for approximately 50 percent of the peak production, while the energy was supplied primarily from market resources.

A critical component to the IRP is the assessment of resources and the corresponding load obligations. UNS Electric's peak demand occurs during the summer months of June and July. Table 6 presents a tabular assessment of UNS Electric's resources and loads for the single-hour peak demand for the years represented.

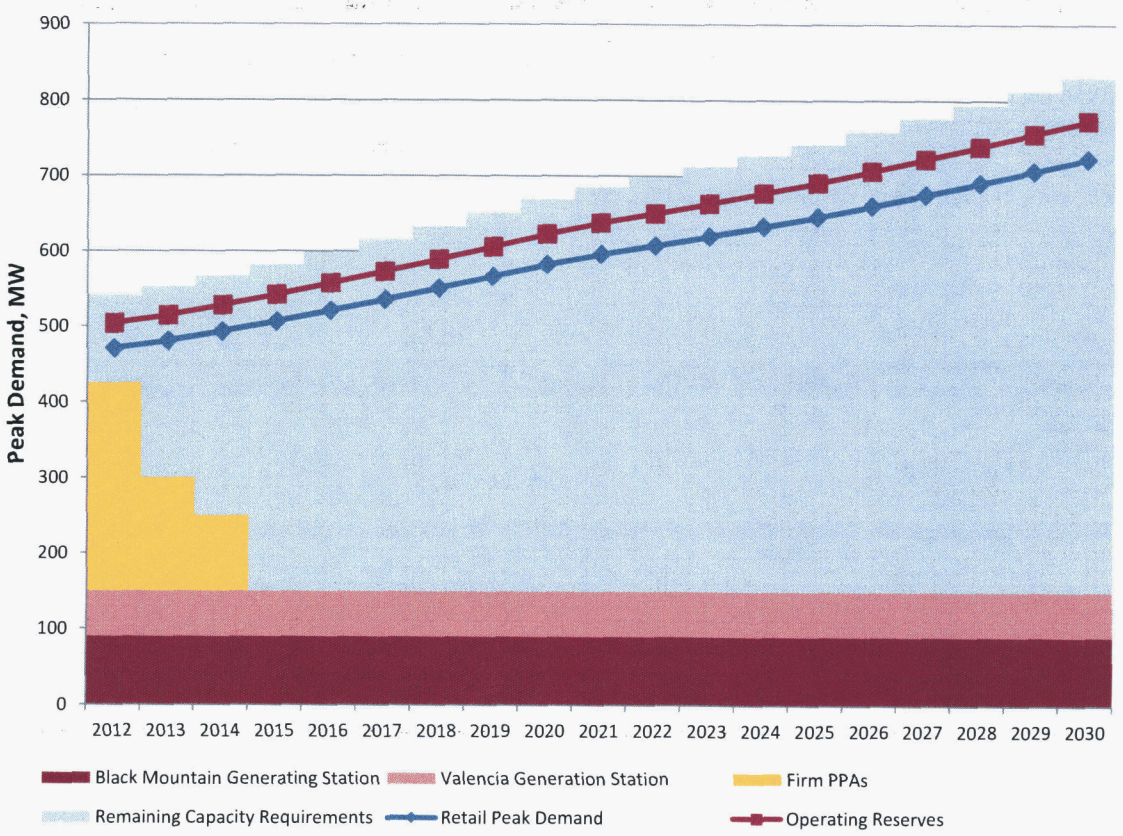
Table 6 - UNS Electric Existing Load and Resources (Excluding Future Resources)

Firm Load Obligations (MW)	2012	2013	2014	2015	2020	2025	2030
Retail Peak Demand	471	481	493	506	582	646	723
Reserve Requirements	71	72	74	76	87	97	108
Retail, Firm & Reserves	541	553	567	582	670	743	831
Total Thermal Resources	150	150	150	150	150	150	150
Total Firm PPAs	275	150	100				
Total Firm Resource Capacity	175	175	150	150	150	150	150
Net Capacity Obligations	-59	78	167	282	370	443	531

The table above presents only retail and wholesale firm peak demands with a 15% reserve margin. The effect of EE programs are explored and detailed on subsequent chapters. Similarly for the supply-side resources; proposed thermal and/or renewable resources will be addressed in other chapters. The intent of this table is to gauge the 'Net Capacity Obligations' for the future. This table reveals a distinct need for resources for this planning horizon and subsequent chapters will discuss the process and results derived for meeting UNS Electric's capacity obligations.

A visual depiction of - UNS Electric Existing Loads and Resources is presented below, in Chart 11. The top-most area in orange represents the Net Capacity Obligation for the planning period. Included in this figure is an 'Operating Reserve' target which represents about 7.5% of retail and firm demand. In the near term, planning reserves transition into operating reserves. Planning reserves account for the potential of generating unit outages, regulating reserves, extreme weather fluctuations, and for unforeseen load growth in the long term, while operating reserves are derived with a more certain and near-term set of planning assumptions.

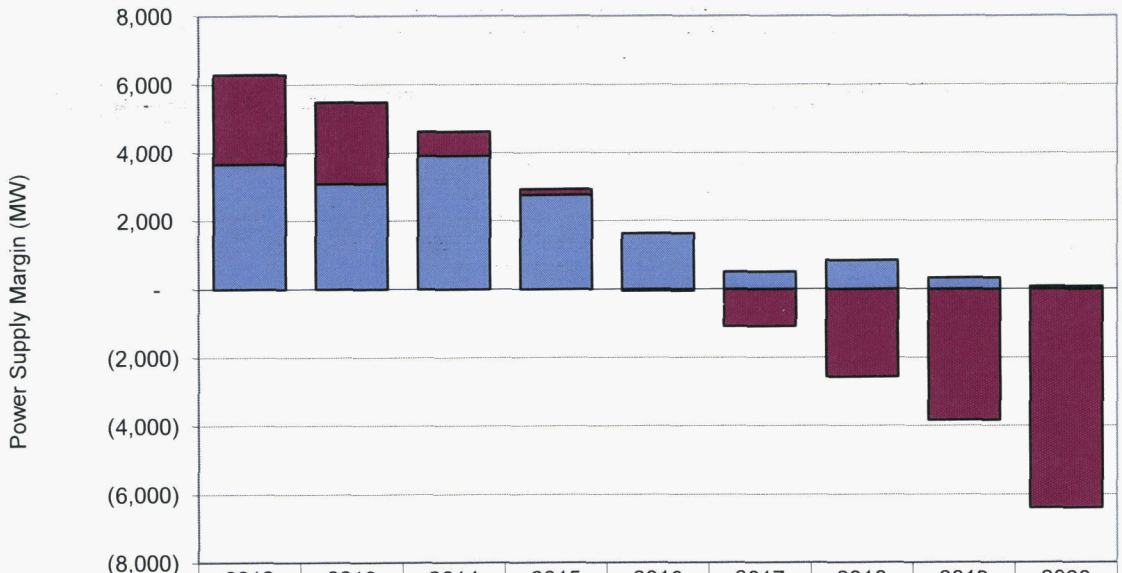
Chart 11 - UNS Electric Existing Loads and Resources
Total Firm Load Obligations versus Firm Capacity Resources



WECC Desert Southwest – Resource Adequacy

Based on a 2011 Power Supply Assessments (PSA) administered by the WECC, the Southwest Region will have adequate operating reserve capacity for the next several years. In New Mexico, Arizona and Southern Nevada, this is designated as 'Desert Southwest' by WECC, the capacity surplus in 2012 is approximately 6,300 MWs. Based on 2012 forecast assumptions, this market surplus should be available through 2019. UNS Electric also has direct accessibility to the Southern California markets; this capacity nears zero in to 2016 while it is 2,620 MW in 2012.

Chart 12 - WECC 2010 Power Supply Margin



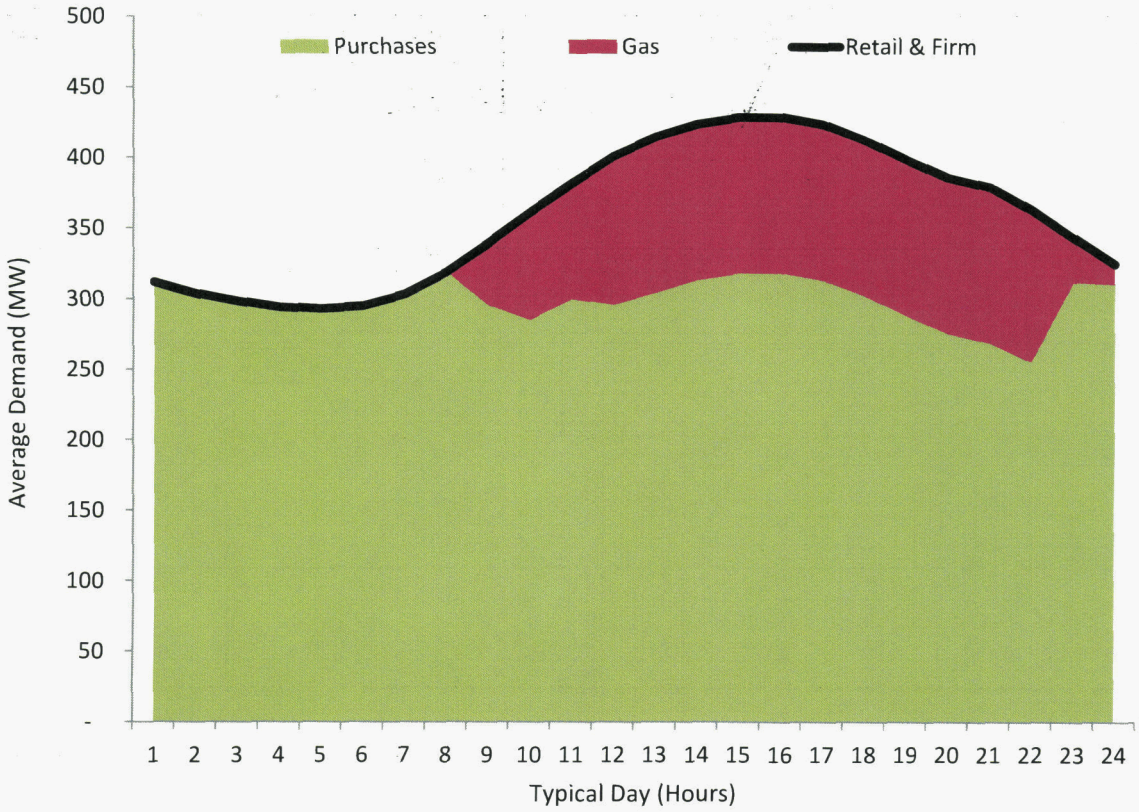
	2012	2013	2014	2015	2016	2017	2018	2019	2020
Southern California	2,620	2,397	709	165	(48)	(1,087)	(2,573)	(3,833)	(6,395)
Desert Southwest	3,670	3,090	3,918	2,764	1,638	498	841	326	73
Total	6,290	5,487	4,627	2,929	1,590	(589)	(1,732)	(3,507)	(6,322)

(WECC, Western Electric Coordinating Council, 2010)

Typical Dispatch Profiles

Chart 13 - 2015 Typical Summer Day Dispatch and Chart 14 - 2015 Typical Winter Day Dispatch illustrates the manner in which existing resources are expected to be dispatched to meet anticipated load requirements in 2015. The figures do not represent a peak day; instead the demand profiles demonstrated in these figures are an average typical day representative of each season for 2015. Chart 13 and Chart 14 are derived from a production costing model that dispatches resources economically to serve firm load and wholesale obligations. The area shown above the 'Retail & Firm' line represents opportunity sales made to the spot market.

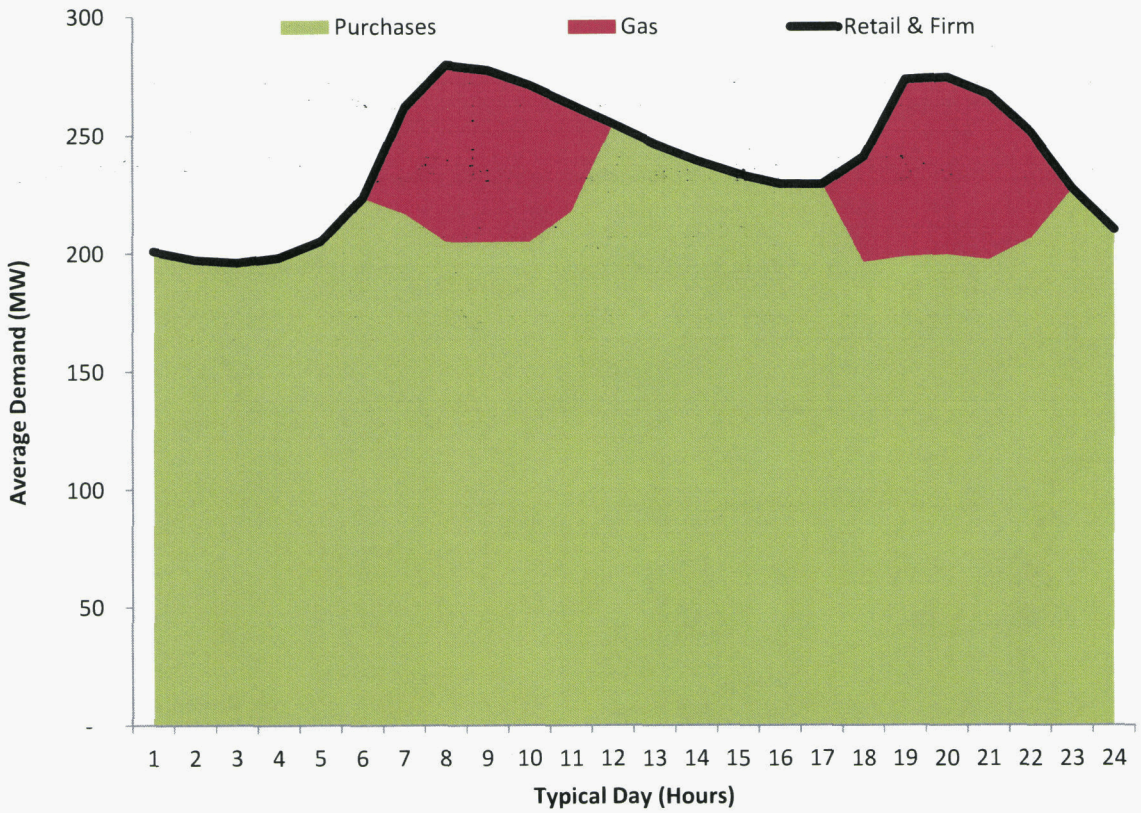
Chart 13 - 2015 Typical Summer Day Dispatch



In Chart 13 above, we observe that the high peak demand experienced in the summer can be met with substantial market purchases and the utilization of existing peaking resources (gas turbines). If indeed there is capacity available for purchase, the gas and energy market price forecasts dictate that a part of UNS Electric's gas resources would be displaced. The portion of the gas resources that are not dispatched serve as stand-by (reserve) capacity, thus serving a vital purpose in maintaining system reliability. As demonstrated in Chart 13, UNS Electric experiences its peak demand at 4 to 5 PM in either July or August.

The UNS Electric winter load profile, as seen in Chart 14 below, differs significantly from the summer profile. The peak demand experienced on weekdays in the winter is dramatically lower than those seen in the summer. In the winter months, the load peaks in the early morning hours and then again in the late evening. The dispatch strategy in the winter differs significantly from the strategy in the summer. With some exceptions, such as planned maintenance on base load generation, gas-peaking resources are not extensively dispatched. There is typically a surplus of coal and other base load resources available in the region. Given this surplus of base load resources, market purchases are often available below the cost of most gas-fired generation.

Chart 14 - 2015 Typical Winter Day Dispatch

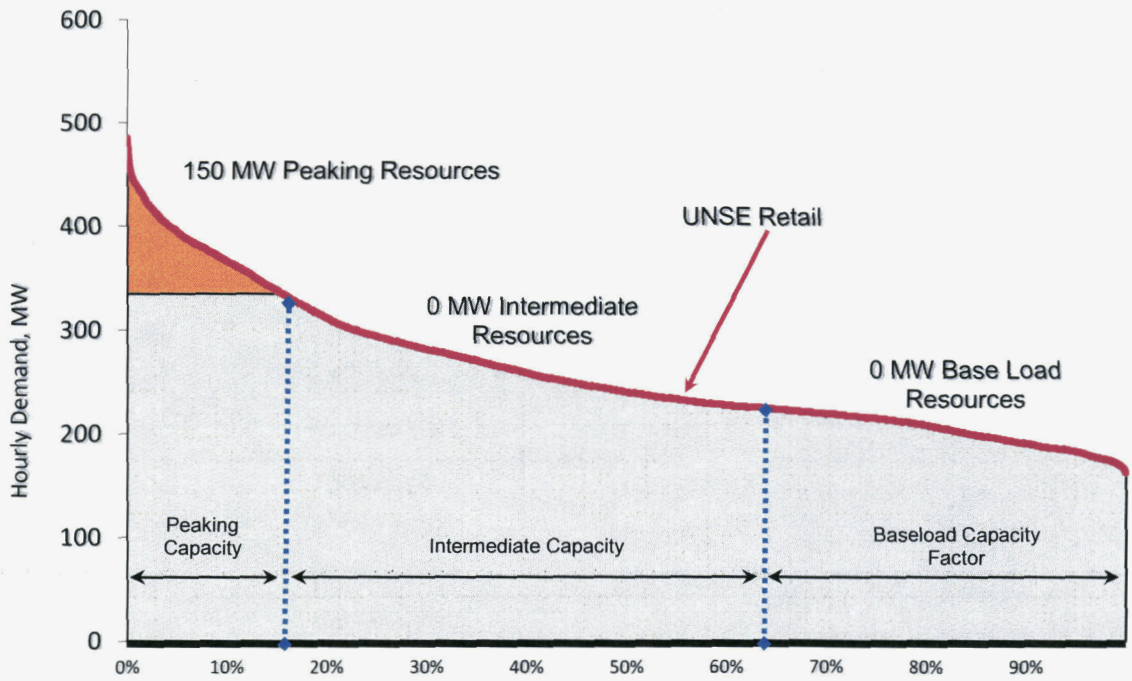


Projected Capacity Requirements

The seasonal load diversity in UNSE's service territory presents different challenges and opportunities. UNS Electric is strictly active as a buyer in the wholesale market during the winter and summer seasons. In the summer, the focus is shifted toward meeting the retail and firm peak demand. Gas turbines are more routinely dispatched to meet firm peak demand. In order to attain an adequate balance of resources, it is crucial to understand the dynamics and characteristics of the customer load. The operating and economic characteristics of the typical generation fleet distinguish the resources into 3 categories; base load, intermediate and peaking resources.

The 'base load' requirement can be defined as a minimum level of demand on an electrical system over a specified time interval. Base load generation is dependable, consistent and low cost and is dispatched to serve above the minimum requirement. This specific type of generation is most efficient and reliable when continuously run at high capacity levels. Base load generation can be expected to operate at high capacity factors that exceed 65% of the base load requirement (See Chart 15 - 2015 UNS Electric Load Duration with Existing Resource Mix below). UNSE has no base load units and currently relies on the market for base load capacity. In 2015, the base load minimum requirement is approximately 200 MWs.

Chart 15 - 2015 UNS Electric Load Duration with Existing Resource Mix



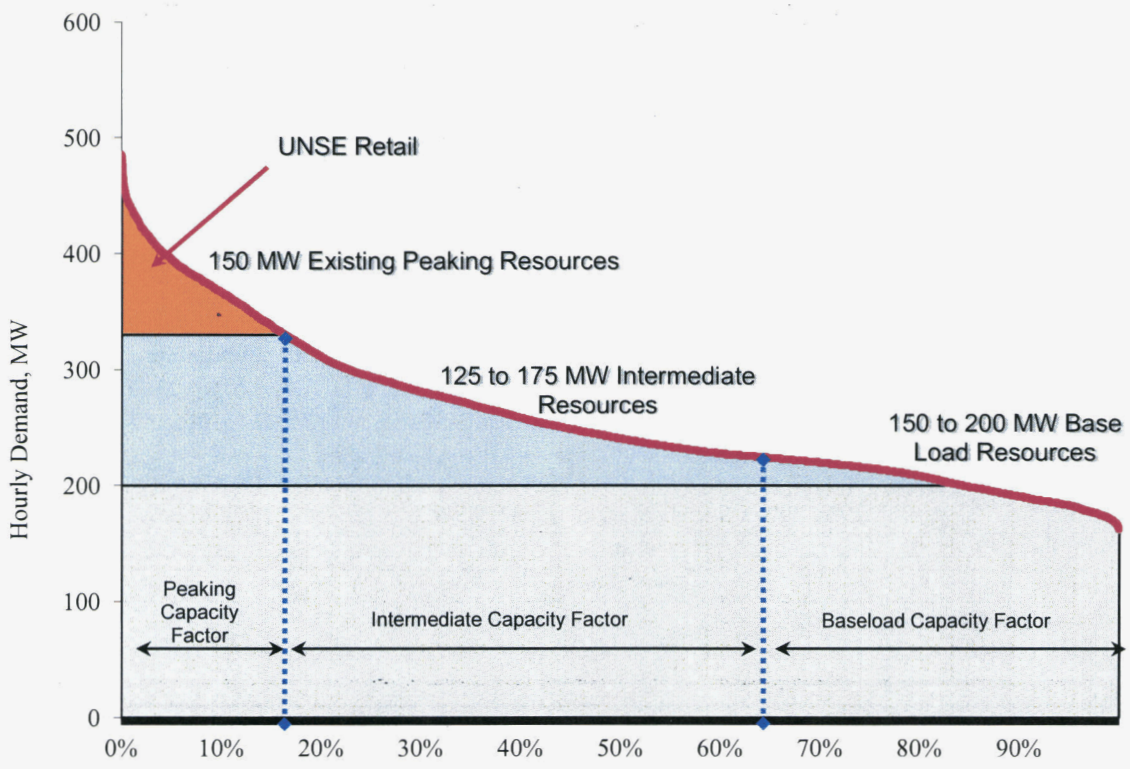
Demand fluctuations above the base load capacity described above are met by intermediate and peaking type resources. These resources are typically more responsive and quicker to ramp and start than base load resources. The dispatch order within the intermediate resource fleet is driven primarily by the fuel source

costs and the unit efficiency. These plants tend to operate between 20 and 60 percent of the time. UNS Electric seeks intermediate type capacity from the market.

Peaking resources are also called upon to serve during the summer peaking hours. 'Peakers' are typically CTs that have a fast start time and are very responsive to peak load fluctuations. This type of resource is typically called upon to operate 15% of the time. UNSE has approximately 150 MW of CTs to utilize during the summer peak season.

Chart 15 above demonstrates the mix of resources (base load, intermediate and peaking) evaluated with a load duration curve for 2015. The load duration curve (8760 hours) is derived from a chronological forecast that has been resorted from highest MW value to the lowest to form the curve. This screening tool reveals that in order to achieve an adequate balance of resources, UNS Electric must address the need for base load and/or intermediate resources prior to 2015. Chart 16 below demonstrates what the desired or suitable mix of resources may consist of for UNSE for base load, intermediate and peaking capacity.

Chart 16 - 2015 UNS Electric Load Duration with Suitable Resource Mix



From Chart 16 we observe that there are approximately 150 MWs of peaking capacity required for 2015. The total peaking capacity present for UNS Electric is at an acceptable level. For UNS Electric, the focus will be on obtaining intermediate and base load resources. In total, this deficiency is approximately 325 MWs without considering a margin for planning. (With a 15% planning reserve, the capacity shortage is approximately 400 MWs.)

Prior to executing the Capacity Expansion model, we've obtained a good sense for the likely results by assessing and evaluating the characteristics of UNS Electric's loads and resources. UNS Electric has an adequate amount of peaking resources. Based on this assessment of loads and resources, we determine that it is reasonable to expect to seek base load and intermediate resources foreseeable future. The addition of combined cycle, market purchases and solar resources (or a combination there of) seem to best complement the existing load and resource portfolio.

MARKET RESOURCES

TEP's Wholesale Marketing Department is charged with procuring firm capacity to meet UNS Electric's peak load and reserve requirements. These firm capacity purchases consist of a diversified mix of purchased power agreements, firm short-term purchases and spot-market purchases. UNS Electric currently utilizes its 3-year hedging policy requirements to systematically lock in future capacity needs. On an on-going basis, UNS Electric is actively engaged in acquiring competitive market-based generation and transmission resources to meet its future load requirements. To date, UNS Electric has secured 250 MW of capacity for 2012. Beyond 2012, 100 MW has been contracted for the years 2012 and 2013 respectively.

Wholesale Market

The Western Electricity Coordinating Council (WECC) evaluates the Power Supply Margins of sub-regions in the Western Interconnection. The annual Power Supply Assessment (PSA) identifies the potential for supply shortages within the sub-regions of the WECC. The report is based on collaborative and comprehensive feedback from the WECC member utilities. The data reported includes but is not limited to demand and resource data, and transmission constraints within and between the sub-regions.

As shown, in Chart 12 - WECC 2010 Power Supply Margin on page 53 of this report, the WECC Power Supply Assessment for the California and Desert Southwest sub-regions demonstrates a positive yet diminishing Power Supply Margin through the year 2019. For the near term, this IRP assumes that capacity availability through 2019 will trend as represented in the PSA.

CHAPTER 6

FUTURE RESOURCE OPTIONS

In considering future resources, the resource planning team evaluated a mix of renewable and conventional generation technologies. This mix of technologies included both commercially available resources and promising new technologies that are likely to become technically viable in the near future. The IRP process takes a high-level approach and focuses on evaluating resource technologies rather than specific projects. This approach allows the resource planning team to develop a wide-range of scenarios and contingencies that result in a resource acquisition strategy that contemplates future uncertainties.

Assumptions on cost and operating characteristics were gathered from several data sources, including:

- PACE Global
- Ventyx,
- U.S. Department of Energy (DOE)
- Black & Veatch
- National Renewable Energy Laboratory (NREL)
- Summit Blue
- ICF International
- National Energy Technology Laboratory (NETL)

In addition, information gathered through our competitive bidding process or request for proposal process (RFP) was used to put both self-build resources and market-based purchase power agreements on a comparative basis. All resources include the costs associated with a transmission interconnection. Additional transmission costs are assumed for any resources sited in remote areas and the costs are based on the required transmission voltage level and the distance to load center.

This section provides a brief overview of the types of generating resources that were included and evaluated in the resource planning process for the 2012 IRP. For each technology type a brief summary of potential risks and benefits are listed. In addition, attributes such as costs, siting requirements, dispatchability, transmission requirements and environmental potential are summarized. The table shown below summarizes the technology types.

Generation Resources – Matrix of Applications

Each type of generating resource has a unique combination of advantages and disadvantages, including costs, benefits, opportunities and risks. The matrix below shows some of the issues that must be taken into consideration when comparing resources. Issues such as location, dispatch characteristics and carbon output must be factored into the cost of each resource.

Table 7 - Resource Matrix

		Zero or Low Carbon Potential	State of Technology	Local Area Option	Intermittent	Peaking	Load Following	Base Load
Energy Efficiency	Energy Efficiency	Yes	Mature	Yes				
Demand Response	Direct Load Control	Yes	Mature	Yes		✓		
Renewables	Wind	Yes	Mature		✓			
	Solar PV	Yes	Newly Commercial	Yes	✓	✓		
	Solar Thermal	Yes	Emerging		✓	✓	Storage (2)	
	Biomass Direct	Neutral	Mature				✓	✓
Conventional	Compressed Air Energy Storage	Low	Emerging			✓	✓	
	CTs		Mature	Yes		✓	✓	
	Combined Cycle		Mature	Yes		✓	✓	✓
	IGCC	CCS (1)	Emerging				✓	✓
	Coal (PC)	CCS (1)	Mature				✓	✓
	Nuclear (NUC)	Yes	Mature					✓

(1) Technology innovations in carbon capture and sequestration (CCS) could result in low carbon output.
(2) Natural Gas hybridization or thermal storage could allow resource to be dispatched to meet utility peak load requirements.

Energy Efficiency

Energy Conservation Technologies

Technology	Wide range of technologies and customer incentives. Many of the program ranges from customer installed high efficiency electrical devices to design and construction of high efficiency building standards.
Characteristics	UNS Electric offers a variety of EE programs designed for both the residential and commercial customers. The primary objective of these programs is to provide customers with consumption based information and financial incentives which reduce overall energy consumption. EE programs give customers the opportunities to reduce their monthly electric bills. EE programs provide incentives for customers to invest in high efficiency technologies such as home appliances, compact fluorescent lighting, pumps, motors and HVAC equipment. Other programs provide incentives for builders to design and construct both residential and commercial buildings based on higher EE construction standards.
Benefits	Lowest cost resource. Environmental benefits include reductions in air emissions and water usage. The effect of EE reduces system losses and often defers the need to construct new power plants and transmission lines.
Risks	Challenges include customer participation, market potential and sustained load reduction.
Resource Lead Time	1-2 Years

Energy Conservation Modeling Assumptions

Technology Type	Energy Conservation
Coincident System Peak Capacity	80%
Capacity Cost $/kW	$100
Fixed O&M $/ kW-Year	0
Annual Capacity Factor, %	45%
Emissions	Zero Emissions
Levelized Cost $/MWh	$60

Demand Response

Direct Load Control Technology (DLC)

Technology	Customer installed thermostats and switches used to control customer demand.
Characteristics	The goal of DR is to reduce customer peak demand rather than overall energy use. Programs target summer peak periods to offset the utilities' need to procure additional resource capacity. Programs may utilize cycling methodologies, load shifting, or direct interruption during summer peaks or system emergencies. For planning purposes, UNS Electric assumed that the sum of the Direct Loan Control (DLC) programs would contribute 80-100% of expected nameplate capacity to coincide with system peak.
Benefits	Depending on program design, DLC is often utilized as a dispatchable resource as part of utility operations. Emissions and water usage reduction. Defers the need to construct new power plants and transmission lines.
Risks	Challenges include limited customer participation, minimum yearly call options and low dispatch duration.
Program Lead Time	1 Year

Demand Response Modeling Assumptions

Technology Type	Demand Response
Coincident System Peak Capacity	80-100%
Capacity Cost $/kW	$150
Fixed O&M $/ kW-Year	0
Annual Capacity Factor, %	N/A
Emissions	Zero Emissions
Levelized Cost $/MWh	N/A

Wind Power Technology

Renewable Resources

Technology	Wind Turbines
Characteristics	Unit capacity can range in size from 1 to 5 MW. Based on recent regional wind studies, annual capacity factors for Arizona wind resources average about 30% and New Mexico wind resources average about 38%. Annual production is predominately in non-summer months during off-peak hours. For planning purposes, UNS Electric assumed that wind resources would contribute 9-13% of nameplate capacity during coincident system peak.
Benefits	Zero emissions and low water usage. Qualifies for 30% federal investment tax credit (ITC) and accelerated asset depreciation.
Risks	Non-firm, non-dispatchable resource. Requires backup capacity and regulation. Remote location and low capacity factors make transmission investment a costly requirement. Primary environmental concerns are avian mortality and visual impacts
Construction Lead Time	2 Years

Utility Scale Wind Farm Modeling Assumptions

Location	Arizona	New Mexico
Coincident System Peak Capacity	9%	13%
Capacity Cost $/kW	$2,200	$2,400
Fixed O&M $/ kW-Year	$50	$50
Annual Capacity Factor, %	30%	38%
Emissions	Zero Emissions	Zero Emissions
System Integration Costs, $/MWh	$5.00	$5.00
Levelized Cost $/MWh	$128	$107

Photovoltaic Solar Power Technology

Renewable Resources

Technology	PV (Fixed) and PV (Single-Axis Tracking)
Characteristics	Unit capacity can vary in size from 1 kW to 20 MW. Annual capacity factors for these units range from 17-24%. Annual production is predominately during on-peak hours. For planning purposes UNS Electric assumed that utility scale solar resources would contribute 33% for PV (Fixed) and 51% of name plate capacity for PV (Single-Axis Tracking) during the coincident system peak.
Benefits	Zero emissions. Units can be sited near or within load centers, thus reducing transmission investment. Scalable resource with low water usage. Qualifies for 30% federal ITC and accelerated asset depreciation.
Risks	Intermittent resource, significant variance with cloud cover. Requires backup capacity and regulation. Significant land requirements of approximately 8 acres per MW.
Construction Lead Time	2 Years

Utility Scale Photovoltaic Modeling Assumptions

Technology	PV Fixed	PV Single Axis
Coincident System Peak Capacity	33%	51%
Capacity Cost $/kW	$2,350	$3,250
Fixed O&M Cost $/ kW-Year	$12	$12
Annual Capacity Factor, %	17%	24%
Emissions	Zero Emissions	Zero Emissions
System Integration Costs, $/MWh	$4.00	$2.00
Levelized Cost $/MWh	$175	$144

Concentrating Solar Power Technology

Renewable Resources

Technology	Trough Concentrating Solar Power (CSP) (with and without storage)
Characteristics	Unit capacity can range in size from 50 to 300 MW. Annual capacity factors for these units range from 30-38%. Annual production is predominately during on-peak hours. For planning purposes UNS Electric assumed that CSP resources would contribute 70% (without storage) and 87% (with storage) of nameplate capacity during coincident system peak.
Benefits	Zero emissions. Thermal inertia dampens cloud effects. CSP with storage or natural gas hybridization can be dispatched to meet utility peak load requirements. Qualifies for 30% federal ITC and accelerated asset depreciation.
Risks	CSP storage is in an emerging stage of development. Due to large facility size, CSP plants tend to be located in remote areas. Remote location and low capacity factors make transmission investment costly requirement. Compared to other renewables, CSP requires high water usage unless dry cooled. Large land requirements.
Construction Lead Time	2 Years

Utility Scale Concentrating Solar Modeling Assumptions

Technology	**CSP**	**CSP with Storage**
Coincident System Peak Capacity	70%	87%
Capacity Cost $/kW	$4,900	$5650
Fixed O&M Cost $/kW-Year	$35	$38
Annual Capacity Factor, %	30%	38%
Emissions	Zero Emissions	Zero Emissions
Water, Gal/MWh	800	800
System Integration Costs, $/MWh	$2.00	$2.00
Levelized Cost $/MWh	$158	$169

Biomass Direct Technology

Renewable Resources

Technology	Biomass Direct (Combustion or Gasification)
Characteristics	Unit capacity typically ranges in size from 15 to 50 MW. Plants are usually operated as base load facilities. Annual capacity factors for these units range from 80-90%. For planning purposes UNS Electric assumed that utility scale biomass resources would contribute 100% of nameplate capacity during coincident system peak.
Benefits	Carbon Dioxide (CO2) emission neutral. One of the lower cost resources for renewable energy. Units can be sited near or within load centers, thus reducing transmission investment.
Risks	Fuel supply and transportation
Construction Lead Time	2 Years

Utility Scale Biomass Modeling Assumptions

Coincident System Peak Capacity	100%
Heat Rate Btu/kWh	11,000
Capacity Cost $/kW	$3,250
Fixed O&M Cost $/kW-Year	$85
Annual Capacity Factor, %	85%
CO2 Rate, lbs/MWh	Carbon-Neutral
SO2 Rate, lbs/MWh	0.008
NOX Rate, lbs/MWh	0.446
PM10 Rate, lbs/MWh	0.100
Water, Gal/MWh	100
Levelized Cost $/MWh	$108

Combustion Turbine Technology (CT)

Peaking Resources

Technology and Fuel	Combustion Turbine (CT), Natural Gas
Characteristics	Unit capacity can range in size from 20 to 150 MW. Performance characteristics range anywhere from 9,000 to 12,000 Btu per kWh. Typically, combustion turbines are considered quick start units that can be dispatched within 10 minutes. Combustion turbines provide ancillary system benefits by meeting non-spinning reserve requirements. Annual capacity factors for these units range from 5 to 18%
Benefits	Combustion turbines meet the need for peaking capacity during peak load conditions. Combustion turbines can be sited closer to the load centers thus reducing transmission infrastructure and provide local area voltage support. Lower capital costs, shorter construction lead time and multiple unit siting configurations allow flexibility to match load serving requirements as well as planned future build outs for combined-cycle conversions. Combustion turbines also have lower water consumption.
Risks	Natural gas price volatility and CO2 risk
Construction Lead Time	4 Years

Combustion Turbine Modeling Assumptions

Unit Description	GE 7FA	GE LMS100	GE LM6000
Dispatch Capacity MW	160	90	45
Heat Rate Btu/kWh	10,500	9,000	9,800
Capacity Cost $/kW	$779	$1,203	$1,156
Fixed O&M $/ kW-Year	$13.60	$11.95	$15.00
Annual Capacity Factor, %	7%	18%	10%
CO2 Rate, lbs/MWh	1,248	1,070	1,165
SO2 Rate, lbs/MWh	0.006	0.005	0.006
NOX Rate, lbs/MWh	0.347	0.323	0.297
HG Rate, lbs/MWh	2.70E-06	2.30E-06	2.50E-06
PM10 Rate, lbs/MWh	0.078	0.067	0.073
Water, Gal/MWh	150	150	150
Levelized Cost $/MWh	$293	$185	$262

Combined Cycle Plant Technology (CC)

Intermediate Resources

Technology and Fuel	Combined Cycle Plants, Natural Gas
Characteristics	Unit capacity can range in size from 250 to 600 MW. Performance characteristics range anywhere from 7,000 to 8,500 Btu per kWh. Annual capacity factors for these units are about 40% for units serving intermediate needs and 85% for baseload.
Benefits	Combined cycle resources are used to serve intermediate and base load obligations. Combined-cycle plants are often used for system regulation and meeting spinning reserve requirements.
Risks	Natural gas price volatility and CO2 emission risk
Construction Lead Time	5 Years

Combined-Cycle Plant Modeling Assumptions

Dispatch Capacity MW	570	570
Heat Rate Btu/kWh	7,200	7,200
Capacity Cost $/kW	$1,320	$1,320
Fixed O&M Cost $/ kW-Year	$16.50	$16.50
Annual Capacity Factor, %	40%	85%
CO2 Rate, lbs/MWh	850	850
SO2 Rate, lbs/MWh	0.004	0.004
NOX Rate, lbs/MWh	0.094	0.094
HG Rate, lbs/MWh	1.80E-06	1.80E-06
PM10 Rate, lbs/MWh	0.054	0.054
Water, Gal/MWh	350	350
Type	Intermediate	Baseload
Levelized Cost $/MWh	$115	$83

Pulverized Coal Technology

Base Load Resources

Technology and Fuel	Sub-Critical Design, Pulverized Coal
Characteristics	Unit capacity can range in size from 250 to 600 MW. Performance characteristics range anywhere from 9,500 to 10,500 Btu per kWh. Annual capacity factors for these units range from 80 to 90% Units
Benefits	Mature technology. Fuel price stability and abundant supply. Resources are used to serve base load obligations. Coal plant plants are often used for system regulation and meeting spinning reserve requirements.
Risks	Coal plants are typically sited in remote locations requiring high capital investment in both plant and transmission. High CO2 emissions risk and high cooling water requirements.
Construction Lead Time	7 Years

Coal Plant Modeling Assumptions

Dispatch Capacity MW	400
Heat Rate Btu/kWh	10,250
Capacity Cost $/kW	$4,164
Fixed O&M Cost $/ kW-Year	$30.45
Annual Capacity Factor, %	85%
CO2 Rate, lbs/MWh	2,101
SO2 Rate, lbs/ MWh	1.046
NOX Rate, lbs/ MWh	0.656
HG Rate, lbs/ MWh	1.17E-05
PM10 Rate, lbs/ MWh	0.210
Water, Gal/MWh	750
Levelized Cost $/MWh	$107

Integrated Gasification Combined-Cycle (IGCC)

Base Load Resources

Technology and Fuel	Combined Cycle Plants, Coal Gasification
Characteristics	Newer technology. Unit capacity can range in size from 400 to 600 MW. Performance characteristics range anywhere from 9,000 to 11,000 Btu per kWh. Annual capacity factors for these units average 75%
Benefits	Designs that incorporate carbon capture and storage (CCS) are projected to be less expensive than coal facilities equipped with CCS.
Risks	Higher capital costs than other coal and natural gas resources. Carbon capture and storage technology unproven.
Construction Lead Time	8 Years for IGCC without CCS, 9 Years for IGCC with CCS.

Integrated Gasification Combined-Cycle (IGCC) Assumptions

CCS Capability	No	Yes
Dispatch Capacity MW	600	380
Heat Rate Btu/kWh	9,200	11,000
Capacity Cost $/kW	$4,448	$5,931
Fixed O&M Cost $/ kW-Year	$50.80	$57.90
Annual Capacity Factor, %	75%	70%
CO2 Rate, lbs/MWh	1,886	226
SO2 Rate, lbs/ MWh	0.117	0.094
NOX Rate, lbs/ MWh	0.406	0.450
HG Rate, lbs/MWh	4.25E-06	4.59E-06
PM10 Rate, lbs/ MWh	0.007	0.007
Water, Gal/MWh	800	900
Levelized Cost $/MWh	$145	$200

Nuclear Power Technology

Base Load Resources

Technology and Fuel	Advanced Boiling Water Reactor, Plutonium
Characteristics	Unit capacity can range in size from 1000 to 1500 MW. Annual capacity factors for these units average 85%
Benefits	Zero Emissions.
Risks	Capital and construction risk, spent nuclear fuel disposal risk. High water requirements.
Construction Lead Time	12 Years

Nuclear Plant Modeling Assumptions

Dispatch Capacity MW	1,000
Heat Rate Btu/kWh	10,400
Capacity Cost $/kW	$7,532
Fixed O&M Cost $/ kW-Year	$75.55
Annual Capacity Factor, %	85%
CO2 Rate, lbs/ MWh	0
SO2 Rate, lbs/ MWh	0
NOX Rate, lbs/ MWh	0
HG Rate, lbs/ MWh	0
PM10 Rate, lbs/MWh	0
Water, Gal/MWh	1,000
Levelized Cost $/MWh	$136

Comparison of Resources

Generation planning and resource analysis can be performed by using a wide spectrum of tools and methodologies. Prior to running detailed simulation models, the resource planning team performed a number of simple comparisons that analyzed each potential resource on a stand-alone basis. Table 8 shown below summarizes these comparisons and shows how each resource performed in terms of levelized cost of energy, water usage and CO_2 profiles.

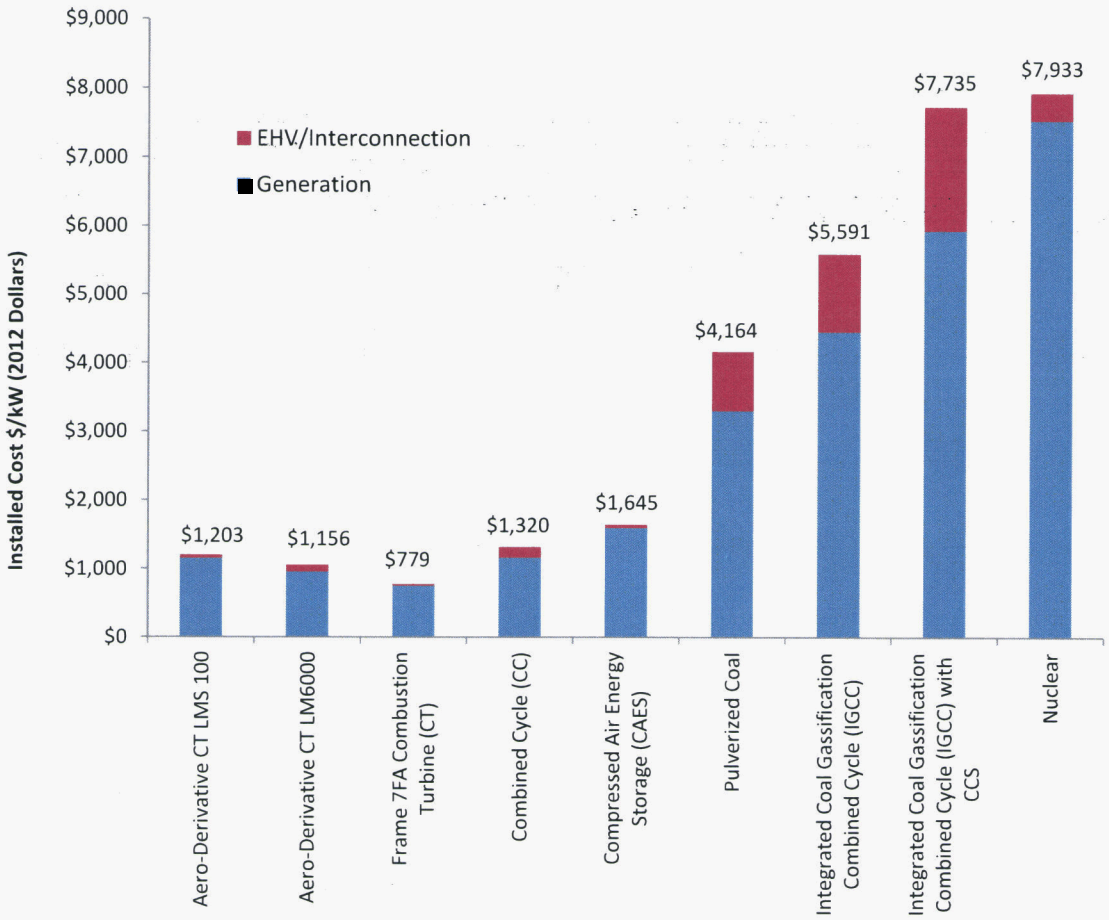
Table 8 - Resource Comparisons

		Levelized Cost of Energy ($/MWh)	Water Usage (Gallons/ MWh)	CO2 Profile (lbs/ MWh)
Energy Efficiency	Energy Efficiency		0	0
Demand Response	Direct Load Control		0	0
Renewables	New Mexico (NM Wind)	107	0	0
	Arizona (AZ Wind)	128	0	0
	Solar PV (Single Axis)	144	0	0
	Solar PV (Fixed)	175	0	0
	Biomass Direct	108	100	0
	Solar CSP	158	800	0
	Solar CSP (Storage)	169	800	0
	Nuclear	136	1,000	0
Conventional	IGCC with CCS	200	900	226
	Compressed Air Energy Storage (CAES)	227	75	267
	Combined Cycle (CC)	83/115	350	850
	Aero-Derivative CT LMS 100	185	150	1,070
	Aero-Derivative CT LM6000	262	150	1,165
	Frame 7FA Combustion Turbine (CT)	293	150	1,248
	IGCC	145	800	1,886
	Pulverized Coal	107	750	2,101

Capital Costs – Conventional Resources

Chart 17 below shows the breakdown on the costs of conventional generation resources used in the 2012 IRP. The costs are shown for both the generating plant and the transmission and associated interconnection costs. All costs reflect 2012 $/kW for invested capital.

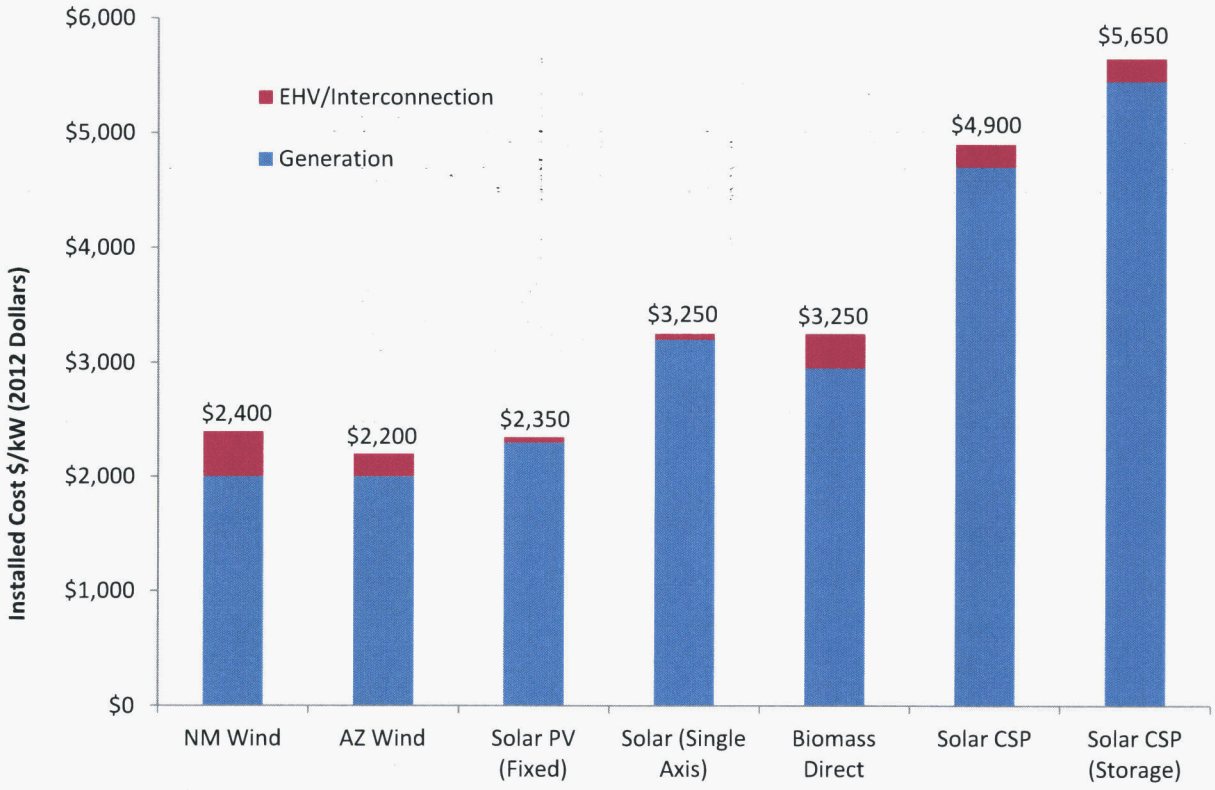
Chart 17 - Conventional Resource Capital Costs



Capital Costs – Renewable Resources

Chart 18 below shows the breakdown on the costs of renewable resources used in the 2012 IRP. The costs are shown for both the generating plant and the transmission and associated interconnection costs. All costs reflect 2012 $/kW for invested capital. This summary reflects the capital cost requirements prior to the adjustment for the 30% federal ITC applied against the generation capital costs.

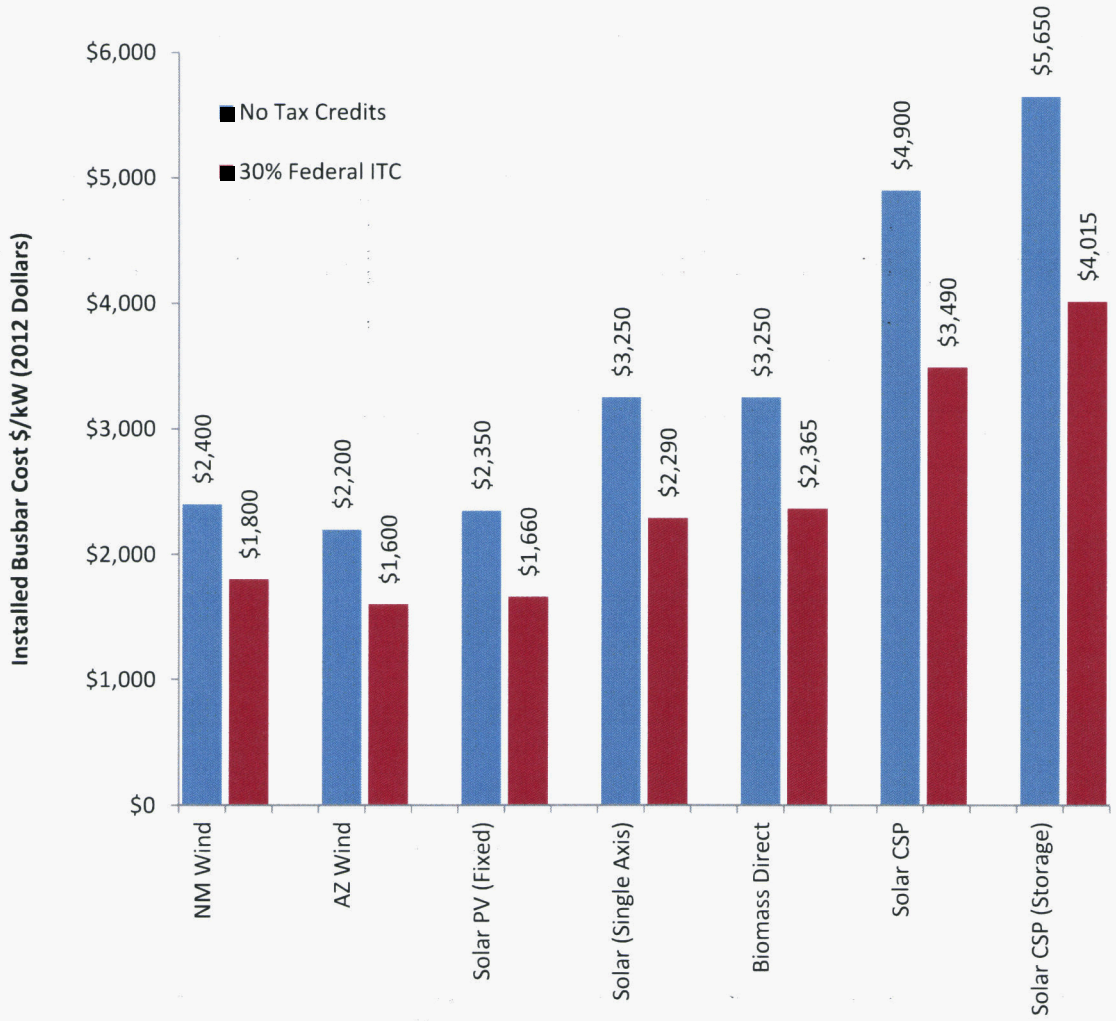
Chart 18 - Renewable Resource Capital Costs



The Effects of Investment Tax Credits on Renewables

Chart 19 below shows the benefit associated the 30% ITC. All costs reflect 2012 $/kW for invested capital after the ITC.

Chart 19 - Investment Tax Credit Impacts on Renewable Resources



LEVELIZED COST COMPARISONS

The calculation of the levelized cost of electricity (LCOE) provides a common way to compare the cost of energy across different demand and supply-side technologies The LCOE takes into account the installed system price and associated costs such as financing, land, insurance, transmission, operation and maintenance, and depreciation and converts them into a common metric: $/MWh. The calculation for the LCOE is the net present value of total life cycle costs of the project divided by the quantity of energy produced over the system life.

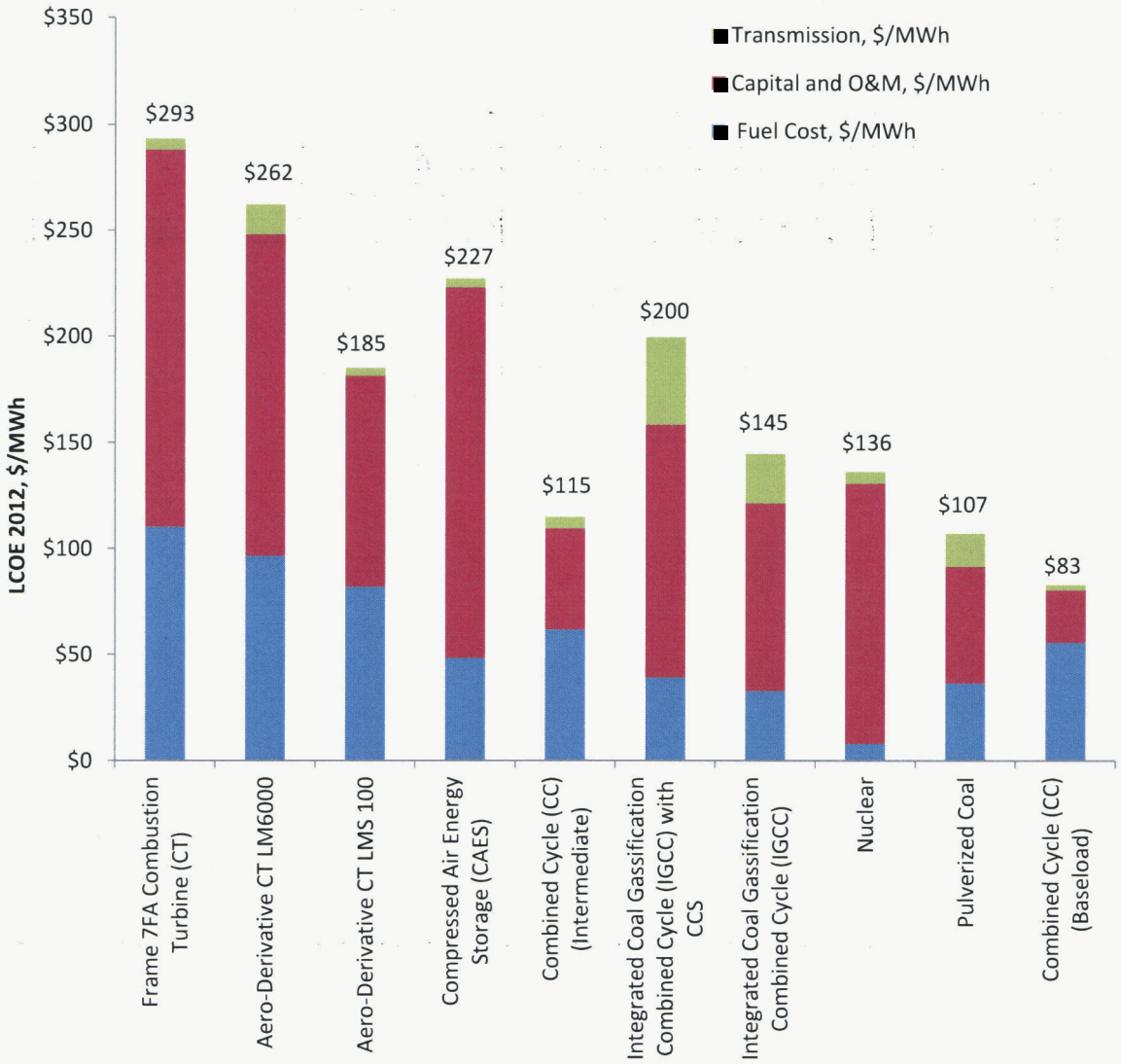
Levelized costs represent the present value of the total cost of building and operating a generating plant over its financial life, converted to equal annual payments and amortized over expected annual generation from an assumed duty cycle.

Because intermittent technologies such as renewables do not provide the same contribution to system reliability as technologies that are operator controlled and dispatched, they require additional system investment for system regulation and backup capacity.

LEVELIZED COST OF ENERGY – CONVENTIONAL RESOURCES

Chart 20 below provides a comparison on the levelized costs of conventional generation resources used in the 2012 IRP. The costs are shown for both the generating plant and the transmission and associated interconnection costs. All costs reflect 2012 $/MWh.

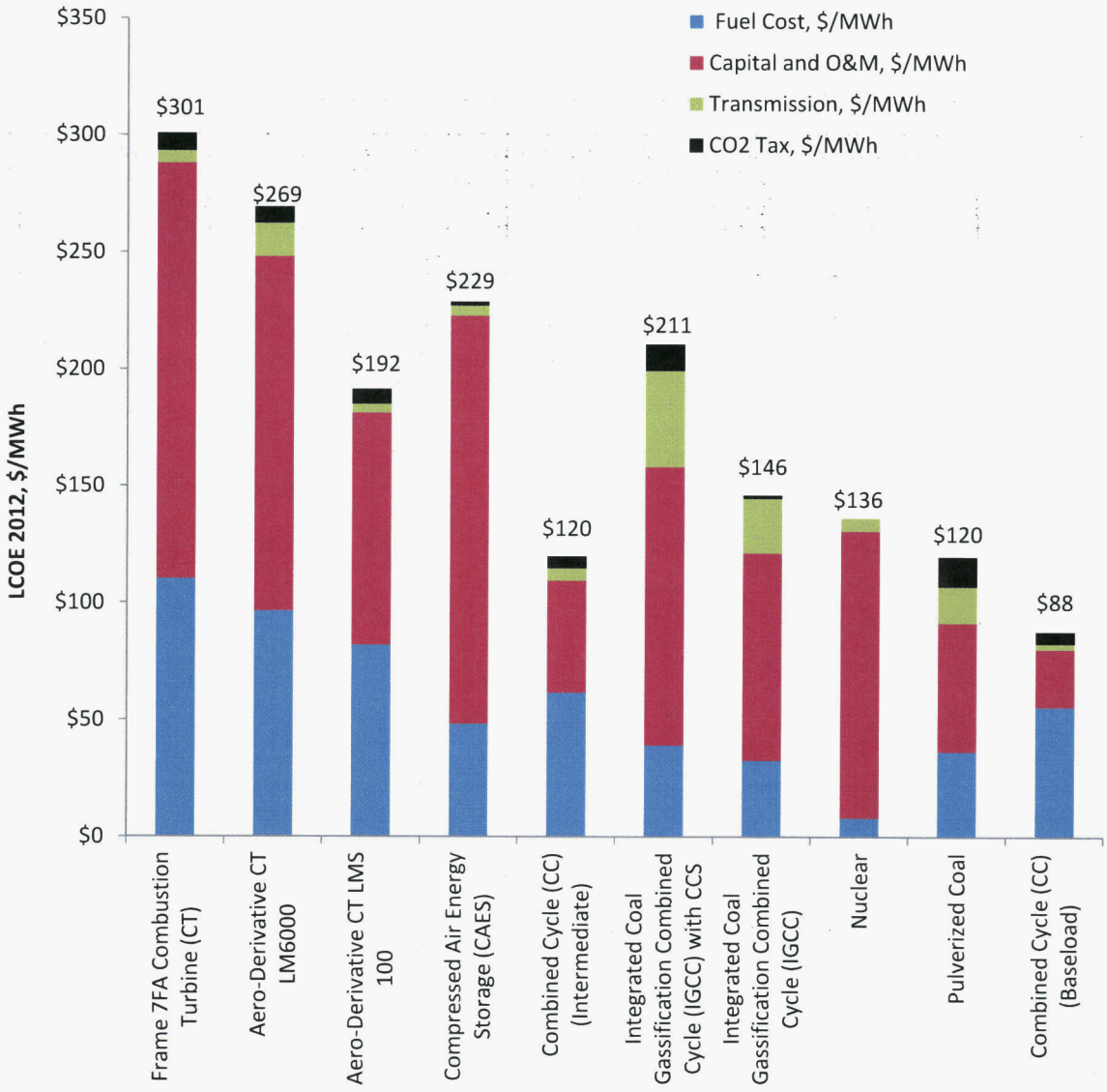
Chart 20 - Levelized Cost of Conventional Resources



LEVELIZED COST OF ENERGY – CONVENTIONAL RESOURCES

Chart 21 below provides a comparison on the levelized costs of conventional generation resources used in the 2012 IRP. The costs are shown for both the generating plant and the transmission and associated interconnection costs and include a carbon tax based on the PACE Global Forecast. All costs reflect 2012 $/MWh.

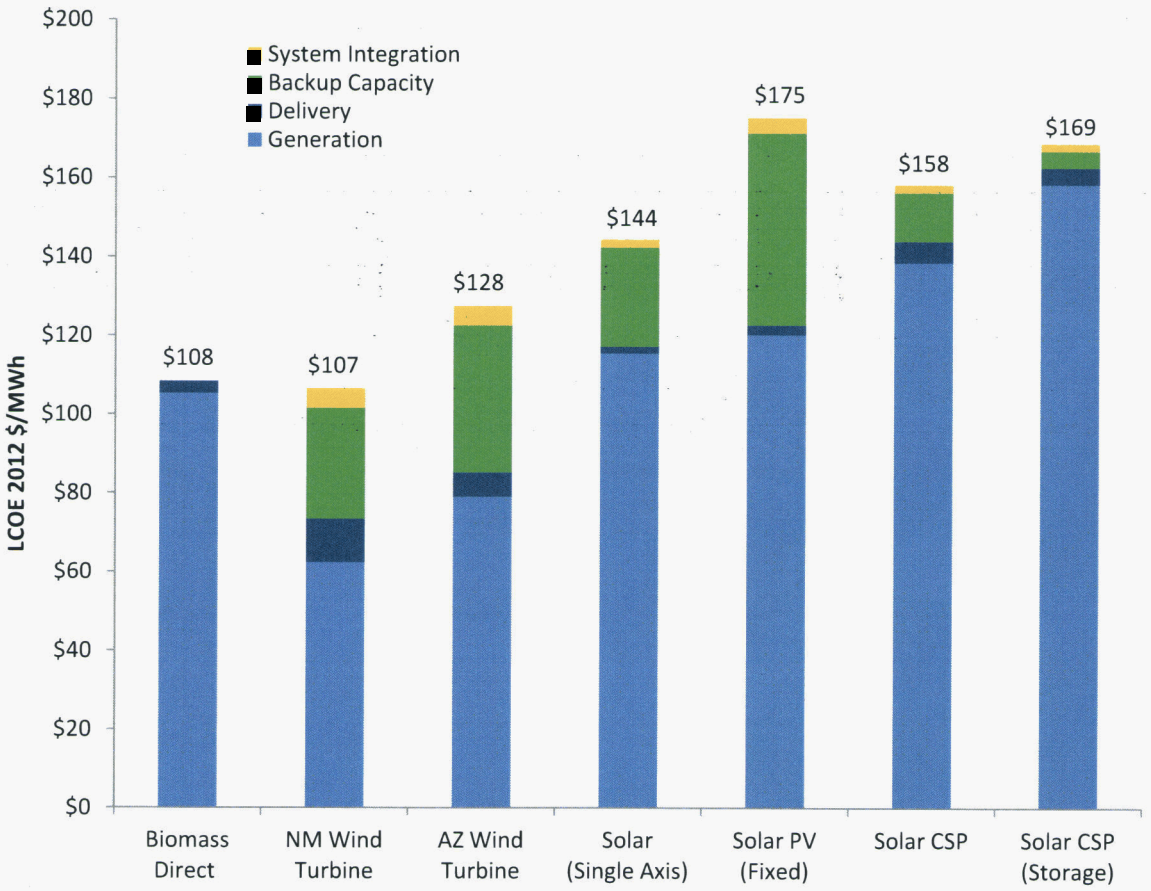
Chart 21 - Levelized Cost of Conventional Resources with CO2 Tax



LEVELIZED COST OF ENERGY – RENEWABLE RESOURCES

Chart 22 below provides a comparison on the levelized costs of renewable resources. The costs are shown for the generating plant, transmission, system integration and backup capacity costs. All costs are adjusted for the 30% federal ITC and reflect 2012 $/MWh.

Chart 22 - Levelized Cost of Renewable Resources



All resources assume 30% federal investment tax credit (ITC).

RENEWABLE TECHNOLOGIES – COST DETAILS

Table 9 includes the renewable technology cost assumptions used in the 2012 IRP.

Table 9 - Renewable Resource Cost Assumptions

Cost and Operating Characteristics	Units	AZ Wind	NM Wind	Solar PV (Fixed)	Solar PV (Single Axis)	Solar CSP	Solar CSP (Storage)	Biomass Direct
Project Lead Time	Years	2	2	2	2	3	4	2
First Year Available	In-Service	2014	2014	2014	2014	2015	2016	2014
Peak Capacity	MW	50	50	20	20	50	50	20
Construction Cost	2012 $/kW	$2,000	$2,000	$2,300	$3,200	$4,700	$5,450	$2,950
EHV/Interconnection Cost	2012 $/kW	$200	$400	$50	$50	$200	$200	$300
Total Construction Cost	2012 $/kW	$2,200	$2,400	$2,350	$3,250	$4,900	$5,650	$3,250
Construction Cost with ITC	2012 $/kW	$1,600	$1,800	$1,660	$2,290	$3,490	$4,015	$2,365
Fixed O&M	2012 $/kW-yr	$50	$50	$12	$12	$35	$38	$85
Variable O&M	2012 $/MWh	$0.00	$0.00	$0	$0	$0	$22.00	$0
Fuel Cost	2012 $/MWh							$51
System Integration Costs	2012 $/MWh	$5.00	$5.00	$4.00	$4.00	$2.00	$0.00	$15.00
Levelized Cost of Energy	$/MWh	$128	$107	$175	$144	$158	$167	$108
Typical Capacity Factor	Annual %	30%	38%	17%	24%	30%	38%	85%
Net Coincident Peak Contribution	NCP %	9%	13%	33%	51%	70%	87%	100%
Water Usage	Gal/MWh	0	0	0	0	800	800	100
30% Federal ITC	Qualify	YES	YES	YES	YES	YES	YES	YES

RENEWABLE TECHNOLOGIES – COST DETAILS

Table 9 includes the renewable technology cost assumptions used in the 2012 IRP.

Table 9 - Renewable Resource Cost Assumptions

Cost and Operating Characteristics	Units	AZ Wind	NM Wind	Solar PV (Fixed)	Solar PV (Single Axis)	Solar CSP	Solar CSP (Storage)	Biomass Direct
Project Lead Time	Years	2	2	2	2	3	4	2
First Year Available	In-Service	2014	2014	2014	2014	2015	2016	2014
Peak Capacity	MW	50	50	20	20	50	50	20
Construction Cost	2012 $/kW	$2,000	$2,000	$2,300	$3,200	$4,700	$5,450	$2,950
EHV/Interconnection Cost	2012 $/kW	$200	$400	$50	$50	$200	$200	$300
Total Construction Cost	2012 $/kW	$2,200	$2,400	$2,350	$3,250	$4,900	$5,650	$3,250
Construction Cost with ITC	2012 $/kW	$1,600	$1,800	$1,660	$2,290	$3,490	$4,015	$2,365
Fixed O&M	2012 $/kW-yr	$50	$50	$12	$12	$35	$38	$85
Variable O&M	2012 $/MWh	$0.00	$0.00	$0	$0	$0	$22.00	$0
Fuel Cost	2012 $/MWh							$51
System Integration Costs	2012 $/MWh	$5.00	$5.00	$4.00	$4.00	$2.00	$0.00	$15.00
Levelized Cost of Energy	$/MWh	$128	$107	$175	$144	$158	$167	$108
Typical Capacity Factor	Annual %	30%	38%	17%	24%	30%	38%	85%
Net Coincident Peak Contribution	NCP %	9%	13%	33%	51%	70%	87%	100%
Water Usage	Gal/MWh	0	0	0	0	800	800	100
30% Federal ITC	Qualify	YES	YES	YES	YES	YES	YES	YES

CONVENTIONAL TECHNOLOGIES – COST DETAILS

Table 10 includes the conventional resource cost assumptions used in the 2012 IRP.

Table 10 - Conventional Resource Cost Assumptions

Plant Construction Costs	Units	GE Aero-Derivative CT LMS 100	GE Aero-Derivative CT LM6000	Frame 7FA Combustion Turbine (CT)	Combined Cycle (CC) (Baseload)	Compressed Air Energy Storage (CAES)	Pulverized Coal	IGCC	IGCC with CCS	Nuclear
Project Lead Time	Years	4	4	4	5	4	7	8	9	12
Installation Years	First Year Available	2016	2016	2016	2017	2016	2019	2020	2021	2024
Peak Capacity	MW	90	45	160	570	100	400	600	380	1000
Plant Construction Cost	2012 $/kW	$1,151	$954	$750	$1,161	$1,593	$3,300	$4,448	$5,931	$7,532
EHV/Interconnection Cost	2012 $/kW	$52	$104	$29	$159	$52	$864	$1,143	$1,804	$401
Total Construction Cost	2012 $/kW	$1,203	$1,156	$779	$1,320	$1,645	$4,164	$5,591	$7,735	$7,933
Operating Characteristics										
Fixed O&M	2012 $/kW-yr	$11.95	$15.00	$13.60	$16.50	$29.00	$30.45	$50.80	$57.90	$75.55
Variable O&M	2012 $/MWh	$3.30	$2.85	$3.75	$3.28	$1.80	$2.35	$4.65	$5.35	$2.12
Gas Transportation, $/kW	2012 $/kW-yr	$16.80	$16.80	$16.80	$16.80	$16.80	$0.00	$0.00	$0.00	$0.00
Annual Heat Rate	Net Btu/kWh	9,000	9,800	10,500	7,200	4,500	10,250	9,200	11,000	10,400
Typical Capacity Factor	Annual %	18%	10%	7%	85%	15%	85%	75%	70%	85%
Expected Annual Output	GWh	138	39	140	2,247	131	5,957	3,942	2,330	7,446
Levelized Cost of Energy	$/MWh	$185	$262	$293	$83	$227	$107	$145	$200	$136

CONVENTIONAL TECHNOLOGIES – ENVIRONMENTAL DETAILS

Table 11 includes the conventional resource environmental assumptions used in the 2012 IRP.

Table 11 - Conventional Resource Environmental Assumptions

Environmental Assumptions	Units	Aero-Derivative CT LMS 100	Aero-Derivative CT LM6000	Frame 7FA Combustion Turbine (CT)	Combined Cycle (CC)	Compressed Air Energy Storage (CAES)	Pulverized Coal	IGCC	IGCC with CCS	Nuclear
CO2 Rate	lbs/MWh	1,070	1,165	1,248	850	267	2,101	1,886	226	0
SO2 Rate	lbs/MWh	0.005	0.006	0.006	0.004	0.001	1.046	0.117	0.094	0
NOX Rate	lbs/MWh	0.297	0.323	0.347	0.094	0.173	0.656	0.058	0.058	0
HG Rate	lbs/MWh	2.30E-06	2.50E-06	2.70E-06	1.80E-06	1.35E-06	1.17E-05	4.25E-06	4.59E-06	0
PM10 Rate	lbs/MWh	0.067	0.073	0.078	0.054	0.039	0.210	0.007	0.007	0
Water Usage	Gal/MWh	150	150	150	350	75	750	800	900	1,000

CHAPTER 7

TRANSMISSION RESOURCES

Overview

Transmission resources are a key and principal element in UNS Electric's resource portfolio. Adequate transmission capacity must exist to meet UNS Electric's existing and future load obligations. UNS Electric resource planning and transmission planning groups coordinate their planning efforts to ensure consistency in development of its long-term planning strategy. On a regional basis, UNS Electric participates in the ACC's Biennial Transmission Assessment (BTA) to develop a statewide transmission plan that ensures that Arizona's transmission organizations are coordinated in their efforts to maintain system adequacy and reliability. UNS Electric's transmission resources include approximately 292 miles of transmission lines owned by UNS Electric, long-term transmission rights (Point to Point and Network service) purchased from Western Area Power Administration (WAPA), and Point to Point transmission purchased from other transmission providers on an ad hoc basis. Given UNS Electric's dependence on third-party transmission providers UNS Electric works closely with WAPA's transmission planning group to ensure adequate long-term transmission capacity is available to serve both the Mohave and Santa Cruz service territories. WAPA is currently in process of conducting an updated System Impact Study (SIS) for UNS Electric to address current and future load growth options.

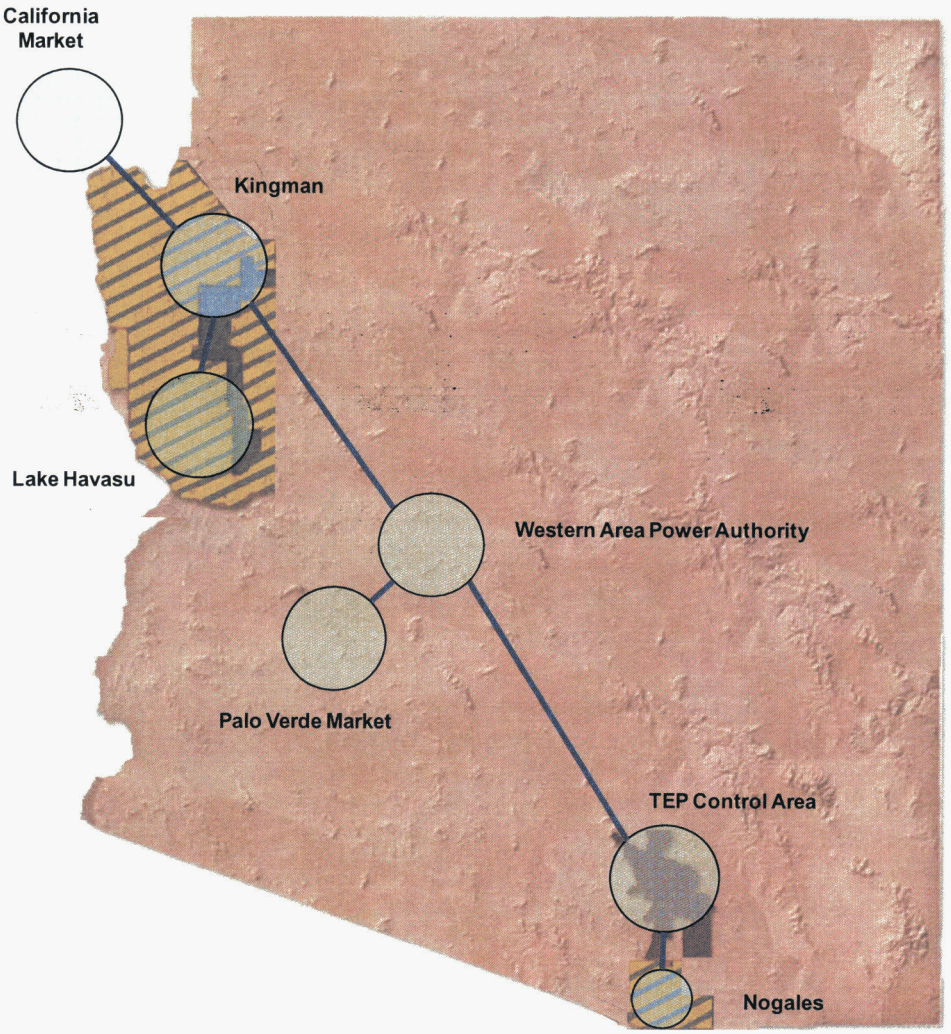
Control Area Services Agreement

Beginning in June 2008, UNS Electric entered into a long-term Control Area Services Agreement with Tucson Electric Power under which UNS Electric will manage, for a fee, the UNS Electric Transmission assets and needs of UNS Electric. Ancillary Services include: Administration, Reactive Supply & Voltage Control, Regulation& Frequency Response, Spinning Reserve and Energy Imbalance. Services and charges under this Control Area Services Agreement are provided under UNS Electric's Federal Energy Regulatory Commission (FERC) approved Open Access Transmission Tariff (OATT).

UNS Electric's Projected Load Serving Capability

For the 2012 IRP, UNS Electric applied an integrated generation and transmission approach to maximize UNS Electric's future retail load serving capability. UNS Electric's load serving capability is defined as the sum of local area generation capacity plus UNS Electric's transmission import capacity at system peak. As a result of this work, UNS Electric developed future generation and transmission portfolios which optimized both the supply-side requirements with future transmission investments. Based on WAPA's available transmission capacity, the load serving capability for Mohave County is sufficiently above the load projections within the study period of this IRP. In Santa Cruz County, either the construction of a 2nd Nogales Transmission line or the Continuity of Service Plan will meet the load serving capacity requirements through 2030.

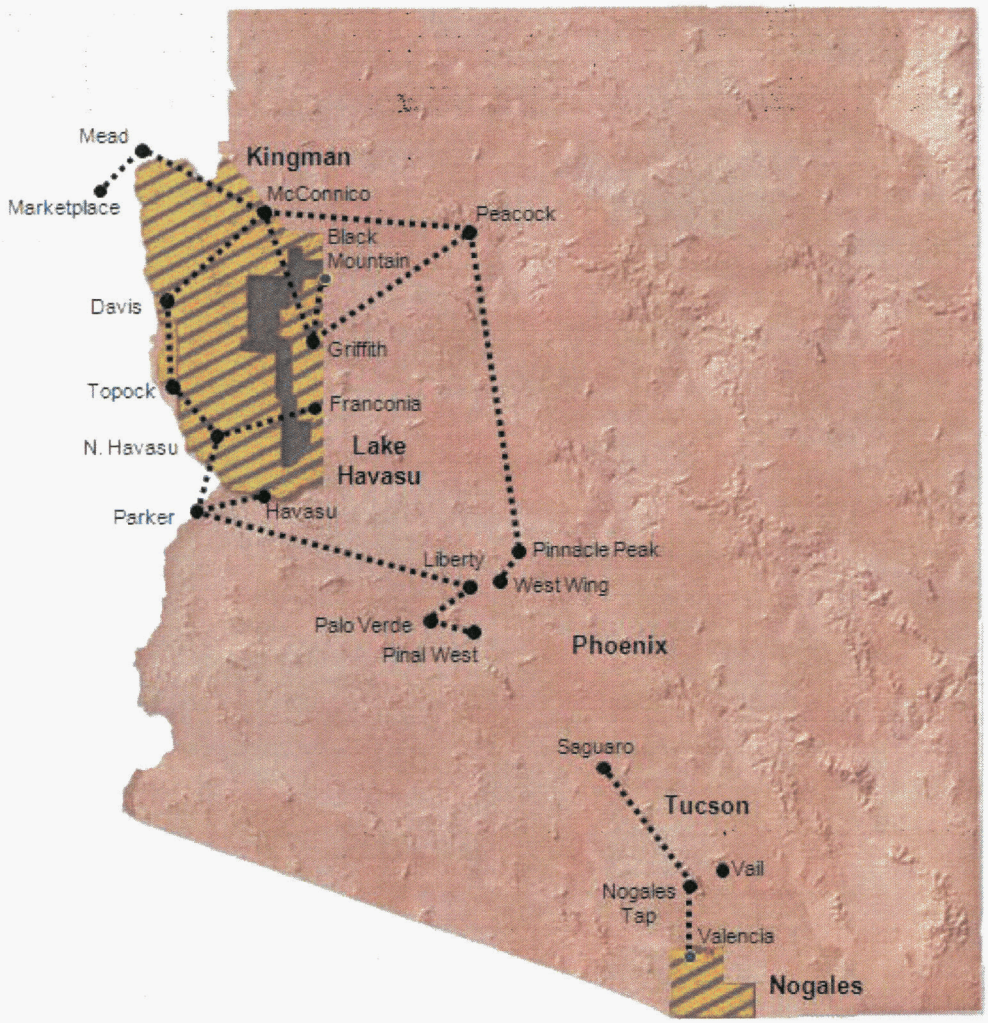
Map 4 - UNS Electric Load and Market Delivery Points



Existing Transmission Resources

UNS Electric existing transmission system as constructed is contained within 2 service areas in Arizona; Mohave and Santa Cruz counties. As shown on Map 5, the UNS Electric-Mohave service territory area supplied by Western's 230 kV network which is interconnected to the EHV transmission system via three 345 kV substations: Mead, Liberty and Peacock. Firm system purchases designated as Network Resources are delivered to Pinnacle Peak. UNS Electric-Mohave receives NITS from Western at several 230 kV points of delivery including: Hilltop, McConnico, Black Mesa, North Havasu, and Griffith. These stations interconnect and supply energy to the local system. UNS Electric owns approximately 236 miles of 69kV transmission lines in Mohave County and 56 miles of 115kV transmission lines in Santa Cruz County.

Map 5 - UNS Electric Transmission Delivery Points

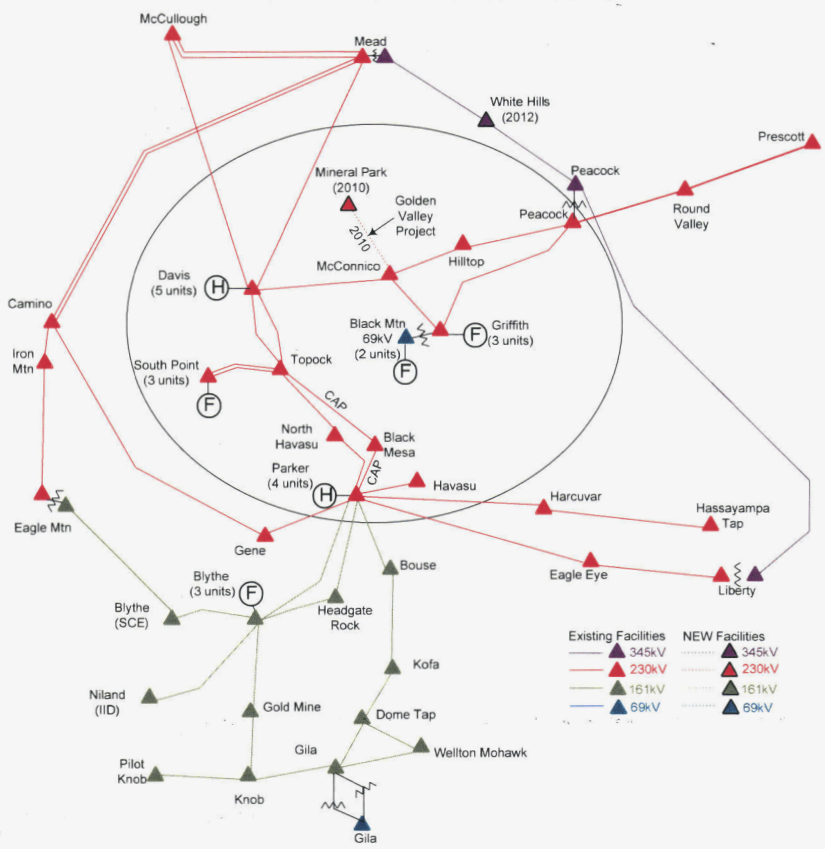


Mohave County Transmission

UNS Electric has three long term transmission contracts with WAPA. One contract provides approximately 225 MW of network service on WAPA's system. The Networked Agreement which currently has Pinnacle Peak as a receipt point and Hilltop, Duval-Warm Springs, Planet Ranch, McConnico and North Havasu as delivery points in Mohave County, and delivery to Saguaro for Santa Cruz County. The networked service agreement is projected to allow 8-10 years of unimpeded load growth in Mohave County.

The second contract provides approximately 100 MWs of point to point service on both WAPA's Parker Davis System and its Central Arizona Power System. A third contract provides 110 MW point to point service on WAPA's Intertie Power System and on its Central Arizona Power System again. UNS Electric also buys point to point transmission over WAPA's Open Access Same-Time Information System (OASIS), on an ad hoc basis. UNS Electric is able to purchase access on transmission systems of other providers in the region as needed.

Map 6 – Mohave County Transmission Delivery Points



Future Transmission Resources

Several of the projects that were included in UNS Electric's ten year transmission plan were considered in the development of this IRP. The final list of transmission projects included in the IRP process was chosen in conjunction with UNS Electric's future generation resource requirements. The result was a short list of transmission projects that improved the overall reliability, import capacity and flexibility for future market resources.

Alternative	Mohave County Transmission Options
Project 1	Griffith-North Havasu Transmission
Project 2	Golden Valley 230 kV Transmission Line Project
Project 3	White Hills Substation

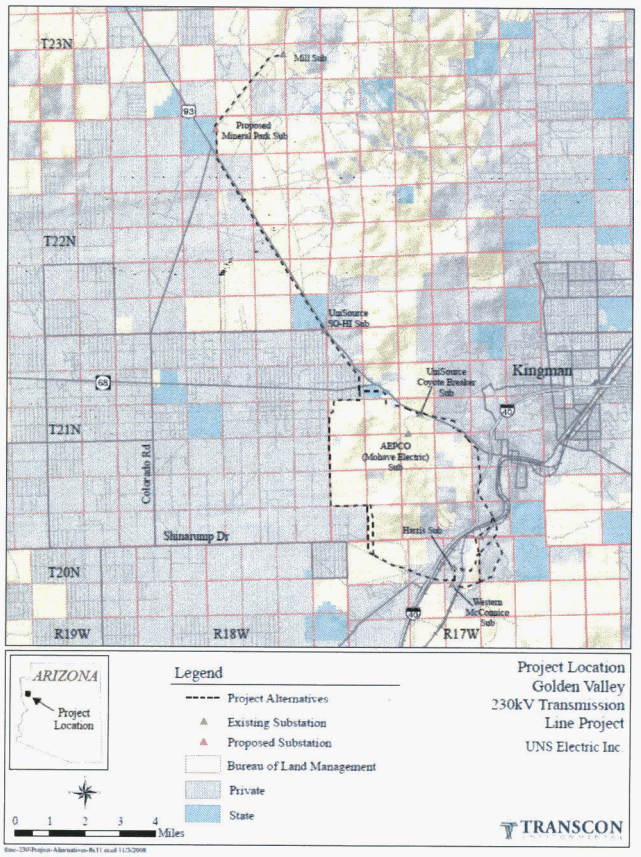
Mohave County

UNS Electric considers the Griffith – North Havasu 230kV line as a viable upgrade, and currently has an approved Certificate of Environmental Compatibility (CEC) for this line addition. UNS Electric has received an extension to the expiration date of this CEC to 2012. UNS Electric is considering a request for further extension to 2016 or beyond, pending further review of the results of the Mohave County RMR study. The timing for construction of this project is predicated on results of load growth in conjunction with limitations on the ability of the Western transmission system to support this load growth. A portion of this project (North Havasu to Franconia) was completed in 2007 and is currently energized at 69kV for distribution needs at Franconia.

Golden Valley 230 kV Transmission Line Project

The Golden Valley 230 kV Transmission Line Project has been delayed indefinitely from its previously proposed 2010 in-service date. This project is to provide service to large mining loads in Mohave County, which have not grown to the extent previously forecasted. In-service will be determined by this customer's expansion decisions.

Map 7 – Golden Valley 230kV Transmission Project



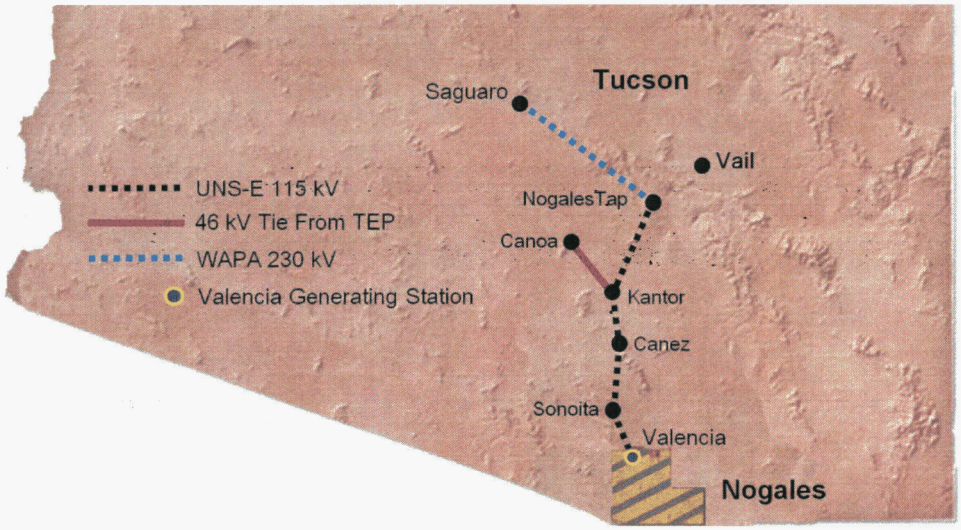
White Hills Substation

The White Hills Substation project has been delayed indefinitely from its previously proposed in-service date of 2012. This substation is to provide service to residential development in the area that has been deferred.

Santa Cruz County Transmission Overview

Santa Cruz County relies on WAPA's 230 kV system for up to 65 MW of firm transmission capacity. This firm network transmission service is used to deliver generation from a number of remote resources. From the Nogales Tap, a single 115 kV transmission line feeds the local distribution grid located in the City of Nogales.

Map 8 – Santa Cruz County Transmission Delivery Points



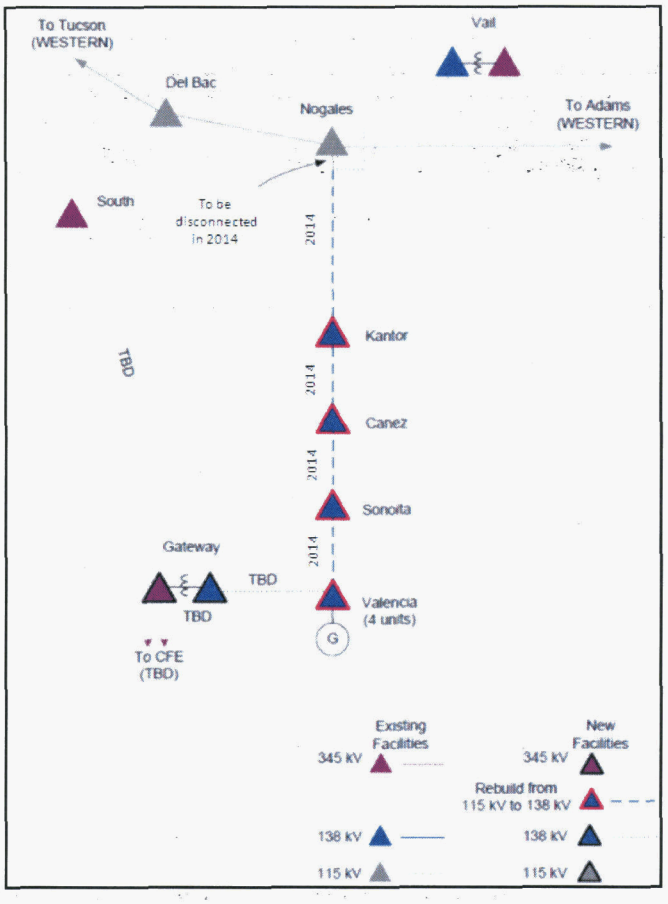
Santa Cruz Long-Term Plans

The UNS Electric long-term plan to improve reliability for the Santa Cruz service territory is to construct a redundant transmission line to the Valencia Substation from TEP's South Substation. UNS Electric has performed studies and filed ten year plans for UNS Electric and UNS Electric Mohave and Santa Cruz with the ACC. The plans are being assessed in the 2010 BTA. Alternatives including, the Gateway project and generation resources at Valencia, were evaluated in the study from both technical and economic perspectives. In addition, a continuity of service project based on upgrading the 115 kV single circuit to 138 kV interconnected at TEP's Vail substation is also included in the IRP plan.

Santa Cruz County Potential Transmission Projects

Alternative	Santa Cruz County Transmission Options
Project 1	Nogales Transmission Line
	Option 1 - Gateway 345/138 kV Substation
	Option 2 - Gateway – Sonoita 138 kV Transmission Line
Project 2	Continuity of Service Plan

Map 9 – Santa Cruz County Potential Transmission Projects

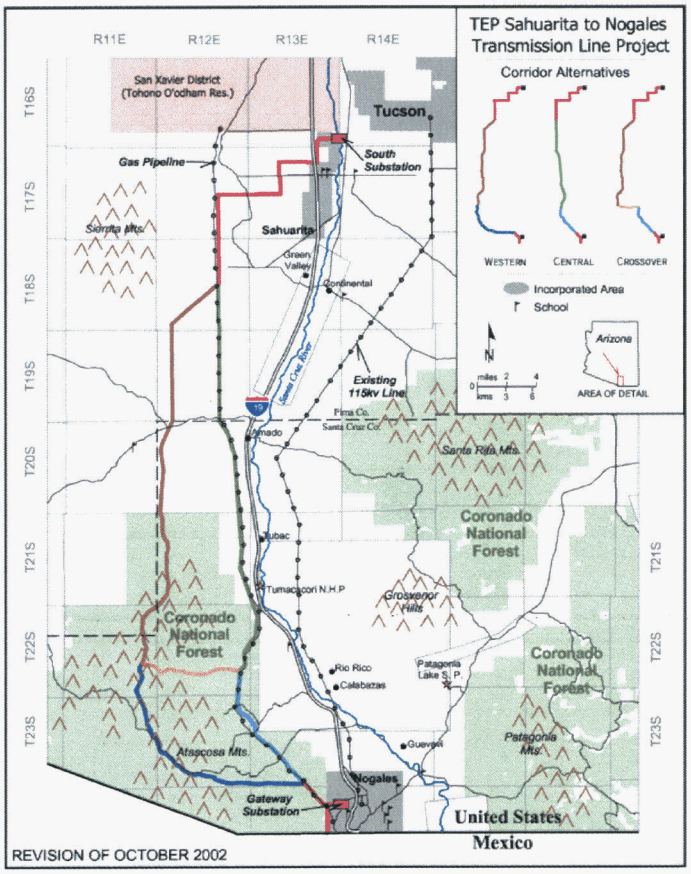


Nogales Transmission Line

In 1998, Citizens Utilities (later to become UNS Electric) and the Western Area Power Administration experienced unprecedented failures of the power delivery system that resulted in an unusual number of power outages for customers in the Nogales, Arizona area. The City of Nogales filed a complaint regarding the quality of service, and the ACC conducted an investigation. As a result, the ACC ordered Citizens to make improvements to its electric system. Those improvements included building a second transmission line that could be tied to the existing 115 kV line and operated as a "closed loop". This "closed loop" configuration would ensure that Santa Cruz County would continue to have reliable service under a single contingency line outage.

In 2001, both TEP and Citizens entered into a joint project agreement to develop a new 345-kV transmission line from TEP's South Substation in Sahuarita to a proposed Citizens substation near Nogales, Arizona. The original project proposal planned to extend the new line into Mexico, enabling international energy exchanges while improving electric reliability on both sides of the border. In January 2002, the ACC authorized constructing a transmission line along the so-called Western Route. The construction of this line is pending the receipt of permits from the U.S. Department of Energy (DOE), the U.S. Forest Service and the Bureau of Land Management.

Map 10 – Santa Cruz County Transmission Corridor Alternatives

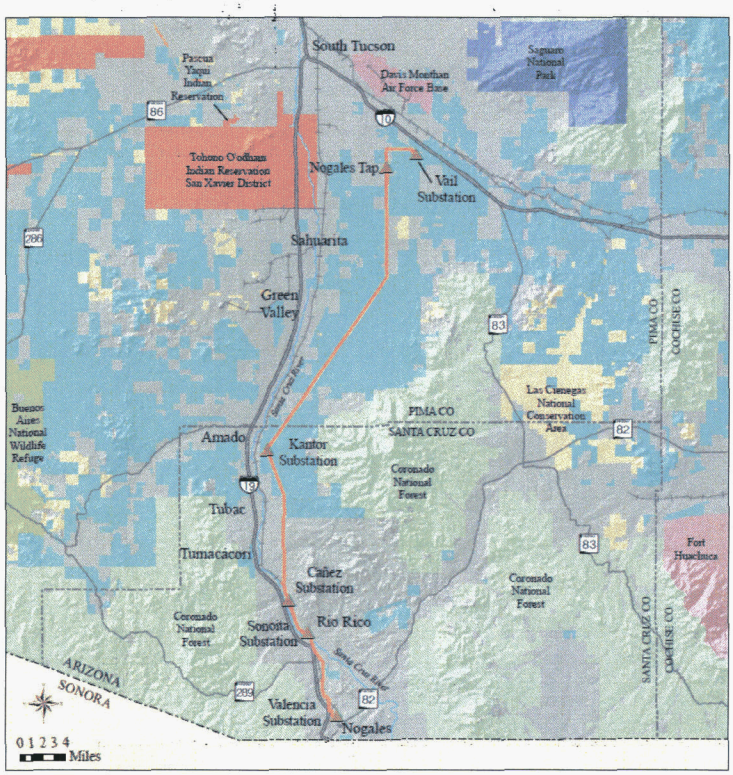


Continuity of Service Plan

Phase 1 - Vail to Valencia 115kV to 138kV Upgrade Project

The Continuity of Service Plan is broken up into two phases. Phase 1 is the Vail to Valencia 138kV Transmission Project and Phase 2 is the construction of additional local area generation in the City of Nogales. The Vail to Valencia 138kV Transmission Line will establish a 138kV link between Tucson Electric Power's Vail Substation and UNS Electric' Valencia Substation in Nogales. A map of the final approved route, which has been approved by the ACC, is shown below. Although much of the new line will follow the same route of the 115kV line it is replacing, portions of the project will follow a new alignment. New steel monopoles structures will be installed in the boundaries of 100-foot-wide right-of-way that will be required to build and maintain the transmission line. The final phase of this project includes transferring the point of interconnection of UNS Electric from Western's Nogales Tap switchyard to a future interconnection in UNS Electric's Vail Substation. Construction of this line is scheduled to be complete by the summer of 2014.

Map 11 – Phase 1 - Vail to Valencia 115kV to 138kV Upgrade Project

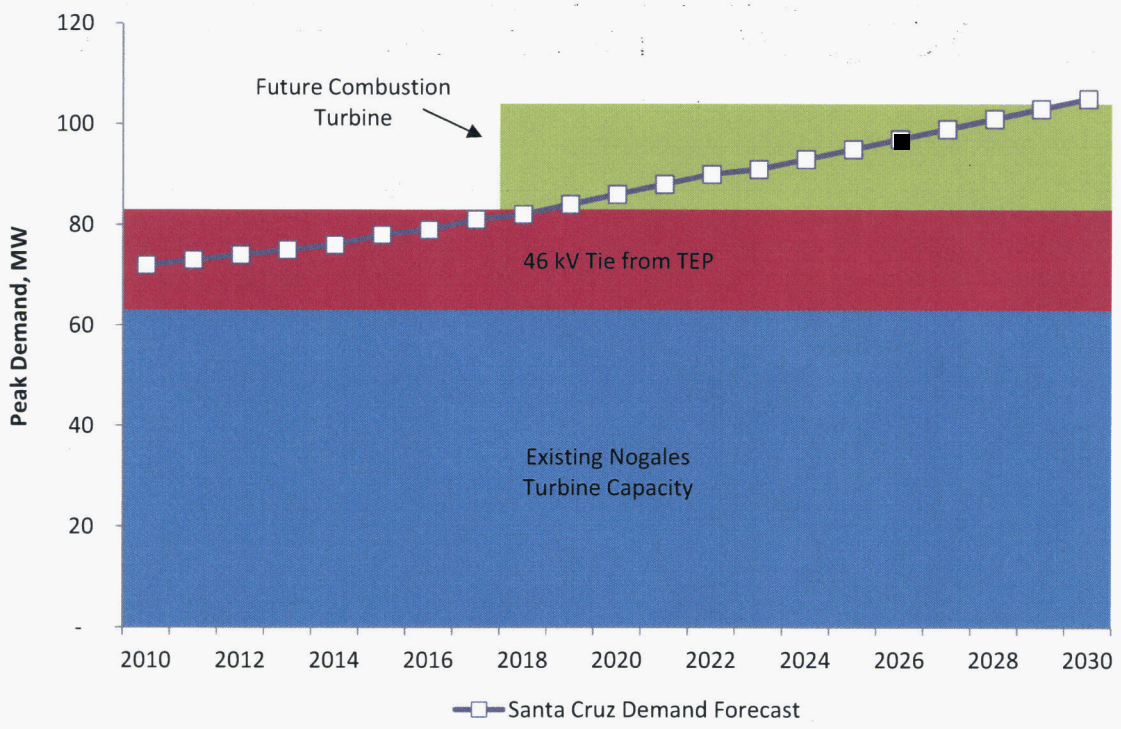


Continuity of Service Plan

Phase 2 – Local Area Combustion Turbine

Phase 2 of the Continuity of Service Plan, will require UNS Electric to build out additional local area generation in order to maintain reliable service to the City of Nogales during transmission outages. In order to maintain this continuity of service UNS Electric expects that a new gas fired CT will be built in 2018. The exact timing of this future resource is dependent on future load growth and the potential effectiveness of Santa Cruz county EE programs. UNS Electric will monitor Santa Cruz county load growth and will adjust its plans to install an additional turbine at the Valencia Power Plant as necessary.

Chart 23 - Santa Cruz Continuity of Service Forecast



Renewable Transmission Projects

UNS Electric supports the efforts to promote the development of Renewable Transmission Projects (RTP) to meet applicable future RES requirements. The RES capacity target for UNS Electric, which is approximately 70 MW of nameplate capacity by 2025, is likely to be met through future renewable resources that utilize the existing transmission infrastructure.

UNS Electric's participation and support of RTPs has been coordinated with the effort of UNS Electric in this process. Like UNS Electric, the most promising opportunities are in RTPs that increase transmission access for renewable projects that have delivery access to the Palo Verde Hub, Pinal Central, Tortolita, or southeast Arizona. For added details see the Tucson Electric Power 2012 IRP.

Transmission Resources Needed for New Generating Resources

For purposes of this resource plan, the resource planning group developed a set of transmission cost assumptions based on the list of potential generation resources. These generation resource options include the additional costs associated with any transmission improvements that would be required to connect the resources to the transmission system.

For example, some of the larger base load resource options are expected to be constructed far from the UNS service territory and would require significant transmission infrastructure improvements with the construction of the generation facility. Smaller generation facilities such as gas turbines would likely be constructed within the Kingman, Havasu or Nogales local areas and would require a much smaller interconnection investment. Finally, in addition to construction capital, the resource plan also includes the cost with the on-going O&M that is required to maintain these transmission facilities. These costs are also included and are factored into the total cost of each resource alternative.

Generation Interconnection Cost Assumptions

Table 12 summarizes the costs components for the substation interconnection, transmission construction and future operations and maintenance associated with each generating resource.

Table 12 - Generation Interconnection Costs and Assumptions

Transmission Assumptions Annual O&M Costs	Units	Aero-Derivative CT LMS 100	Aero-Derivative CT LM6000	Frame 7FA Combustion Turbine (CT)	Combined Cycle (CC)	Compressed Air Energy Storage (CAES)	Pulverized Coal	Integrated Coal Gasification Combined Cycle (IGCC)	Integrated Coal Gasification Combined Cycle (IGCC) with CCS	Nuclear
Voltage Level	kV	138	138	138	138-345	138	345	345	345	500
EHV Transmission O&M Costs/kW	2010 $/kW	$1.00	$1.00	$1.00	$2.50	$1.00	$3.50	$3.50	$3.50	$5.00
Annual EHV Transmission O&M Costs	$000	$90	$45	$160	$1,425	$1,000	$1,400	$2,100	$1,330	$5,000

Transmission Assumptions Project Capital	Units	Aero-Derivative CT LMS 100	Aero-Derivative CT LM6000	Frame 7FA Combustion Turbine (CT)	Combined Cycle (CC)	Compressed Air Energy Storage (CAES)	Pulverized Coal	Integrated Coal Gasification Combined Cycle (IGCC)	Integrated Coal Gasification Combined Cycle (IGCC) with CCS	Nuclear
Transmission Line Cost	$000/Mile	$1,200	$1,200	$1,200	$1,700	$1,200	$1,700	$1,700	$1,700	$2,600
Transmission Distance	Miles	1	1	1	50	25	100	400	400	150
Transmission Line Cost	$000	$1,200	$1,200	$1,200	$85,000	$1,200	$170,000	$680,000	$680,000	$390,000
Substation Interconnection	$000	$3,500	$3,500	$3,500	$5,700	$3,500	$5,700	$5,700	$5,700	$10,500
Total Interconnection-Transmission Cost	**$000**	**$4,700**	**$4,700**	**$4,700**	**$90,700**	**$4,700**	**$175,700**	**$685,700**	**$685,700**	**$400,500**

CHAPTER 8

Energy Efficiency

UNS Electric – Overview

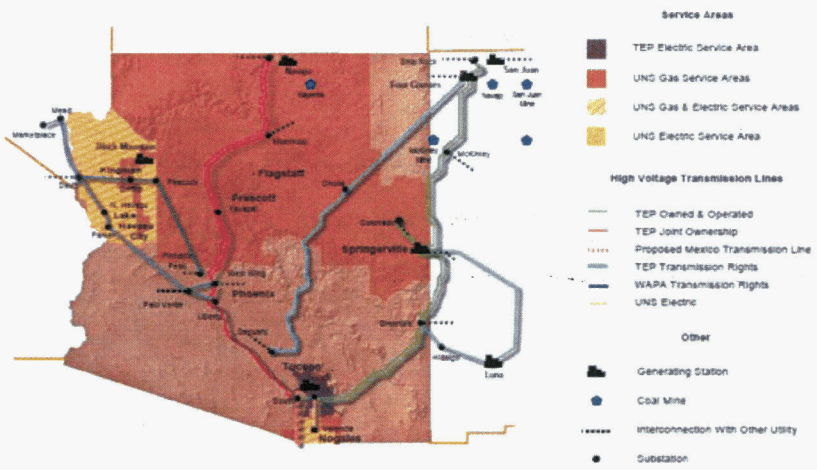
UNS Electric recognizes that EE can be a cost-effective way to reduce our reliance on fossil fuels. UNS Electric offers a variety of energy saving options for customers, from simple consultation to incentives that encourage both homeowners and businesses to invest in efficient heating and cooling and other EE upgrades.

UNS Electric is striving to achieve the aggressive goals in Arizona's (the EE Standard). The EE Standard calls on investor-owned electric utilities in Arizona to increase the kWh savings realized through customer ratepayer-funded EE programs each year until the cumulative reduction in energy achieved through these programs reaches 22 percent by 2020.

This section presents a detailed overview of the proposed electric DSM programs targeted at the residential, commercial and industrial ("C&I") sectors, as well as their associated proposed implementation costs, savings, and benefit-cost results.

UNS Electric, with input from other parties such as Navigant Consulting, Inc (Navigant) and the Southwest Energy Efficiency Project (SWEEP), has designed a comprehensive portfolio of programs to deliver electric energy and demand savings to meet annual DSM energy savings goals outlined in the Arizona Energy Efficiency Standard. These programs include incentives, direct-install and buy-down approaches for energy efficient products and services; educational and marketing approaches to raise awareness and modify behaviors; and partnerships with trade allies to apply as much leverage as possible to augment the rate-payer dollars invested. For context and reference, UNS Electric's service territory is shown in Figure 7.

Figure 7 - UniSource Energy Services Territory



2012 Implementation Plan, Goals, and Objectives

UNS Electric's high-level EE-related goals and objectives are as follows:

- Implement only cost-effective EE programs.
- Design and implement a diverse group of programs that provide opportunities for participation for all customers.
- Achieve goals which are cumulatively 3% of the 2011 electricity retail sales.
- When feasible, maximize opportunities for program coordination with other efficiency programs (e.g., Southwest Gas Corporation, APS) to yield maximum benefits.
- Maximize program savings at a minimum cost by striving to achieve comprehensive cost-effective savings opportunities.
- Provide UNS Electric customers and contractors with web access to detailed information on all efficiency programs (residential and business) for electricity savings opportunities at www.uesaz.com.
- Expand the EE infrastructure in the state by increasing the number of available qualified contractors through training and certification in specific fields.
- Use trained and qualified trade allies such as electricians, HVAC contractors, builders, architects and engineers to transform the market for efficient technologies.
- Inform and educate customers to modify behaviors that enable them to use energy more efficiently.

Planning Process

UNS Electric's portfolio of programs incorporates elements of the most successful EE programs across North America. Where possible, many of the program designs were enhanced to further incentivize the Tucson market area and UNS Electric customers in particular. A substantial amount of information including evaluations, program plans and potential studies were used to develop specific programs for UNS Electric. With input from Navigant and SWEEP, UNS Electric also used a benchmarking process to review the most successful EE programs from across the country, with a focus on successful Desert Southwest programs to help shape the portfolio.

Portfolio Risk Management

Arizona is in the process of recovering from economic setbacks. In this economic environment, UNS Electric's ability to attract residential and business customers to voluntarily take on additional expenses for the installation of cost-effective measures, even with very short pay-back periods, continues to be a challenge. UNS Electric recognizes this challenge and has developed a portfolio of programs that provide opportunities for participation at multiple levels. By proposing a multi-faceted and broad portfolio of programs, UNS Electric will attempt to capitalize on those sectors of the market willing to invest in EE regardless of the challenging economic landscape. In balance, this will allow us to meet aggressive regulatory EE goals.

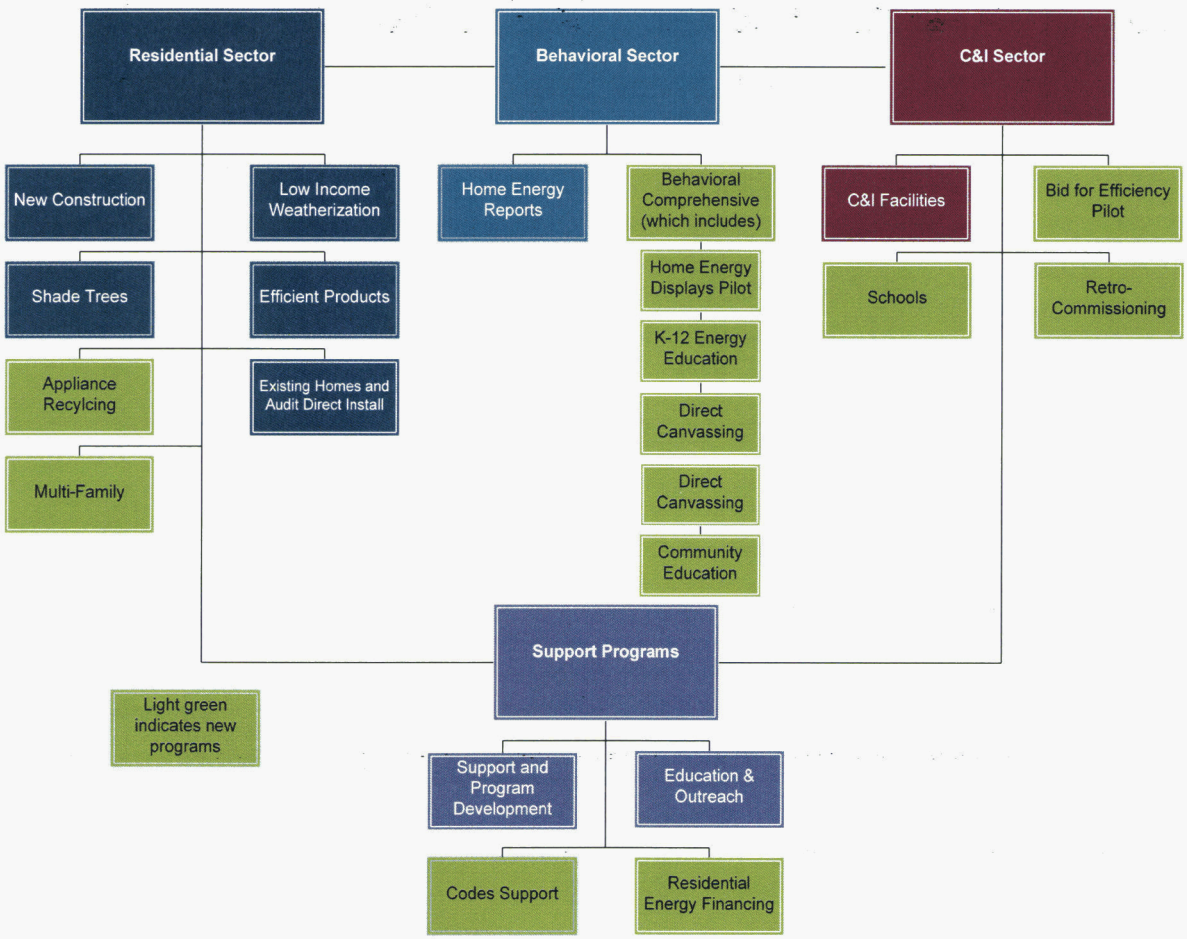
UNS Electric used the following strategies to minimize the risks and produce the lowest cost portfolio of EE programs:

- Implementing primarily "tried and true" programs that have been successfully applied by other utilities in the Southwest and across the country.
- Implementing programs through a combination of third-party contractors and UNS Electric staff. UNS Electric designs programs on the most cost-effective basis utilizing implementation contractors where they provide the lowest cost per kWh and likewise utilizing UNS Electric staff when appropriate.

Program Portfolio Overview

As demonstrated in Figure 8, UNS Electric's portfolio of programs can be divided into residential, commercial, behavioral, and support sectors with administrative functions providing support across all program areas.

Figure 8 - UNS Electric Portfolio of Programs



Savings, Budgets, and Benefit-Cost Results Overview

In January 2011, UNS Electric submitted a two-year Implementation Plan (2011-2012) to meet the requirements of the Energy Efficiency Standard. While the 2011-2012 Implementation Plan presents a two-year portfolio of investment consistent with the requirements of the Energy Efficiency Standard, UNS Electric will continue to monitor projected program funding and program participation. As such, we expect there may be some slight adjustments in the forecasted investment levels. While the focus of this IRP is a 15-year outlook on utility resources from 2012-2027, UNS Electric chose to include the 2011 projections of the joint two-year Implementation Plan (2011-2012) that was filed to meet the savings targets of the Energy Efficiency Standard. Since the date of the 2011-2012 Implementation Plan filing, UNS Electric has updated its electricity retail sales forecast, which adjusted the incremental annual MWh savings requirement to meet the Standard for 2012 accordingly.

Additionally, incentive levels and other program elements will be reviewed and modified on an annual basis to reflect changes in market conditions or implementation processes in order to maximize cost-effective savings. Such modifications will be reported in the annual reports submitted to the ACC.

As detailed in Table 13, UNS Electric has developed this plan with the intent of meeting statutory electric savings goals as a percentage of prior year retail sales as outlined in Energy Efficiency Standard Section R14-2-2418 in the ACC Rules. For 2011, UNS Electric's budget forecast was $3.4 million increasing to $5.5 million in 2012.

Table 13 - Energy Efficiency Implementation Plan Summary Costs and Savings

Program Year	Total Program Budget ($000)	Annual Savings (MWh)	Lifetime Savings (MWh)	Total Net Benefits ($000)	Portfolio Societal Costs
2011	$3,357	14,067	113,153	$3,677	2.0
2012	$5,450	30,077	206,315	$5,955	2.1
Total	**$8,807**	**44,145**	**319,5468**	**$9,632**	**2.0**

As noted in Table 14, the 2011 Energy Efficiency Standard target was 1.25% savings as a percent of sales of the previous calendar year; for 2012 this increases to 1.75%, but the cumulative target by 2012 is 3.00% savings. UNS Electric believes it is prudent to factor project fall-out and delay in approval to achieve the Energy Efficiency Standard goals.

Table 14 - Planned Savings and Energy Efficiency Standard Target Savings based on Implementation Plan

Targets	2011	2012
MWh Savings (required by Energy Efficiency Standard)	23,215	34,856
Planned MWh Savings	14,067	30,077
Planned Savings (% of Retail Sales of prior year)	0.76%	2.31%
% of Planned Savings Goal Achieved (Incremental Year)	61%	89%

Note: MWh Savings include line loss reductions created from energy reductions which are not included in the Authorized Revenue Requirement True-up.

Review of Different Benefit-Cost Tests and Results

Program development involves selecting the technologies to include in each program as well as estimating participation levels and program costs. Though the DSM portfolio must be cost-effective, there are a number of perspectives on cost effectiveness. Some of these alternative perspectives are described below.

As detailed in Table 15 - Comparative Benefit-Cost Tests, there are five major benefit-cost tests commonly utilized in the EE industry, each of which addresses different perspectives. The Arizona Energy Efficiency Standard established that the societal cost test should be used as the key perspective for judging the cost-effectiveness of the EE measures and programs. Regardless of which perspective is used, benefit-cost ratios greater than or equal to 1.0 are considered beneficial. While various perspectives are often referred to as tests, the following list of criteria demonstrates that decisions on program development go beyond a pass/fail test.

Table 15 - Comparative Benefit-Cost Tests

	SOCIETAL TEST	TOTAL RESOURCE COST TEST	UTILITY RESOURCE COST TEST	PARTICIPANT COST TEST	RATE IMPACT MEASURE TEST
BENEFITS					
Reduction in Customer's Utility Bill				✓	
Incentive Paid by Utility				✓	
Any Tax Credit Received		✓		✓	
Avoided Supply Costs	✓	✓	✓		✓
Avoided Participant Costs	✓	✓		✓	
Participant Payment to Utility			✓		✓
External Benefits	✓				
COSTS					
Utility Administration Costs	✓	✓	✓		✓
Participant Costs	✓	✓		✓	
Incentive Costs			✓		
External Costs	✓				
Lost Revenues					✓

Although UNS Electric is only required to analyze its programs using the SCT, the Company evaluated the cost-effectiveness of its measures, programs, and overall portfolio based on all of the following standard tests.

Utility Resource Cost Test

The Utility Resource Cost Test (UCT), also referred to as the Program Administrator Test (PAT), measures the net benefits of a DSM program as a resource option based on the costs and benefits incurred by the utility

(including incentive costs) and excluding any net costs incurred by the customer participating in the efficiency program. The benefits are the avoided supply costs of energy and demand, the reduction in transmission, distribution, generation and capacity valued at marginal costs for the periods when there is a load reduction. The costs are the program costs incurred by the utility, the incentives paid to the customers, and the increased supply costs for the periods in which load is increased.

Total Resource Cost

The Total Resource Cost (TRC) is a test that measures the total net resource expenditures of a DSM program from the point of view of the utility and its ratepayers. Resource costs include changes in supply and participant costs. A DSM program that passes the TRC test (i.e., has a ratio greater than 1) is viewed as beneficial to the utility and its customers because the savings in electric costs outweigh the DSM costs incurred by the utility and its customers.

Participant Cost Test

The Participant Cost Test (PCT) illustrates the relative magnitude of net benefits that go to participants compared to net benefits achieved from other perspectives. The benefits derived from this test reflect reductions in a customer's bill and energy costs plus any incentives received from the utility or third parties, and any tax credit. Savings are based on gross revenues. Costs are based on out-of-pocket expenses from participating in a program, plus any increases in the customer's utility bills.

Rate Impact Measure Test

The Rate Impact Measure (RIM) Test measures the change in utility energy rates resulting from changes in revenues and operating costs. Higher RIM test scores indicate there will be less impact on increasing energy rates. While the RIM results provide a guide as to which technology has more impact on rates, generally it is not considered a pass/fail test. Instead, the amount of rate impact is usually considered at a policy level. The policy level decision is whether the entire portfolio's impact on rates is so detrimental that some net benefits have to be forgone.

Societal Cost Test

The SCT is similar to the TRC test, but it is also intended to account for the effects of externalities (such as reductions in CO_2, nitrogen oxides (NOx), and sulfur dioxide (SO_2). One additional difference between the TRC and the SCT is that the SCT uses a societal discount rate in the analysis. The SCT is the regulated benefit cost analysis required in the Standard and UNS Electric has provided a SCT that accounts for the societal discount rate. UNS Electric is however, unable to provide a true societal test given the uncertain values of environmental externalities. UNS Electric will work with stakeholders to develop appropriate metrics for and to monetize the costs of water, SO_2, PM_{10} and NO_x emissions savings as part of the societal cost test in program filings. Until a true market value is available for CO_2, the Company will not separately monetize carbon. In compliance with ACC Decision No. 72028 (December 12, 2010), UNS Electric filed the societal costs as the results of the stakeholder meetings.

Residential Energy Efficiency Programs

Residential New Construction

The Residential New Construction Program is a continuation of an existing program designed with an incentive structure that awards larger incentives for more efficient homes. To qualify for an incentive, homes must be tested by an approved energy rater, and meet one of the three tiers in the program based on a Home Energy Rating System (HERS) Index score. On the HERS index scale, a score of 100 is considered the average efficiency of baseline new construction. A HERS index score of 0 represents a home that produces all of its energy through on-site generation from renewable energy. Therefore, the lower the HERS score, the more efficient the home. Tier 1 requires a minimum of a HERS that is less than or equal to 85, Tier 2 requires a minimum of HERS that is less than or equal to 70, and Tier 3 requires a minimum of HERS that is less than or equal to 45. The objectives of the residential new construction program are to advance energy efficient building practices through builder training, and customer awareness of the benefits of energy efficient construction, combined with application of and renewable technologies, such as solar photovoltaic and solar hot water systems consistent with achieving the goals of Arizona Renewable Portfolio Standard.

Existing Homes and Audit Direct Install

The Existing Homes and Audit Direct Install Program is a newly approved program that replaces the former Residential HVAC Retrofit Program. The program is targeted to all existing homes in need of EE improvements. The program has two components: an initial energy audit with direct install of compact fluorescent light bulbs (CFLs) and advanced power strips, followed by identification of actionable, larger scale home EE improvements and referral to local Building Performance Institute (BPI) certified contractors to implement major home energy improvements such as insulation, air-sealing and high efficiency HVAC equipment.

The program achieves energy and demand savings from the installation of energy efficient measures and contributes toward transforming the residential building industry to emphasize best practice building science principles. The program invests in training and mentorship programs with contractors to empathize energy efficient building science techniques to achieve BPI certification. UNS Electric has included a Residential Financing Pilot Program in its 2011-2012 Implementation Plan, which will be used to enhance participation in this program.

Shade Tree

The Shade Tree program is an ongoing environmental element of the program portfolio. The program promotes energy conservation and environmental benefits by motivating customers to plant desert-adapted trees in targeted locations where the trees will provide shade to habited dwellings, thus reducing cooling load. UNS Electric partners with Trees for Tucson, a local non-profit organization that manages and administers the program. The objectives of the program are to promote the strategic planting of trees to provide shade, thereby reducing the cooling load of homes and associated energy usage, and to educate school-age children and the public on the conservation and environmental benefits of planting trees.

Low Income Weatherization

The Low Income Weatherization Program helps conserve energy and lower utility bills for UNS Electric households with limited incomes by funding the weatherization of eligible homes. Weatherization measures fall into four major categories of duct repair, pressure management/infiltration control, attic insulation, and repair or replacement of non-functional or hazardous appliances. Weatherization is conducted in accordance with the Weatherization Assistance Program (WAP), a program funded by the DOE. Household income and participation guidelines will be consistent in an on-going manner with current policy criteria used by the Arizona Energy Office, a division of the Arizona Department of Commerce. UNS Electric is requesting budget approval to continue this program and approval to modify income eligibility from 150% of poverty level to match the poverty level set by Low-Income Home Energy Assistance Program (LIHEAP) as it may change from time to time. The current level set by LIHEAP is 200% of poverty level. UNS Electric coordinates with the Arizona Energy Office to follow approved state WAP rules when using funding from UNS Electric, to lower the average household energy consumption for low-income customers and to increase the number of homes weatherized annually. The program funding provides up to $3,000 per residence for energy efficient weatherization measures, equipment replacement and/or repair, etc. for low-income customers within the UNS Electric service area. Agencies are allowed to use up to 25% of their annual budget for Health and Safety related repairs. Agencies may request a waiver of the $3,000 limitation on a case-by-case basis.

Efficient Products

This is an existing program previously known as the CFL Buy-Down Program that is now being re-named to recognize that it will serve as the delivery channel to address other efficient products beyond CFLs, and rebated through the major retail channels. This program promotes the purchase of energy efficient retail products through in-store buy-down promotions. Starting in 2012, energy efficient pool pumps, pool timers, residential LED lighting, and advanced power strips will be promoted, in addition to currently promoted CFLs.

Appliance Recycling

The Appliance Recycling Program will target the removal and recycling of operable second refrigerators and freezers. An appliance recycling contractor will provide implementation services that include verification of customer eligibility, scheduling of pick-up appointments, appliance pick-up, and recycling services. The objective of the program is to produce long-term electric energy savings in the residential sector by permanently removing operable second refrigerators and freezers from the power grid and recycling them in an environmentally safe manner.

Multi-Family

The Multi-Family Program is a new program offering for the UNS Electric's 2012 program portfolio and will target multi-family buildings with 5 dwelling units or greater. The Program will recruit multi-family building owners to participate in a direct-install campaign to install CFLs and low-flow water devices in individual units. Multi-family facility managers will also be referred to the Small Business Direct Install program to encourage measure installation for the common areas.

Due to various market barriers, such as split incentives, capital constraints, and lack of awareness, EE improvements typically fall far below other types of improvements on the priority list. Although the current rebate programs offer some opportunities for EE improvements in this market, primarily through the Efficient Products Program, there is not a comprehensive offering that addresses the unique needs of this market.

Through the direct installation, and renovation/rehabilitation implementation framework, this program seeks to fill this important gap in the UNS Electric program portfolio and provide substantial energy savings.

The objectives of the program are to reduce peak demand and overall energy consumption in the multifamily housing market segment; to promote EE retrofits of both dwelling units and common areas in this market segment; and to increase overall awareness about the importance and benefits of EE improvements to the landlord and property ownership community.

Commercial and Industrial (C&I) Programs

The following section presents a summary of UNS Electric's Commercial and Industrial ("C&I") programs including new programs and enhancements to existing programs.

C&I Facilities

The UNS Electric C&I facilities program parallels the TEP Small Business Direct Install Program in many ways. It is an existing program that offers incentives for a select group of retrofit ("RET") and replace-on-burnout ("ROB") EE measures in existing facilities. Eligible customers include small and large commercial customers. The program offers incentives for the installation of energy-efficiency measures including lighting equipment and controls, HVAC equipment, motors and motor drives, compressed air and refrigeration measures. In order to increase program participation, UNS Electric is requesting approval to remove the $10,000 incentive cap and the restriction that only two large commercial customers can participate at a limit of $50,000 incentive cap each year. These limiting components of the approved program negatively impact participation and prevent UNS Electric from reaching participation goals.

The C&I Facilities program is designed to address the barriers to this market segment, including limited investment capital, limited awareness of energy cost savings, and required short-term payback. The program's purpose is to persuade small business customers to install high-efficiency equipment at their facilities and encourage contractors to promote the program.

There are about 50 unique existing and new measures, through which incentives are offered to large business customers in UNS Electric's service territory, including:

- Coin Operated Clothes Washers
- Advanced Power Strips
- Refrigerator Displays, Gaskets, Door Closers
- Ice Makers and Reach-In Refrigerators
- Strip Curtains and Night Covers
- LED Pedestrian Signals and Traffic Lights
- LED Street and Parking Lights
- Induction, LED, CFL and Advanced Lighting Technology
- Heat Pump Water Heaters
- CO_2 Sensors, CO Sensors
- Shade Screens, Window Films
- Air Conditioners and Heat Pumps
- Efficient Motors and Variable Speed Drives
- Custom Measures

Bid for Efficiency – Pilot Program

The Bid for Efficiency (BFE) Pilot Program is designed to take an innovative approach towards EE by using elements of competition and the potential for high rewards to enhance customer interest. The BFE concept creates a pool of funds that is bid on through unique customer-driven proposals which include costs, savings and incentives. UNS Electric selects winning applicants based on specified criteria.

The BFE concept is an innovative approach that is being successfully deployed in other utilities' EE programs, and will encourage creativity in designing system-optimized energy use reduction. BFE participants and project sponsors may include commercial customers, ESCOs or other aggregators who organize proposals that involve multiple sites.

This program addresses customer market barriers such as small savings levels at multiple sites, longer payback periods and difficulty in organizing implementation contractors. Results will be verified through MER activity. UNS Electric will begin implementing this program in 2012 through the 2013 timeframe. Pilot results will be evaluated in 2013. If the market response and measure savings indicate the program is cost effective, UNS Electric will include the full program offering in its 2014 EE implementation plan.

School Facilities

UNS Electric is requesting budget approval for a new School Facilities program that will be open to participation by all existing school facilities in the UNS Electric service territory, including charter schools, beginning in 2012. The primary goal of the program is to encourage schools in UNS Electric's service territory to install EE measures in existing facilities. More specifically, the program is designed to:

- Encourage schools to install high-efficiency lighting equipment and controls, HVAC equipment, and energy-efficient refrigeration system retrofits in their facilities.
- Encourage contractors to promote the program and provide turn-key installation services to schools.
- Assure that the participation process is clear, easy to understand and simple.
- Increase the awareness and knowledge of school facility managers and other decision-makers on the benefits of high-efficiency equipment and systems.

Since 2008, participation by schools in the UNS Electric C&I Facilities Program has been modest. In order to increase participation in EE retrofits by schools, UNS Electric has developed this Program, which proposes to fund up to 100% of installed costs while engaging the contractor community to provide turn-key services. This is a 15% increase from the 85% allowed in the UNS Electric C&I Facilities Program. The Schools Program will follow the design of the UNS Electric C&I Facilities Program because the direct-install concept has a proven track record of high participation and cost-effective life cycle savings for hard-to-reach markets, including schools.

Retro-Commissioning

UNS Electric is requesting budget approval for a new Retro-Commissioning (RCx) program to be implemented in 2012. The Retro-Commissioning program would use a systematic approach to identify building equipment and processes that are not achieving optimal performance or results in existing facilities. Eligible program applicants will receive free screening energy audits. Participants will also receive training to ensure proper operating and maintenance practices over time.

The program seeks to generate significant savings for DSM portfolio objectives by tapping into energy savings opportunities in existing commercial and industrial facilities. The program will deliver customer benefits by lowering energy bills and improving building performance and occupant comfort while reducing maintenance calls. The program will also facilitate the development of an RCx contractor pool, and will enable UNS Electric to develop relationships with commercial and industrial customers leading to other areas of participation in UNS Electric's portfolio of DSM programs. RCx programs in other utility service territories have been shown to deliver average facility savings in the range of 5-15% per facility, and measures implemented as a result of program activity typically pay for themselves in savings in less than two years.

Behavioral Energy Efficiency Programs

Behavioral Energy Efficiency programs are designed to affect habitual behaviors like turning off lights or adjusting the thermostat, purchasing behaviors such as buying efficient lights and appliances, and the behavior of participating in utility DSM programs. More specifically, the types of behaviors to be influenced include:

- Habitual Behaviors
  - » Adjust thermostat setting
  - » Turn off unnecessary lights
- Small Purchasing and Maintenance Behaviors
  - » Purchase and install faucet aerators and low flow shower heads
  - » Purchase and install CFLs
  - » HVAC maintenance
- Larger Purchasing Decisions
  - » Purchase an ENERGY STAR appliance
  - » Purchase higher EE heating and cooling system through participation in a UNS Electric DSM program

UNS Electric proposes for the 2011-2012 program year portfolio two different offerings to affect habitual behaviors: Home Energy Reports, direct-mail reports that inform customers about their energy consumption patterns and behaviors, and the Behavioral Comprehensive Programs, a suite of five delivery mechanisms to achieve EE objectives, as shown in Table 16.

Table 16 - Summary of Behavioral Energy Efficiency Programs

Behavioral Energy Efficiency Programs	
Offering 1: Home Energy Reports	
Home Energy Reports	Comparison of energy use to that of neighbors
Offering 2: Behavioral Comprehensive Programs	
Direct Canvassing	Door to door awareness and direct install campaign
K-12 Education	Classroom education including take home direct install kits
Community Education	"Train the trainer" approach and give away direct install kits
In Home Energy Use Monitors	A sub-pilot of the smart meter program, displays provide near real time usage information
CFL Giveaway	CFL giveaways at outreach events

Home Energy Reports

The Home Energy Report program is designed to affect: (1) habitual behaviors like turning off the lights or adjusting the thermostat; (2) maintenance behaviors such as changing furnace filters and cleaning refrigerator coils; and (3) purchasing behaviors such as buying efficient light bulbs and appliances as well as participation in DSM programs. The program influences behavioral change in customers to reduce their energy consumption through targeted and comparative education and awareness of their energy consumption compared to others. The Home Energy Report does so through monthly or quarterly direct-mail reports on energy consumption and tips on how to save energy, at no cost to the customer. Making customers aware of their energy consumption patterns, especially in comparison with those of the other customers, has been shown to inspire behavioral changes toward EE.

This program will be offered to a select group of residential customers and phased in at four levels. UNS Electric expects the target group of customers to be chosen based on their historical energy use (higher than average energy use). UNS Electric expects this group to include customers who display an annual consumption of 15,000 kWh or more for Phase 1 (15,000 customers with a control group). In Phase 2, first year program participation will be evaluated and the program refined according to findings, while in Phase 3 (2nd program year), participation is planned to increase to 20,000 customers. Finally, in Phase 4, an independent MER evaluation is planned.

The major objectives from this program are to: generate significant savings for DSM portfolio objectives; educate and empower customers to take advantage of other DSM programs; promote efficient building operations; and lower energy bills for consumers.

Behavioral Comprehensive Programs

The Behavioral Comprehensive program is meant to address the fact that technology-based EE achieves only a finite amount of efficiency potential. The barriers to wider-spread implementation of EE are sociological, not technological. The suite of five programs approaches such sociological barriers using different avenues, such as schools, community organizations, and technology:

Direct Canvassing
The direct canvassing initiative is a grassroots, door to door approach in which volunteers from local community organizations are trained and deployed to go door-to-door and talk to customers about EE. Customers receive two CFLs as well as program materials for appropriate UNS Electric DSM programs. This approach capitalizes on the sociological research which shows people are more likely to take action when the information is delivered by a trusted source, such as a member of their own community.

K-12 Education
The K-12 Education approach is an extension of the existing UNS Electric education program. In this approach, in addition to energy-based classroom curriculum, students will be instructed in energy saving approaches that can be implemented in their homes. Students will be provided a take home kit which includes several energy saving devices such as CFLs, refrigerator thermometers, and educational materials regarding actions that can be taken to reduce energy use.

In-Home Display Pilot
The In-Home Display Pilot Program works by providing a digital display that show customers their individual current cost of energy in cents per hour and their cumulative cost for the month. The program makes customers aware of their energy consumption with instant, easy-to-access information. It also allows them to monitor changes in household energy usage as they choose behavioral modifications suitable for their individual lifestyle. The concept is simple: once customers are able to identify energy savings after making behavioral modifications, sociological instincts take over and customers are induced to use less energy. Providing feedback in this and other forms such as home energy reports have been demonstrated to provide real and measurable savings. UNS Electric will evaluate and report any reduction in energy consumption and will recommend continuation of the program pending positive results showing this as a cost-effective option producing measurable energy savings.

Community Education
The Community Education Program will engage community groups and work with public entities on "train the trainer" hands-on EE seminars. Community trainers will be given a broad-based review of energy, EE, and comfort principles. This creates a level of understanding which dovetails into identifying specific actions and behaviors to reduce energy consumption at home, work or play. Community groups such as the Metropolitan Energy Commission, the Sonoran Environmental Research Organization, and other neighborhood organizations are engaged both to identify mentors to be trained and to schedule sessions led by these mentors for community members on a grassroots level. The seminars include hands-on training with a wide sample of materials such as weather stripping, low flow showerheads, caulk or foam sealant, CFL's, etc. provided to participants.

CFL Give-Away
The CFL Give-Away program will complement UNS Electric's presence at community events, its overall education and outreach efforts, and efficiency messaging. Free CFLs will be made available at community events and to community organizations such as those involved in our Community Education Program. Flexibility to add methods and develop partnerships to aid in the distribution of these bulbs is a program design element which will enhance program effectiveness over its lifespan.

Support Programs

Support programs cut across residential and commercial program areas and provide technical and financial support for the effective implementation of all other programs.

Education and Outreach (E&O)

The program consists of education and marketing intended to inform customers about the benefits of energy conservation and to inform those customers on how to achieve energy savings. All components of this program are a continuation of current program offerings. Components of the E&O programs include:

- General Energy Efficiency advertising component to cover seasonal ad's that encourage energy savings through energy saving tips, marketing the on-line energy audit, and marketing other EE programs to customers;

- On-Line Energy Audits and Carbon calculator on UNS Electric website that will be part of the Behavior Energy Efficiency Program offering;
- Academic Education that is anticipated to be part of the Behavioral Energy Efficiency Program offering;
- Time-of-Use education to teach residential and small commercial customers about the benefits of TOU rates and enable customers to maximize savings through load shifting; and
- Program evaluation.

Because the aim of this program is to change behavior it is difficult to objectively assess cost effectiveness or measure actual energy or environmental savings. However, since it is anticipated to consist only of education and marketing, this program does not require a cost-effectiveness test.

Energy Codes Enhancement Program (ECEP) – Pilot

The Energy Codes Enhancement Program (ECEP) will strive to maximize energy savings through adherence to local building energy codes across the local jurisdictions within UNS Electric service area through a variety of activities. Activities can include participation in energy code adoption committees and providing public testimony in support of codes before city councils.

The program will employ a variety of tactics aimed at: 1) improving levels of compliance with existing building energy codes; and 2) supporting and informing periodic updates to energy codes as warranted by changing market conditions. Specific program activities will depend on the market needs expressed by local code officials and are likely to include a combination of efforts to:

- Better prepare code officials and building professionals to adhere to existing standards;
- Provide data and market insight to document the specific local benefits of code enforcement, and inform energy code changes over time;
- Ensure utility incentive programs align well with local energy codes;
- Collaborate with relevant stakeholders to help build a more robust community working to advance strong and effective building energy codes across local jurisdictions; and
- Advocate for energy code updates over time.

Residential Energy Financing

The Financing Program will provide customers with the capital needed (through loans) to make cost-effective EE upgrades to their homes and is anticipated to improve customer participation as well as expand the pool of customers that can afford to participate in EE programs. Loan proceeds can be used for EE measures that have been approved by the ACC as part of the Existing Homes/ Direct Install Program.

The Residential Financing Program's objective is to offer low interest unsecured loans for up to $15,000 per home for EE measures installed in existing homes. UNS Electric anticipates starting the Residential Energy Financing Program with a two year pilot program which will allow sufficient time to evaluate the program, including participation, default rates, and overall value to customers.

The program may also offer classroom training sessions for contractors and building professionals who will offer the financing program to customers, collaborate with the SWEEP and other regional groups to support research on utility financing programs; and work together with APS and Southwest Gas to determine a plan to 'partner' on financing programs offered in joint territories with different financing partners.

2012 Resource Planning Integration

DSM Forecasting

Consistent with the ACC's Decision No. 71435 on Resources Planning, UNS Electric forecasted cumulative energy savings for UNS Electric's DSM portfolio over a 15-year time period from 2012 – 2027 towards meeting Arizona's Energy Efficiency Standard. UNS Electric prepared a monthly energy savings distribution for a full calendar year's annual savings impacts that results from the implementation of the 2012 DSM programs then projected forward. This was done to showcase how the savings from the Implementation Plan at the program-level would be spread throughout a year. In addition, UNS Electric prepared a monthly peak savings distribution for a full calendar year's savings from the programs to incorporate how coincident peak reduction impacts the UNS Electric's system load and gets factored into resources planning. Energy efficiency forecasts for UNS Electric were projected over a 15-year time period (2012 – 2027) that coincides with the Standard requirement of 22% cumulative energy savings by 2020.

Methodology

In order to integrate the savings impact of UNS Electric's portfolio of DSM programs into 15-year planning horizon, UNS Electric determined the hourly savings of each individual EE measures and then aggregated them at the portfolio-level by customer rate class. The hourly savings resolution can be summed into monthly energy and peak demand savings.

UNS Electric carefully considered all available resources and options for determining EE measure hourly level savings data. One option was to conduct long-term end-use metering and analysis for the measures installed at customer premises, which would be multi-year projects and very costly. Another option was to utilize data made available from national and other state-level funded multi-year studies and research that incorporated best practices for determining hourly level measure savings. UNS Electric found this latter option to be more prudent given the time sensitivity and expense.

UNS Electric relied upon 8,760 hourly savings load shapes taken from the most widely referenced and recognized industry sources for individual EE measures that comprised each particular DSM program. These sources include California's Database for Energy Efficient Resources (DEER), which is developed by the California Public Utilities Commission; California's Commercial End-Use Survey (CEUS), which was prepared by Itron, Inc for the California Energy Commission in cooperation with California's investor-owned utilities (i.e., Pacific Gas and Electric, San Diego Gas and Electric, Southern California Edison, Southern California Gas Company) and the Sacramento Municipal Utilities District; and the Building America – National Residential Efficiency Measures Database, which is developed by the National Renewable Energy Laboratory (NREL) with support from the DOE. These load shapes were developed through extensive building end-use metering and energy simulation modeling and were normalized for historical weather conditions and patterns applicable to particular climate regions. The load shapes selected from these sources targeted the residential and customer sectors separately with different building end-uses that relate to the EE measures in the programs. UNS Electric selected the load shapes carefully to account for seasonal or diurnal variations in operational or end-use patterns for different measures. UNS Electric utilized the CA-based DEER and CEUS load shapes only as a means to develop 8,760 hourly shaping on the EE measures. The annual savings values that will be attributed to these hourly savings load shape are calculated specifically for UNS Electric's programs through program design and third-party Measurement, Evaluation, and Research (MER).

Since the weather-sensitive EE measure load shapes from DEER and CEUS were developed for California, UNS Electric had to apply adjustment factors appropriate for its particular service territory in Arizona. First for weather calibration purposes, UNS Electric utilized typical meteorological year (TMY3) weather data for major jurisdictions in its service territory (i.e., Kingman, Lake Havasu City, and Nogales) and compared those to the load shapes developed for CA's Climate Zone 15, which is the closest geographically as well as the most compatible weather region in CA to the major jurisdictions in UNS Electric's service territory, and then adjusted hourly indexed values as needed. This approach of weather calibration ensures that weather-sensitive EE measures that have seasonal or diurnal variations in energy savings would have the appropriate effect for UNS Electric's climate region. Furthermore, the TMY3 weather data sets, which were developed by NREL with support from DOE, are based on climate data from a period from 1991-2005. Utilizing recent historical weather data helps to weather normalize the savings effects of weather-sensitive EE measures at the hourly level. The Building America database included measure savings load shapes developed utilizing TMY3 weather data for the major jurisdictions (i.e., Kingman, Lake Havasu City, and Nogales); therefore, no such weather adjustments were needed for these load shapes.

After determining the measure shapes, UNS Electric was able to apply a measure's annual energy savings value with the appropriate measure end-use load shape to determine a unique measure-specific savings load shape. UNS Electric was then able to aggregate the hourly savings value for all given measures in a particular program to determine a program-level savings load shape. From these composite program-level savings load shape, UNS Electric is able to apply its definition of peak periods to determine coincident and non-coincident peak demand savings.

Additionally, to determine long-term cumulative energy savings forecasted on the 15-year time-frame, UNS Electric multiplied the effective measure life for each particular measure to the measure's annual energy savings value and aggregated these cumulative savings at the program-level and portfolio-level. The end result of the aggregation is a 15-year outlook on how the total incremental program year savings will carry out through the effective measure lives of all the measures that comprise the programs.

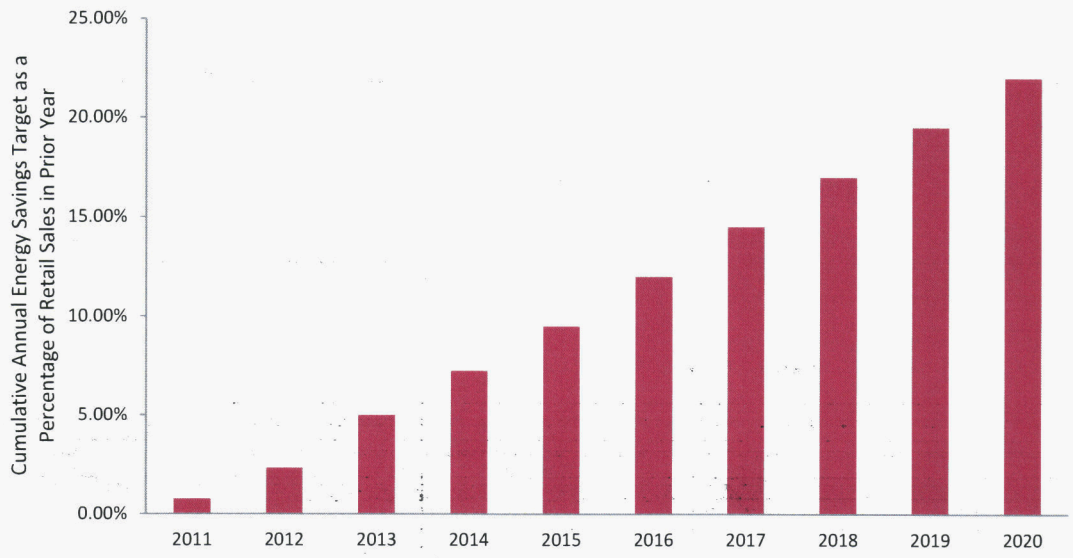
While the focus of this IRP is on future resources planning, UNS Electric also acknowledges the importance of attributing verified savings values for individual measures and programs from Measurement, Evaluation, and Research (MER) results. UNS Electric has retained the services of Navigant to serve as the MER contractor for UNS Electric's portfolio of DSM programs. Navigant verifies energy savings for the programs utilizing the most rigorous industry evaluation standards and protocols as outlined by sources such as the International Performance Measurement and Verification Protocol (IPMVP) and Federal Energy Management Plan (FEMP).

Load Shape Results

The hourly savings determined through the Methodology Section above allowed UNS Electric to forecast annual energy and peak demand savings for UNS Electric's 2012 portfolio of DSM programs both to determine a 15-year outlook on resources and to meet the Energy Efficiency Standard savings targets by 2020.

The cumulative annual energy savings from the implementation of the 2012 DSM programs and prior 2011 programs contributing to the Energy Efficiency Standard are shown in the following figure.

Figure 9 - Cumulative Annual Savings Impacts through 2020



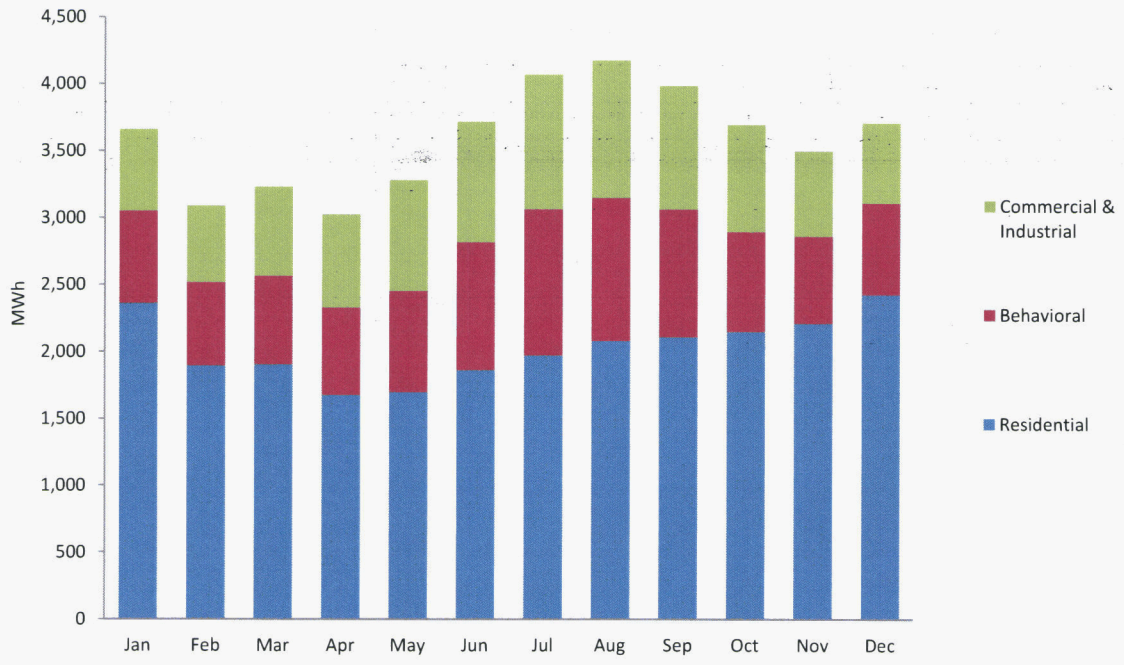
UNS Electric chose to include the savings impact from 2011 due to the fact that the Energy Efficiency Standard is a cumulative annual energy savings target goal that began in 2011 and carries through the end of 2020. While there is a projected shortfall of the cumulative 2011 and 2012 savings target goals, UNS Electric will strive to achieve the cumulative targets in the years following. The Energy Efficiency Standard has significant savings target ramp ups in 2013 through 2020 that will require increase in DSM program investments for those years to meet those savings targets. UNS Electric is strongly committed to investing in DSM to meeting the cumulative annual savings target in the Energy Efficiency Standard and also integrating DSM into its Resource Planning. As taken from the Energy Efficiency Standard, Table 17 illustrates the ramp up effect of the Energy Efficiency Standard (i.e., an increase in the cumulative annual energy savings by the end of each calendar year as a percentage of the retail energy sales in the prior calendar year).

Table 17 – Energy Efficiency Standard Cumulative Annual Savings Target

Calendar Year	Energy Efficiency Standard (Cumulative Annual Energy Savings by the End of Each Calendar Year as a Percentage of the Retail Energy Sales in the Prior Calendar Year)
2011	1.25%
2012	3.00%
2013	5.00%
2014	7.25%
2015	9.50%
2016	12.00%
2017	14.50%
2018	17.00%
2019	19.50%
2020	22.00%

While the focus of this IRP is the long-term savings impact of the implemented programs in UNS Electric's 2012 DSM portfolio, considering the full incremental year's savings impacts is beneficial to understanding how DSM program savings will affect UNS Electric's load on a monthly level. Utilizing the hourly savings load shape data, UNS Electric is able to portray the monthly energy savings that result from a full year's effect starting in 2013 for the 2012 portfolio of programs. Figure 10 shows monthly energy savings for a full year's impact that result from the implementation of the UNS Electric's portfolio of programs in 2012. The monthly energy savings were determined from aggregating hourly measure-level savings in the Methodology section above.

Figure 10 – Monthly Energy Savings - 2012 DSM Portfolio



Energy savings across the portfolio are greatest in the summer months due to measures that seek to reduce cooling consumption associated with hot summer temperatures. In addition, the energy savings are relatively high in the winter months largely due to measures that reduce heating consumption and due to residential lighting measures that have greater usage from limited daylight hours and sunlight exposure. As expected, the shoulder months have the least savings due to limited heating or cooling usage and a more even distribution of daylight to non-daylight hours.

Figure 11 shows monthly energy savings for a full year's impact that result from the implementation of the 2012 Residential and Behavioral DSM programs.

Figure 11 - Monthly Energy Savings - 2012 Residential & Behavioral DSM Programs

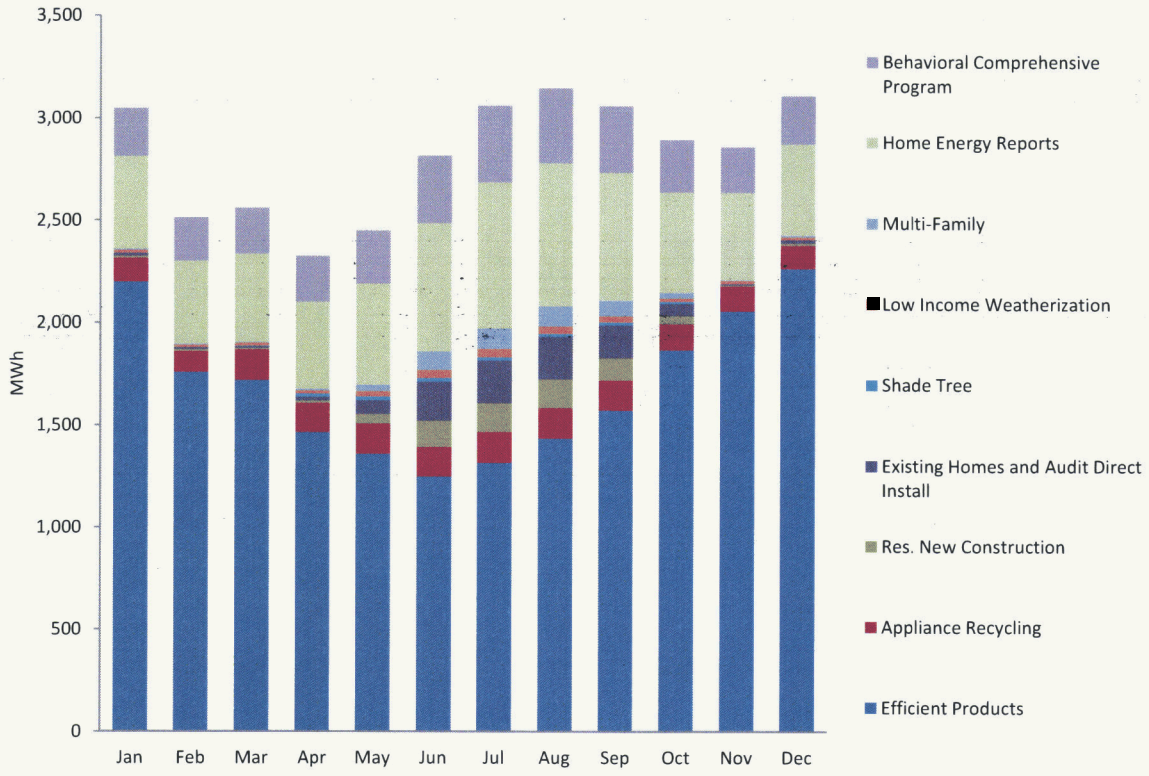


Figure 11 shows the monthly distribution of savings that result from residential and behavioral DSM programs. The Efficient Products Program, which is largely comprised of indoor lighting measures have the greatest savings during winter months. This reflects the fact that winter months have on average fewer daylight hours and less sunlight exposure than those of the summer months; this seasonal difference typically results in greater lighting usage in the winter months. In addition, as expected, savings where higher in summer months due to programs and measures that targeted reducing cooling consumption.

Figure 12 shows monthly energy savings for a full year's impact that result from the implementation of the 2012 commercial and industrial DSM programs.

Figure 12 - Monthly Energy Savings - 2012 Commercial & Industrial DSM Programs

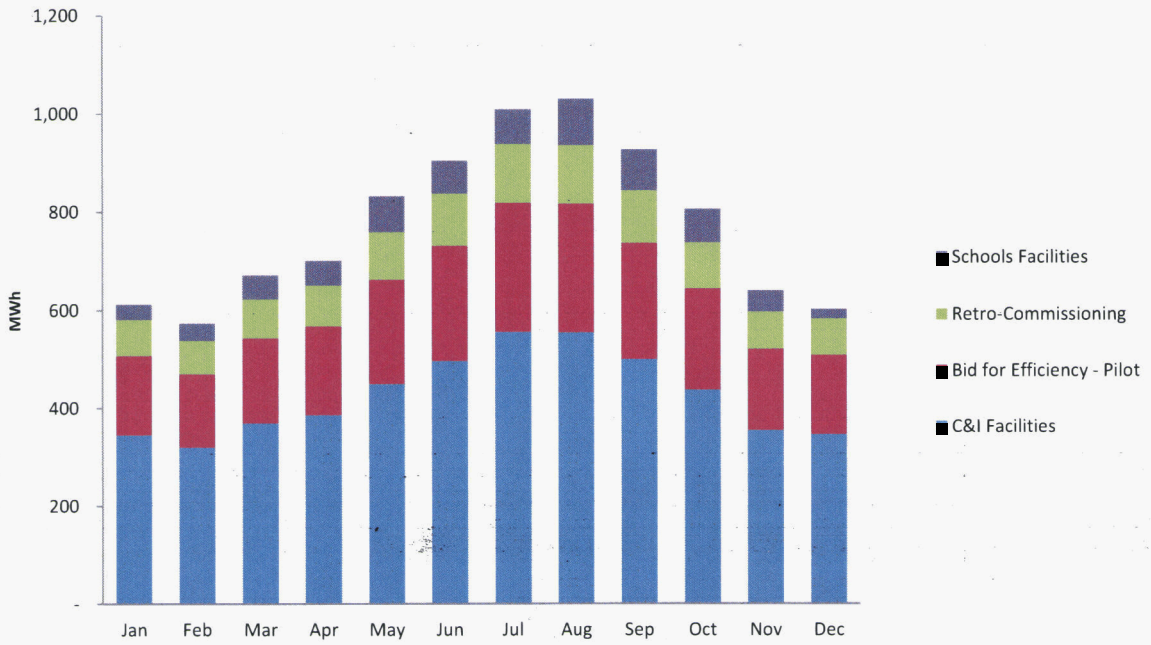
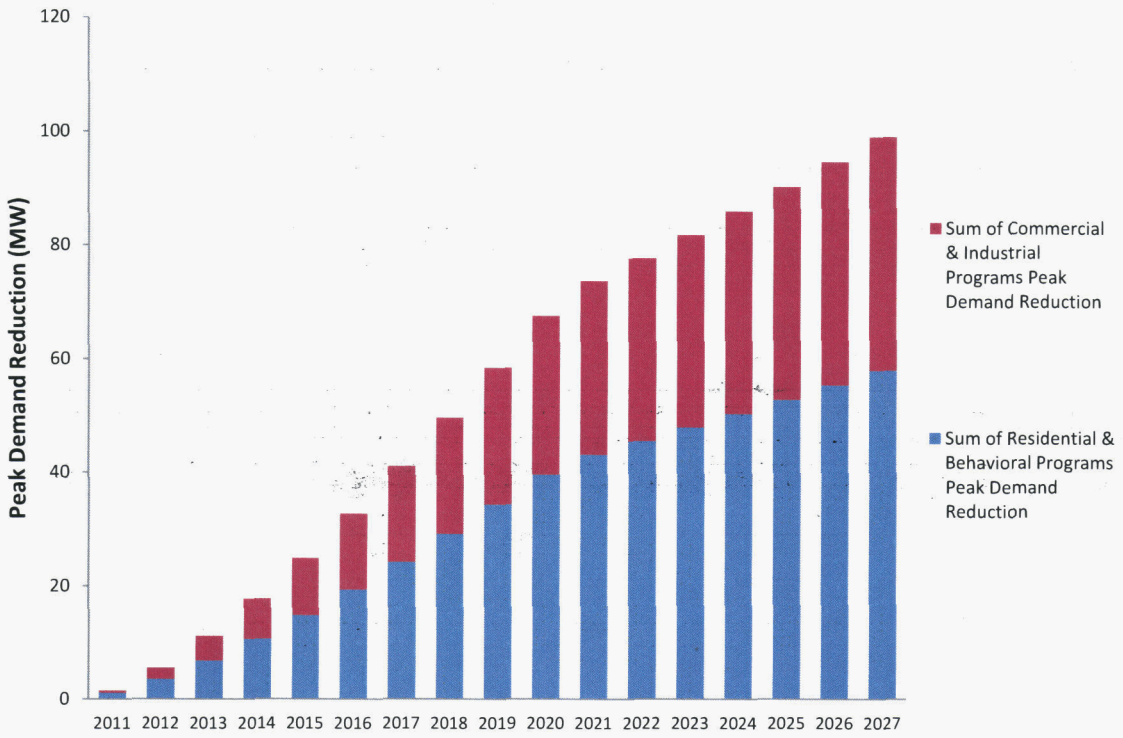


Figure 12 shows the monthly distribution of savings that result from commercial and industrial DSM programs. Many of these programs show the greatest impact in the summer months resulting from EE measures that are targeted towards reducing cooling consumption during those months. Unlike the residential programs, commercial programs are generally unaffected by limited daylight hours during winter months as most interior lighting measures are more reflective of business operations, which is typically consistent year-round.

While UNS Electric's goal is to meet the Energy Efficiency Standard goal by 2020 and determine DSM program savings through 2027, UNS Electric also considered the impact that UNS Electric's portfolio of DSM programs will have on reducing UNS Electric's system peak demand. UNS Electric's system peak period occurs throughout the summer months; therefore, UNS Electric determined the cumulative long-term impact that its programs will have on reducing UNS Electric's system peaks throughout the peak period. Again, peak demand reduction for 2011 is included because UNS Electric must consider the savings impact from that year towards meeting the Standard. The following figure depicts the cumulative annual peak demand savings for UNS Electric's portfolio of programs in 2011 and 2012 through 2027.

Figure 13 - Cumulative Annual Peak Demand Reduction through 2027



As expected, the cumulative annual peak demand savings from UNS Electric's DSM programs will increase with the increase in cumulative annual savings target goals in the Standard that UNS Electric will meet. The peak demand reduction that occurs through UNS Electric's programs will allow EE to reduce UNS Electric's system peak that occurs throughout the summer months.

Conclusion

The implementation of UNS Electric's 2012 DSM programs will help UNS Electric towards meeting cumulative annual savings targets and incorporate EE into its 15-year resource planning time-frame. Furthermore, stratifying annual measure-level energy savings from a full calendar year's savings on a 8,760 hourly level and then aggregating hourly savings on a monthly program-level portrays the impacts of UNS Electric's DSM programs with respect to seasonal and diurnal weather variations and UNS Electric's system peak periods. With the Energy Efficiency Standard savings target ramping up annually this decade, DSM programs are expected to play a much larger role in UNS Electric's Resource Plan. UNS Electric will continue to monitor DSM program activity and research EE industry best practices to determine the most cost-effective portfolio of programs that provides EE solutions to its customers and allows DSM investments to become more incorporated into UNS Electric's resource planning.

CHAPTER 9

Renewable Resources

Overview

The resource planning team relied on a number of industry experts such as Black and Veatch, DOE, National Renewable Energy Laboratory and Ventyx to help develop the operational and cost assumptions for renewable technologies. This chapter provides an overview on the assumptions used in the resource planning evaluations. For the 2012 resource plan the following renewable technologies were considered:

- Solar - Photovoltaic
- Solar - Concentrating PV Technology (CPV)
- Solar - Concentrating Solar Power Technology (CSP)
- Wind Turbines
- Bio-Resources

Renewable resource assumptions were based on the following data sources:

1. United States Department of Energy (DOE), Energy Efficiency & Renewable Energy Website http://www1.eere.energy.gov/solar/
2. National Renewable Energy Laboratory (NREL) Website http://www.nrel.gov/
3. 2011 Spring Reference Case, Electricity and Fuel Price Outlook, WECC Region
4. PACE Global Insights
5. UNS Electric's competitive procurement process and on-going R&D efforts.

EXISTING RENEWABLE RESOURCES

Overview

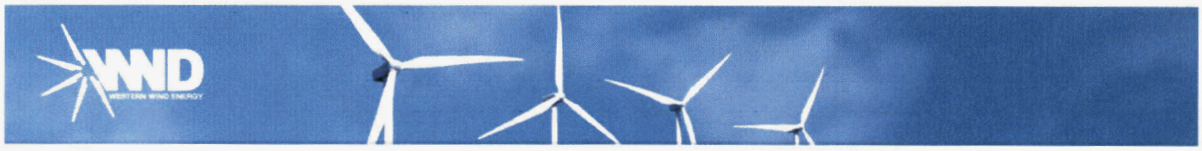
Over the last two years, UniSource Electric has worked with third-party contractors to develop two new renewable resource projects within UNS Electric's service territory. This is part of the company's commitment to meeting the Arizona Renewable Energy standard. The table below lists UNS Electric's renewable resources as of December 31, 2011 and includes one that is currently under development. This table is followed by descriptions of the various renewable technologies and detailed descriptions of the individual projects.

Table 18 – UNS Electric's Existing Renewable Resources

Resource-Counterparty	Owned/PPA	Technology	Location	Operator-Manufacturer	Completion Date	Capacity MW
Western Wind	PPA	Wind	Kingman, AZ	Western Wind	Sept 11	10.5
La Senita School	PPA	SAT PV	Kingman, AZ	Solon	Nov 11	1.22
Black Mountain	PPA	SAT PV	Kingman, AZ	Solon	Jun 12	10

Notes: PPA – Purchase Power Agreement - Energy is purchased from a third party provider.
SAT PV – Single Axis Tracking Photovoltaic

Western Wind and Solar



Resource-Counterparty	Owned/PPA	Technology	Location	Operator-Manufacturer	Completion Date	Capacity MW
Western Wind	PPA	Wind	Kingman, AZ	Western Wind	Sept 11	10.5

The Western Wind and Solar project is a 10MW renewable energy project that began construction in December 2010 and Commercial Operations are estimated to commence in the third quarter of 2011. The project is sited on 1,100 acres located in Kingman, Arizona. UNS electric has entered into a 20-year power purchase agreement for 100% of the output from the fully integrated combined wind and solar energy project. The Kingman Project began commercial operations effective September 24, 2011. The assets include five (5) Gamesa turbines, 500 KW of Suntech Crystalline PV solar cells, a collection system, a substation, roads, interconnection facilities, a maintenance building and a fixed price PPA with UNS Electric, Inc, a subsidiary of UniSource Energy Corporation of Arizona ("UNS"), which expires on September 24, 2031.

Kingman Wind Farm (10 MW Project)

UniSource Energy Wind & Solar Project

La Senita Elementary School Solar Project

Resource-Counterparty	Owned/PPA	Technology	Location	Operator-Manufacturer	Completion Date	Capacity MW
La Senita School	PPA	SAT PV	Kingman, AZ	Solon	Nov 11	1.22

Powered by SOLON systems and modules, the power plant will provide a faster, more cost-effective way for UES to integrate solar power into its renewable energy portfolio for Kingman residents. UNS Electric will own and operate the system on six acres owned by the Kingman Unified School District (KUSD) behind La Senita Elementary School. It will be the largest single physical photovoltaic (PV) system on school property in the state of Arizona. This system went into service in November, 2011

SOLON Single-Axis Tracker

System Details	
System Type	SOLON Andromeda Solar System — 6 Single-Axis Trackers
Location	La Senita Elementary School
In Service	11/4/11
Capacity	1.22 MW DC

Black Mountain Solon Solar Project

Resource-Counterparty	Owned/PPA	Technology	Location	Operator-Manufacturer	Completion Date	Capacity MW
Black Mountain	PPA	SAT PV	Kingman, AZ	Solon	Jun 12	10

Powered by SOLON's technology, including its single-axis tracking system, the 10 MW solar project will provide a faster, more cost-effective way for UNS Electric to integrate solar power into its renewable energy portfolio. Under the hosted PPA model, SOLON will finance, design, construct and maintain the system, with UNS Electric responsible only for purchasing the electricity that the system generates.

The system will be located on approximately 60 acres of land near UNS Electric' Black Mountain Generating Station that lies within the Mohave County Energy Overlay–Solar Photovoltaic Zone. SOLON secured permits for the project in less than three months, and is leading the engineering, procurement and construction services. Project construction will begin this fall, with the systems slated to be commissioned and in-service in first half of 2012. The system will create more than 200 local jobs for the construction of this project.

For this UNS Electric PPA project, SOLON is providing a comprehensive level of products, development and support. In total, the system will feature 60 of SOLON's single-axis trackers, utilizing more than 40,000 utility solar modules. To help ensure the plant's performance and efficiency, the company is also providing its own SCADA system, which enables remote control and monitoring.

Black Mountain - SOLON Project

SOLAR PV TECHNOLOGY

Solar cells, also called photovoltaic (PV), convert sunlight directly into electricity. PV gets its name from the process of converting light (photons) to electricity (voltage), which is called the *PV effect*. The PV effect was discovered in 1954, when scientists at Bell Telephone discovered that silicon (an element found in sand) created an electric charge when exposed to sunlight. Soon solar cells were being used to power space satellites and smaller items like calculators and watches. Today, thousands of people power their homes and businesses with individual solar PV systems. Utility companies are also using PV technology for large power stations.

Solar panels used to power homes and businesses are typically made from solar cells combined into modules that hold about 40 cells. A typical home will use about 10 to 20 solar panels to power the home. The panels are mounted at a fixed angle facing south, or they can be mounted on a tracking device that follows the sun, allowing them to capture the most sunlight. Many solar panels combined together to create one system is called a solar array. For large electric utility or industrial applications, hundreds of solar arrays are interconnected to form a large utility-scale PV system.

Traditional solar cells made from silicon, are usually flat-plate, and generally are the most efficient. Second-generation solar cells are called thin-film solar cells because they are made from amorphous silicon or non-silicon materials such as cadmium telluride. Thin film solar cells use layers of semiconductor materials only a few micrometers thick. Because of their flexibility, thin film solar cells can double as rooftop shingles and tiles, building facades, or the glazing for skylights.

Third-generation solar cells are being made from variety of new materials besides silicon, including solar inks using conventional printing press technologies, solar dyes, and conductive plastics. Some new solar cells use plastic lenses or mirrors to concentrate sunlight onto a very small piece of high efficiency PV material. The PV material is more expensive, but because so little is needed, these systems are becoming cost effective for use by utilities and industry. However, because the lenses must be pointed at the sun, the use of concentrating collectors is limited to the sunniest parts of the country.

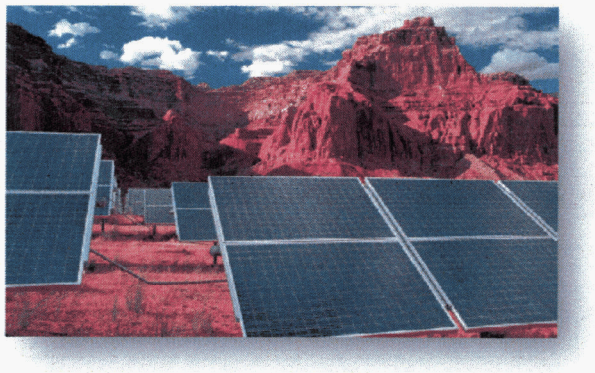
Solar Resource Characteristics

Several forms of solar power technology are available. One form is photovoltaic solar power, in which semiconductor solar cells use the photovoltaic effect to absorb sunlight and convert it into direct current power. An inverter then converts the direct current power into alternating current power. Another form of solar concentrating solar power CSP uses large reflectors and tracking systems to gather energy from sunlight and focus it into a concentrated beam. Heat from the concentrated beam then creates steam that turns a turbine generator to generate alternating current power.

In certain respects, the technological development and commercialization of utility-scale solar power is currently at a stage similar to that of wind power prior to its recent period of rapid growth and widespread adoption by the electric utility industry. For example, large amounts of capital are being invested in research, design and demonstration efforts to improve solar power generating technologies and achieve improved economies of scale. Examples include intensive R&D on advanced forms of solar photovoltaic technologies, and construction of demonstration projects based on large-scale concentrating solar generating technology.

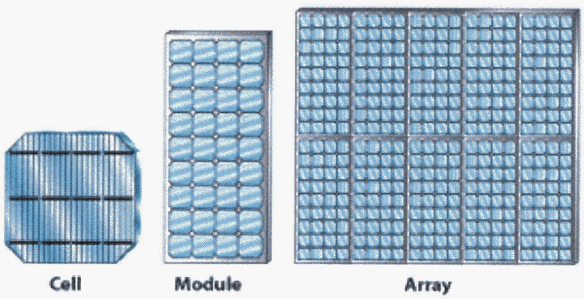
Photovoltaic Solar Power Technology

As noted above, the two primary forms of solar power generating technologies are photovoltaic and concentrating solar. Photovoltaic systems make up the bulk of existing installed solar generating facilities, and can be produced at practically any size. A photovoltaic (PV) or solar cell is the basic building block of a PV (or solar electric) system. An individual PV cell is usually quite small, typically producing about 1 or 2 watts of power. To boost the power output of PV cells, we connect them together to form larger units called modules. Modules, in turn, can be connected to form even larger units called arrays, which can be interconnected to produce more power, and so on. In this way, we can build PV systems able to meet almost any electric power need, whether small or large.



Flat-Plate Photovoltaic Array

Source: Renewable Energy Atlas of the West: A Guide to the Region's Resource Potential

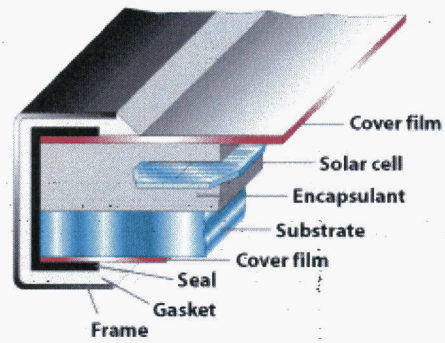


Source: NREL: National Renewable Energy Laboratory

The basic photovoltaic or solar cell typically produces only a small amount of power. To produce more power, cells can be interconnected to form modules, which can in turn be connected into arrays to produce yet more power. Because of this modularity, PV systems can be designed to meet any electrical requirement, no matter how large or how small.

Flat-Plate PV Systems

The most common array design uses flat-plate PV modules or panels. These panels can either be fixed in place or allowed to track the movement of the sun. They respond to sunlight that is either direct or diffuse. Even in clear skies, the diffuse component of sunlight accounts for between 10% and 20% of the total solar radiation on a horizontal surface. On partly sunny days, up to 50% of that radiation is diffuse. And on cloudy days, 100% of the radiation is diffuse.



Source: NREL: National Renewable Energy Laboratory

One typical flat-plate module design uses a substrate of metal, glass, or plastic to provide structural support in the back; an encapsulant material to protect the cells; and a transparent cover of plastic or glass.

Mounting Structures

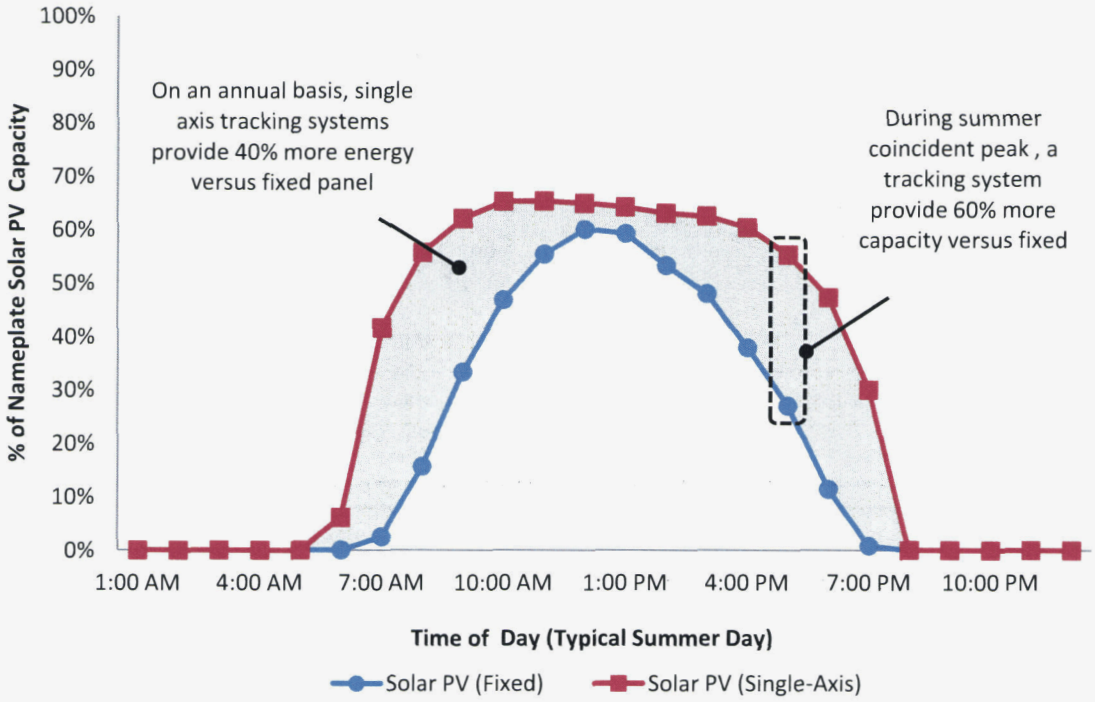
Photovoltaic arrays must be mounted on a stable, durable structure that can support the array and withstand wind, rain, hail, and other adverse conditions. However, stationary structures are usually used with flat-plate systems. These structures tilt the PV array at a fixed angle determined by the latitude of the site, the requirements of the load, and the availability of sunlight. Among the choices for stationary mounting structures, rack mounting may be the most versatile. It can be constructed fairly easily and installed on the ground or on flat or slanted roofs.

The advantages of fixed arrays are that they lack moving parts, there is virtually no need for extra equipment, and they are relatively lightweight. These features make them suitable for many locations, including most residential roofs. Because the panels are fixed in place, their orientation to the sun is usually at an angle that practically speaking is less than optimal. Therefore, less energy per unit area of array is collected compared with that from a tracking array. However, this drawback must be balanced against the higher cost of the tracking system.

Single Axis Tracking Systems

Sometimes, the solar mounting structure is designed to track the sun. There are two basic kinds of tracking structures: one-axis and two-axis. The one-axis trackers (SAT PV) are typically designed to track the sun from east to west. They are used with flat-plate systems and sometimes with concentrator systems. The two-axis type is used primarily with PV concentrator systems. These units track the sun's daily course and its seasonal course between the northern and southern hemispheres. Naturally, the more sophisticated systems are the more expensive ones, and they usually require more maintenance.

Chart 24 - Comparison of Solar Photovoltaic Systems (Fixed Panel vs. Single Axis Tracking)



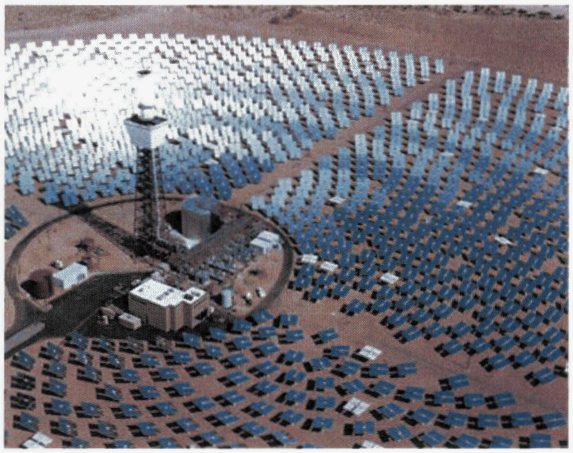
Concentrating Solar Power Technology (CSP)

CSP is the second main type of solar power generation. CSP uses mirrors to reflect and concentrate sunlight onto receivers that collect the solar energy and convert it to heat. This thermal energy can then be used to produce electricity via a steam turbine or heat engine driving a generator. In virtually all applications, CSP is large in scale, on the order of 100 MW or larger.

There are three generic system architectures: line-focus (trough systems), point-focus central receiver (power towers), and point-focus distributed receiver (dish-engine systems).

Power Tower Systems

Power tower systems consist of a field of large, nearly-flat mirror assemblies (heliostats) that track the sun and focus the sunlight onto a receiver at the top of a tower. In a typical configuration, a heat-transfer fluid such as water/steam or molten nitrate salt mixture is pumped through the receiver, and used to generate steam to power a conventional steam-turbine power cycle generating electricity. In some systems, excess thermal energy can be stored during daylight hours to provide electricity at times when the sun is not available and at night. An advantage of power tower systems over linear concentrator systems is that higher temperatures can be achieved in the working fluid, leading to higher efficiencies and lower-cost electricity.

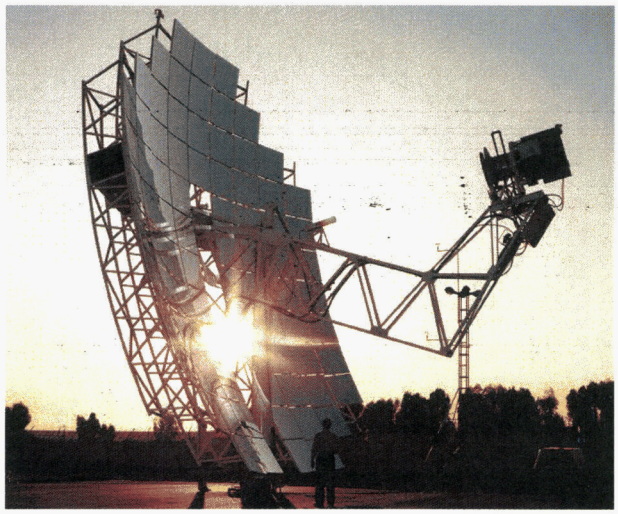


10 MW Solar Two Power Tower System (NREL).

There are no commercial power tower plants in operation in the U.S. today. In 1982, a 10MW power tower plant, Solar One, located near Barstow, California, operated from 1982 to 1988 and produced over 38 million kilowatt-hours (kWh) of electricity. Solar One generated steam directly in the receiver. To implement improved heat transfer and thermal storage, the plant was retrofitted (and renamed Solar Two). Solar Two operated from 1998 to 1999. Although Solar Two successfully demonstrated efficient collection of solar energy and dispatch of electricity, including the ability to routinely produce electricity during cloudy weather and at night.

Dish/Engine Systems

In a dish engine system the concentrator tracks continuously reflecting the solar energy solar energy onto a receiver where it is absorbed, converted to heat, and transferred to the heat to the engine/generator, thereby, producing electricity. These systems vary in size from 1 to 40 kW and can be combined into large systems to generate utility-scale electric power. The primary heat engines used in dish systems are Sterling engines but microturbines and concentrating photovoltaics are also being evaluated as possible future power conversion units on dish systems.



25 MW Solar Parabolic Dish-Engine System (NREL)

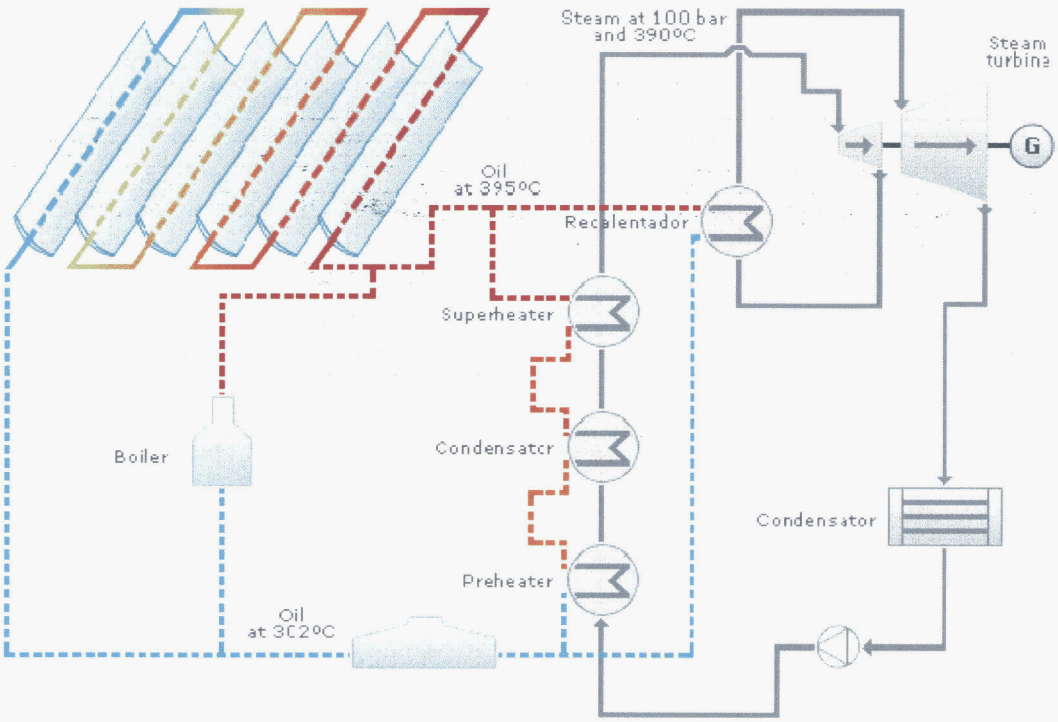
Trough Systems

A trough system is usually oriented in a north-south direction and tracks the sun from east to west focusing solar energy on a long tubular receiver. The typical working fluid in a trough system is synthetic oil that is heated to about 390 C. The hot oil is used to generate steam for use in a conventional Rankine cycle steam turbine system. The predominant CSP systems in operation in the United States are linear concentrators using parabolic trough collectors. In addition, trough systems can be hybridized (natural gas co-firing) or use thermal storage to dispatch power to meet utility peak load requirements. A few of these technologies are discussed further.

Harper Lake Solar CSP Project (NREL)

Concentrating Solar Power Technology

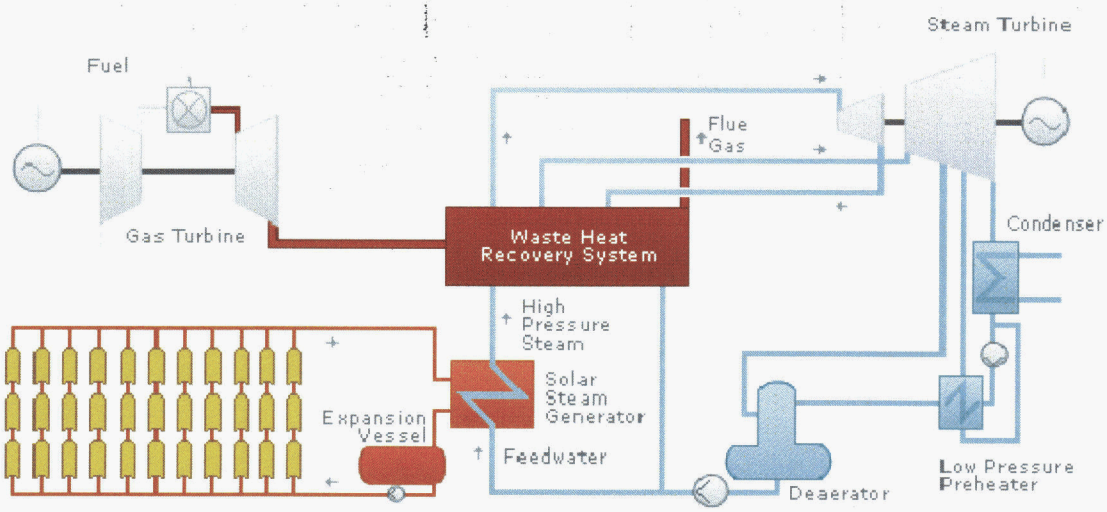
As shown below, the solar trough field heats synthetic transfer oil. Energy in the oil is used to generate superheated, high pressure steam that is delivered to a steam turbine. This turbine powers an electrical generator, creating electricity



Solar CSP (Abengoa Solar)

Concentrating Solar Power Technology – Hybridized Configuration with Natural Gas Co-Firing

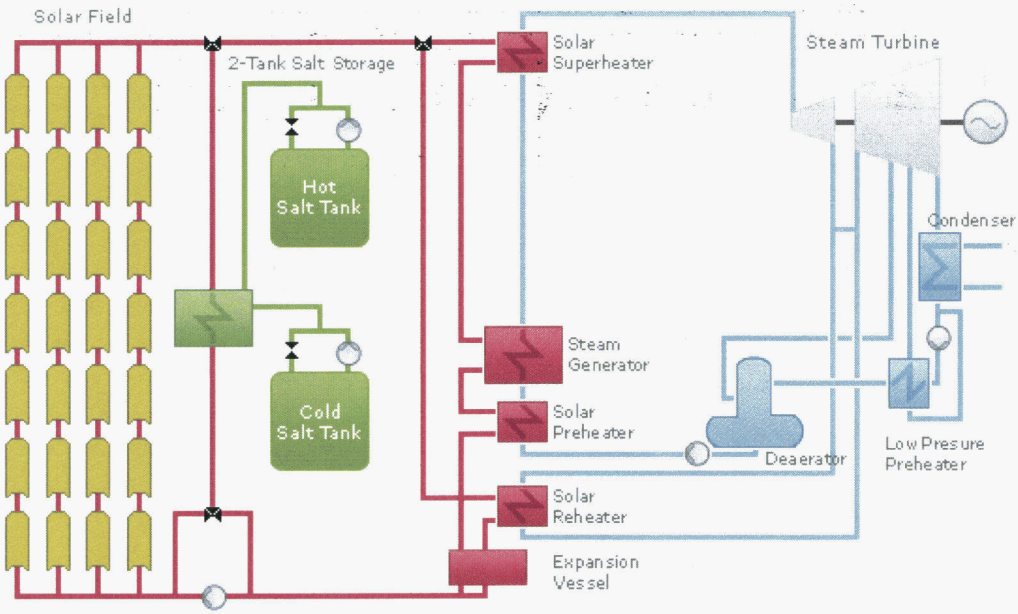
New innovative designs that incorporate hybridized configurations such as Integrated Solar Combined Cycle (ISCC) are also in the early stages of development. ISCC technology combines the benefits of solar energy with the benefits of a combined cycle. The solar resource partially substitutes the fossil fuel. The operation of a solar combined hybrid plant is similar to the one of a conventional CC plant. The fuel (preferably natural gas) is burned generally on a combustion chamber of a gas turbine. The heat coming from the solar field is added to escape gases that are directed to the heat retriever, resulting in increased steam generation and, consequently, an increase of electricity production from the steam turbine.



Solar CSP Hybrid with Natural Gas Co-Firing (Abengoa Solar)

Concentrating Solar Power Technology – Storage Configuration based on Two-Tank Molten Salt System

Future solar technologies are being enhanced with the addition of energy storage systems. With the use of a thermal energy storage system, future solar plants will be able to produce output during non-daylight hours. One of the promising materials being used to store the sun's thermal capacitance is molten-nitrate salt. In this design configuration, large insulated tanks filled with molten salt are used with solar trough technology to store the heat from the synthetic transfer oil. This stored heat is used to improve the dispatchability of the solar resource. Current projects being developed using this type of advanced thermocline thermal storage system are projecting a six hour storage capacity.

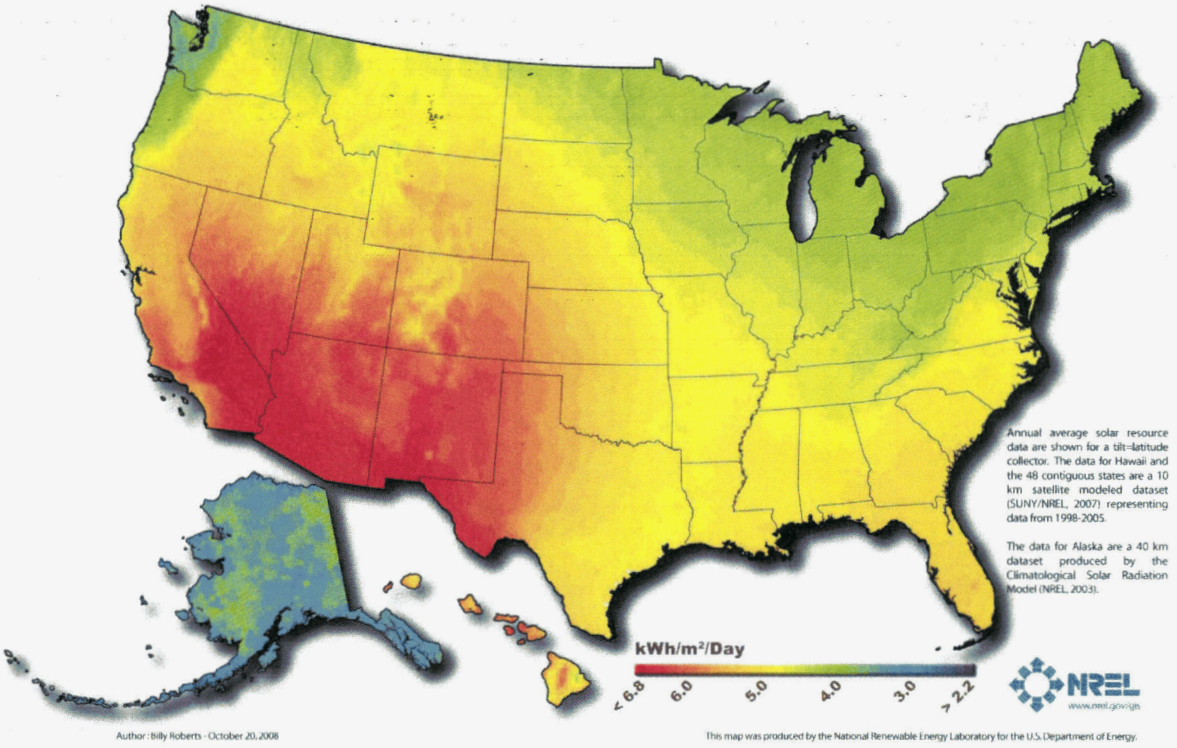


Solar CSP with Thermal Storage (Abengoa Solar)

U.S. SOLAR MAP

This map shows the national solar photovoltaics (PV) resource potential for the U.S. This map is based on the monthly average daily total solar resource potential on grid cells. The insolation values represent the resource available to a flat plate collector, such as a photovoltaic panel, oriented due south at an angle from horizontal to equal to the latitude of the collector location. This is typical practice for PV system installation, although other orientations are also used.

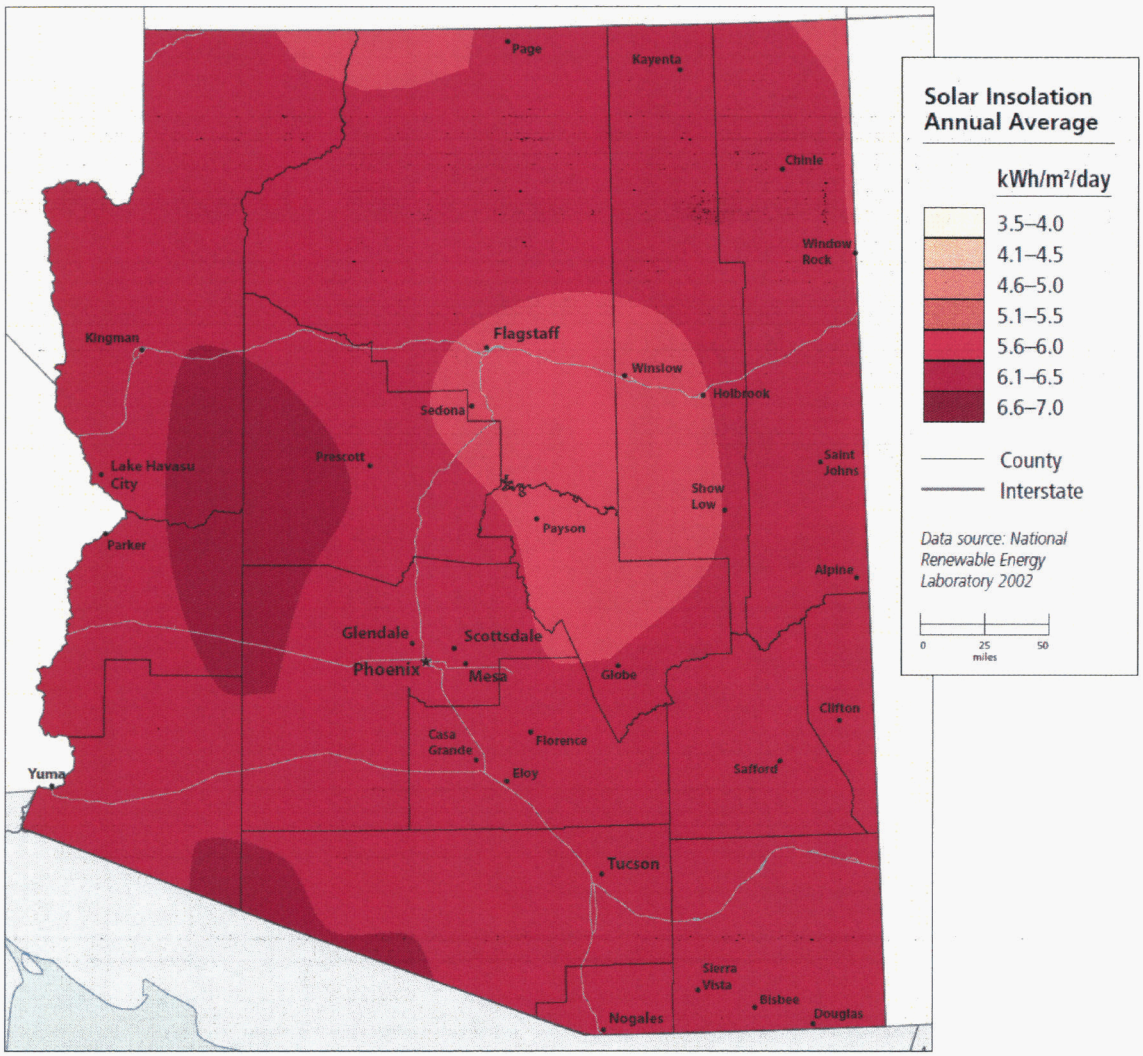
Map 12 – U.S. NREL Solar Radiation Map



ARIZONA SOLAR POWER MAP

Based on the Arizona Renewable Energy Assessment done by Black and Veatch 2008, the technical potential for both solar thermal and solar photovoltaic projects in Arizona is very large. Results of this study indicate that there is sufficient solar capability to meet the states RES demand through 2025. (4,300 MW and 11,000 GWh per year)

Map 13 - Arizona NREL Solar Insolation Map



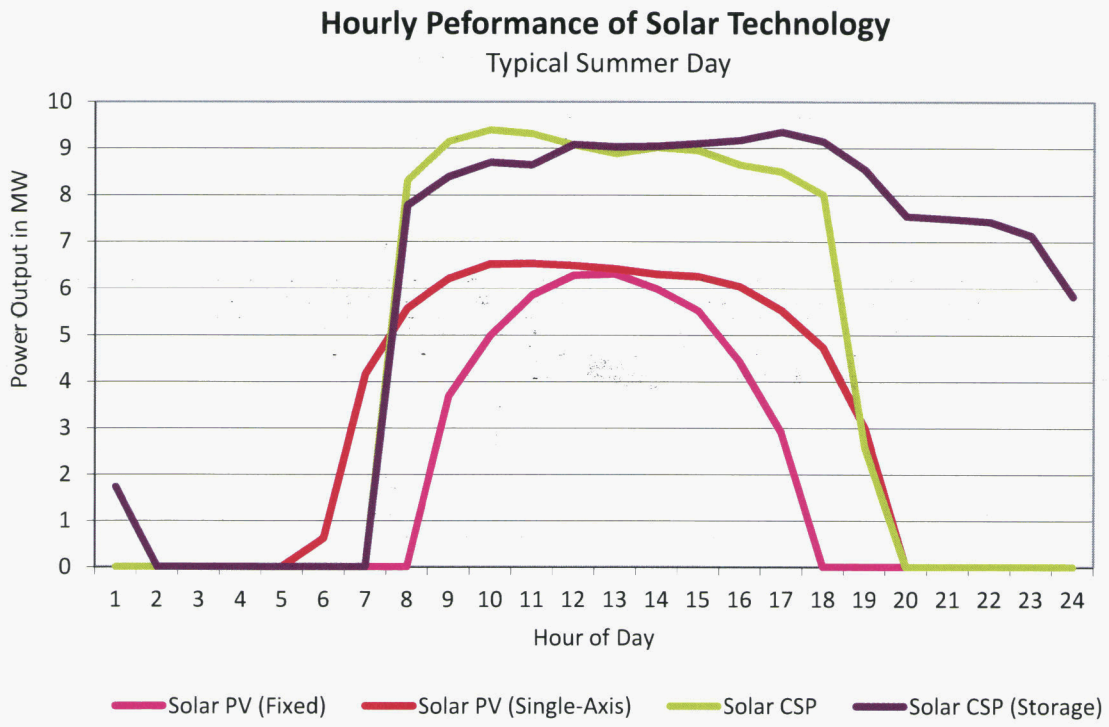
SOLAR RESOURCES MODELED

There are four types of solar electric generating technologies considered for cost modeling: solar parabolic trough (without energy storage), solar parabolic trough (with energy storage), and solar photovoltaic (Fixed) and solar photovoltaic (Single Axis).

Cost and Operating Characteristics	Units	Solar PV (Fixed)	Solar PV (Single Axis)	Solar CSP	Solar CSP (Storage)
Project Lead Time	Years	2	2	2	2
Installation Years	First Year Available	2012	2012	2012	2012
Peak Capacity	MW	20	20	50	50
Construction Cost	2012 $/kW	$2,300	$3,200	$4,700	$5,450
EHV/Interconnection Cost	2012 $/kW	$50	$0	$200	$200
Total Construction Cost	2012 $/kW	$2,350	$3,250	$4,900	$5,650
Construction Cost with ITC	2012 $/kW	**$1,660**	**$2,290**	**$3,450**	**$4,015**
Fixed O&M	2012 $/kW-yr	$12.00	$12.00	$35.00	$38.00
Variable O&M	2012$/MWh				$22.00
System Integration Costs	2012 $/MWh	$4.00	$4.00	$2.00	$0.00
Levelized Cost of Energy	$/MWh	$175	$144	$158	$167
Typical Capacity Factor	Annual %	17%	24%	30%	38%
Net Coincident Peak Contribution	NCP %	33%	51%	70%	87%
Water Usage	Gal/MWh	0	0	800	800
30% Federal ITC	Qualify	YES	YES	YES	YES
Tax Depreciation	Qualify	5-Year	5-Year	5-Year	5-Year

SOLAR RESOURCES MODELED

DOE's Solar Advisor Model (SAM) was used to model solar resources based on Arizona sites. SAM's hourly power output was used to estimate annual capacity factors and capacity values.



Technology Energy & Capacity Value	Units	Solar PV (Fixed)	Solar PV (Single Axis)	Solar CSP	Solar CSP (Storage)
Typical Capacity Factor	Annual %	17%	24%	30%	38%
Net Coincident Peak Contribution	NCP %	33%	51%	70%	87%

WIND POWER

Resource Characteristics

Wind power is the process of mechanically harnessing kinetic energy from the wind and converting it into electricity. The most common form of utility-scale wind technology uses a horizontal-axis rotor with turbine blades to turn an electric generator mounted at the top of a tall tower. For utility-scale wind power production, dozens of wind turbines may be grouped together at a wind farm project. Power generated by the wind turbines is collected at a substation where transformers increase the voltage and the power is then fed into the transmission system.

Because air has low mass, the wind itself has low energy density. The amount of wind power that can be produced at a given project site is dependent on the strength and frequency of wind. Wind velocity determines quantity of power that can be produced. For example, a doubling of wind speed allows roughly eight times as much power to be produced

Over the last decade, the use of wind power has increased rapidly, making it the predominant form of new renewable generation resource, with many large-scale installations around the world. Major advances in wind power technology were achieved in the 1990s and 2000s, allowing much larger turbines to be developed. Today wind turbines are generally considered to be the most mature form of renewable energy technology, with industrial giants such as Siemens and GE amongst the leading manufacturers. For example, wind turbines with a capacity of 1.5 megawatts to 2.5 megawatts are now common and wind turbines as large as 6 megawatts are being developed. This has created economies of scale, driving down the unit cost of energy from wind power resources.

Kingman Wind Farm (10 MW Project)

UniSource Energy Wind Project

A small wind farm just outside of Kingman, Arizona developed by Western Wind Energy Corporation.

Wind Resource Technology

As the wind starts to blow, yaw motors turn a turbine's nacelle so that the rotor and blades face directly into wind. The blades are shaped with an aerofoil cross section (similar to an aircraft wing) and this causes air to move more quickly over one side than the other. This difference in speed causes a difference in pressure which in turn causes the blade to move, the rotor to turn and a rotational force (or torque) to be generated.

The rotor is connected to a gearbox (on most turbines) and in turn to a generator housed in the nacelle that converts the torque into electricity. The electricity is then fed into a transformer located either inside or just outside the turbine which steps up the voltage to reduce losses in transportation. From there the electricity travels through underground cables to a small sub-station, usually on the wind farm site, where the voltage is stepped up through further transformers and exported to the local grid.

Typically turbines start to generate electricity in wind speeds of 3-4 m/s (7-9 mph). The amount of torque (and so electricity) generated increases with wind speed up to around 15 m/s (34 mph) where the maximum (or rated) capacity of the turbine is reached. Output is then maintained at this level until a turbine is shut down when the wind reaches high speeds of around 25m/s (57 mph) to protect it from excessive loads - though the turbines are in fact designed and certified to withstand wind speeds up to 70 m/s (157 mph).

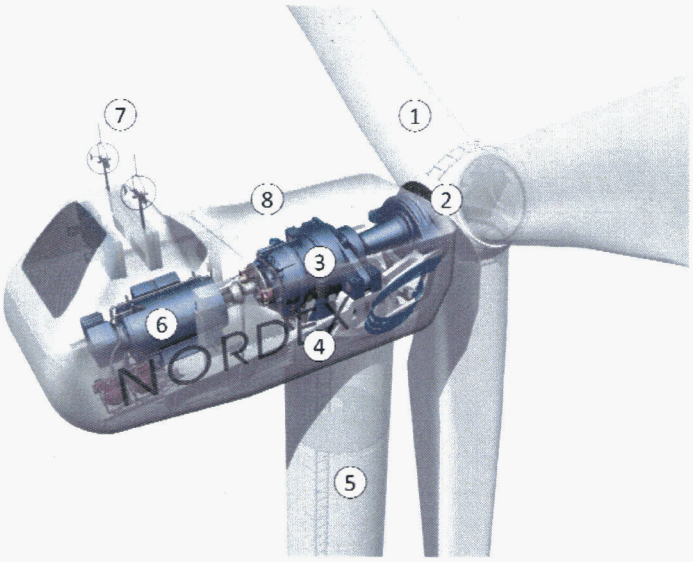


Figure 14 - 3D Drawing of Nordex N80/2500kW Wind Turbine

HOW A WIND TURBINE WORKS

1. Rotor assembly of three blades mounted on a hub which is connected via the main shaft to the gearbox.

2. Pitch motors change the angle of attach of the blades so as to control rotational speed and torque.

3. Gearbox converts the rotational speed of the rotor to a suitable speed for the generator.

4. Yaw motors continually turn the nacelle so as to ensure the rotor faces into the wind.

5. Tower supports the nacelle and rotor. The tower contains electrical cables and access ladders.

6. Generator converts the torque generated by the rotor to electrical energy.

7. Anemometers measure the wind speed and direction, used as inputs to the wind turbine control system.

8. Nacelle is the housing in which the main components are located.

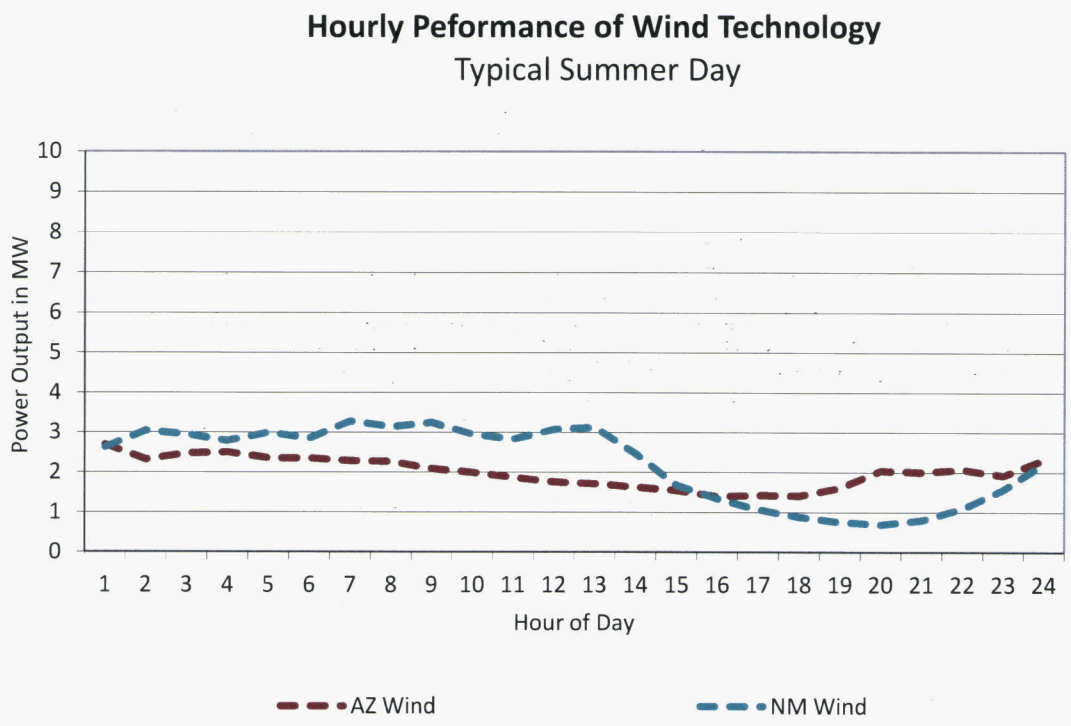
WIND RESOURCES MODELED

The resource plan modeled wind resources that reflected the seasonal and hourly wind profiles that were sited in either New Mexico or Arizona.

Cost and Operating Characteristics	Units	NM Wind	AZ Wind
Project Lead Time	Years	2	2
Installation Years	First Year Available	2012	2012
Peak Capacity	MW	50	50
Construction Cost	2012 $/kW	$2,000	$2,000
EHV/Interconnection Cost	2012 $/kW	$400	$200
Total Construction Cost	2012 $/kW	$2,400	$2,200
Construction Cost with ITC	2012 $/kW	$1,400	$1,600
Fixed O&M	2012 $/kW-yr	$50.00	$50.00
System Integration Costs	2012 $/MWh	$5.00	$5.00
Levelized Cost of Energy	$/MWh	$107	$128
Typical Capacity Factor	Annual %	38%	30%
Net Coincident Peak Contribution	NCP %	13%	9%
Water Usage	Gal/MWh	0	0
30% Federal ITC	Qualify	YES	YES
Tax Depreciation	Qualify	5-Year	5-Year

WIND RESOURCES MODELED

NREL's Western Wind Resource Dataset (WWRD) provided hourly wind resource data. This data was used to develop the anticipated coincident peak and expected capacity factors used in the resource planning process.

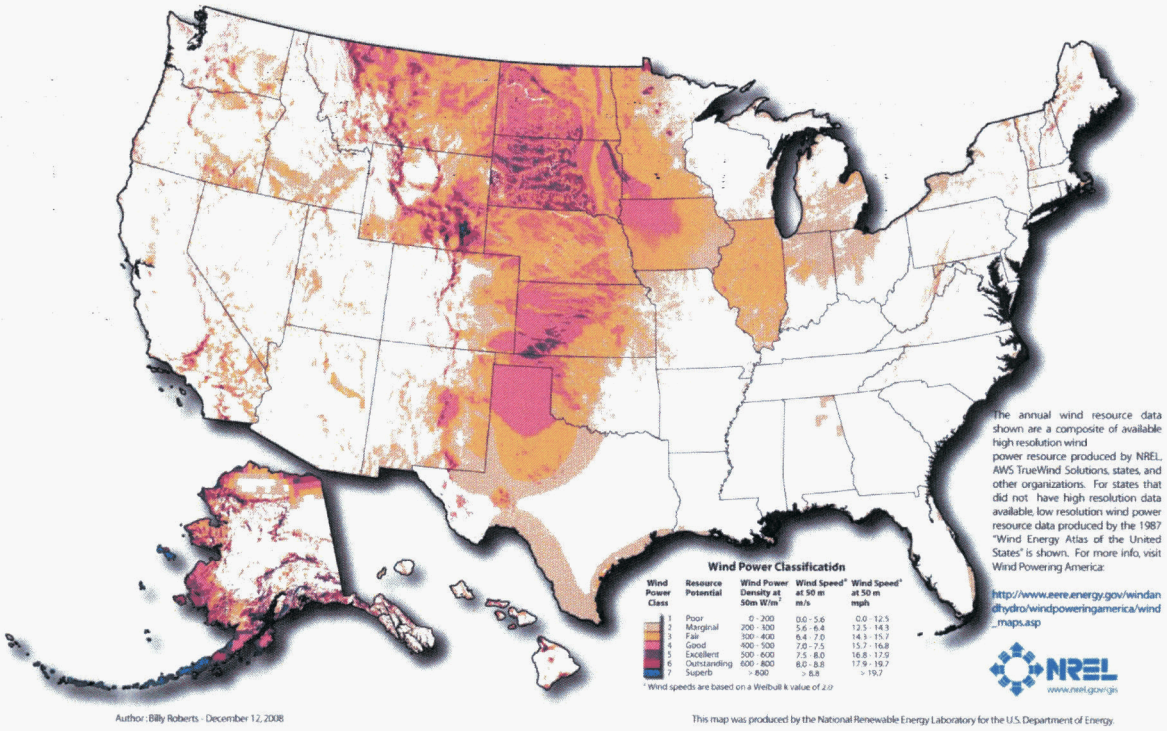


Cost and Operating Characteristics	Units	NM Wind	AZ Wind
Typical Capacity Factor	Annual %	38%	30%
Net Coincident Peak Contribution	NCP %	13%	9%

U.S. WIND RESOURCE MAP

The U.S. Department of Energy's Wind Program and the National Renewable Energy Laboratory (NREL) publish wind resource maps for the United States. These maps shows wind speed estimates at 50 meters above the ground and depict the resource potential by Wind Power Class.

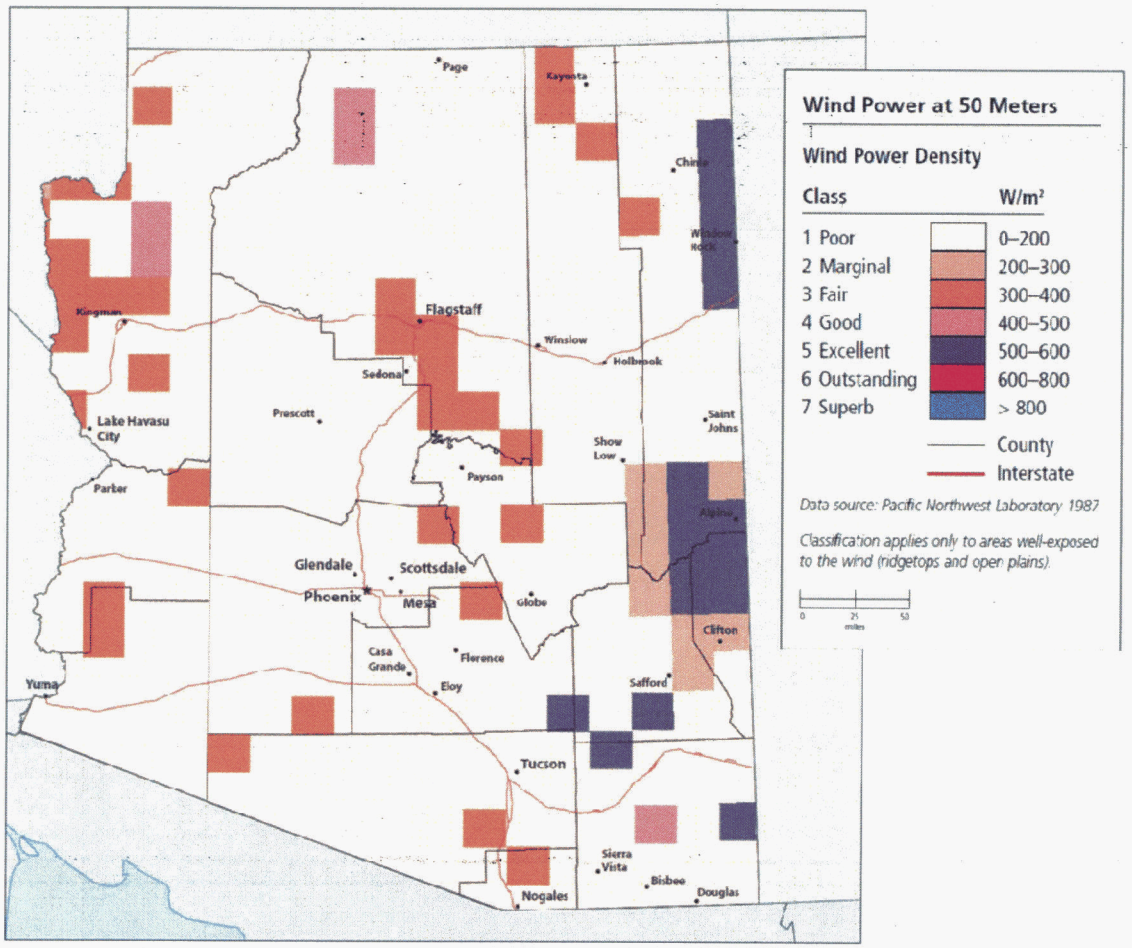
Map 14 - U.S. Wind Resource Map



ARIZONA WIND RESOURCE MAP

Map 15 - Arizona Wind Resource Map shows wind power density data for Arizona. Relative to the TEP and UNS Electric service territories there is good wind potential (Class 4) located in small areas north of Kingman and east of Tucson. The most promising areas for large-scale wind development in Arizona are located along the eastern border in both the Window Rock and Alpine areas.

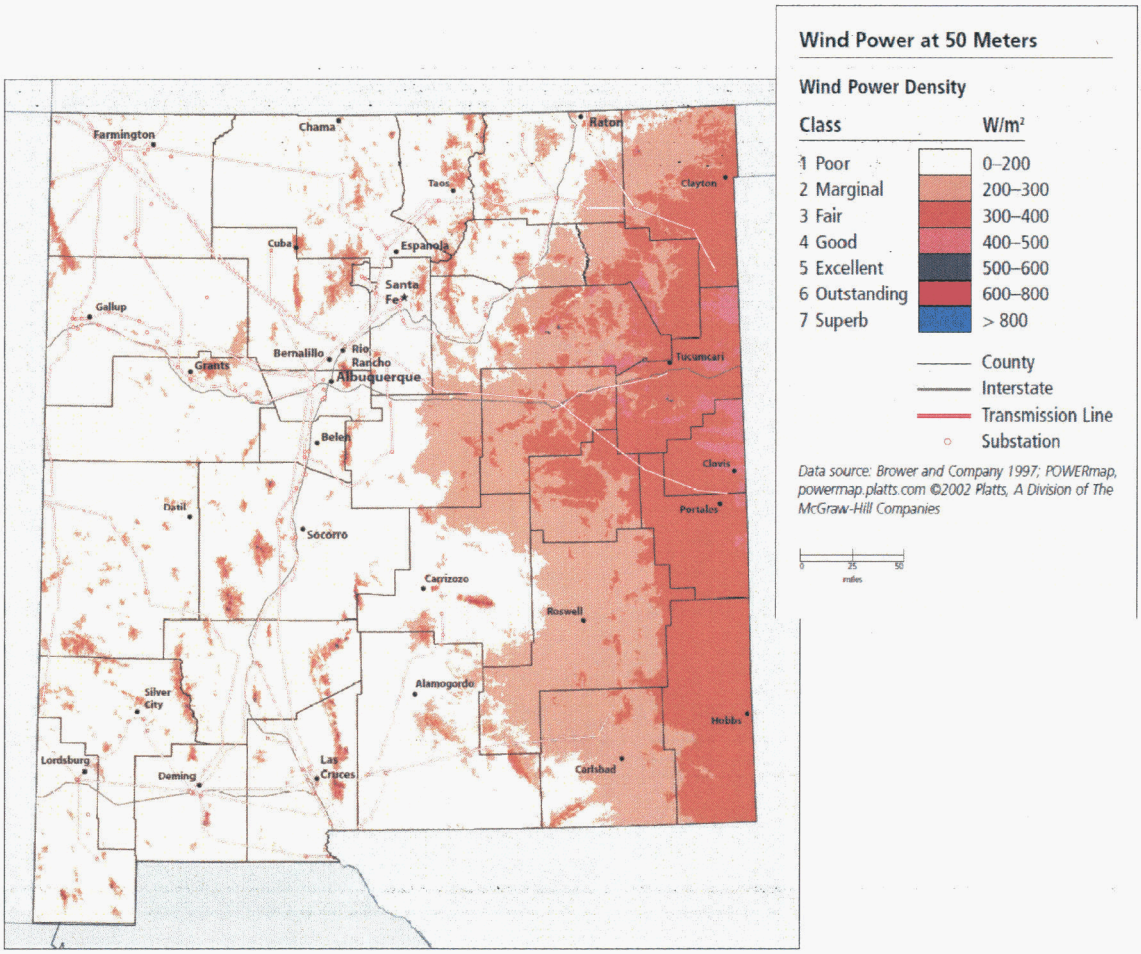
Map 15 - Arizona Wind Resource Map



NEW MEXICO WIND POWER MAP

New Mexico has abundant wind power resources primarily on the eastern plains. New Mexico is estimated to have over 1 million acres of windy land suitable for commercial development.

Map 16 - New Mexico Wind Power Map



Bio-Resources (Biofuels)/ Land Fill Gas

Biofuel power plants utilize the heat produced from the combustion of biological materials to produce electricity. In contrast to many other potential renewable energy sources, biofuel generation from multiple sources is a relatively mature, proven technology. In addition, biomass resources have the advantage of being carbon-neutral. Being carbon-neutral refers to achieving net zero carbon emissions by balancing a measured amount of carbon released with an equivalent amount sequestered or offset. These attributes merit the consideration of biofuel resources as part of UNS Electric's generation portfolio, and as such they were analyzed in the IRP process. However, the favorable carbon emissions characteristics and technological reliability must also be weighed against some significant disadvantages (most significantly economic considerations as well as the environmental impact of significant emissions of several pollutants).

Technology Overview

Biofuel energy sources can be divided into two broad categories: biomass and biogas.

Biomass: This category includes all solid biological materials. The most common source of biomass fuel is wood. However this category can also include manure, sewage sludge, agricultural waste, and even cultivated biomass agricultural products such as grasses.

Biomass plants operate in a manner very similar to coal plants. In general, the heat produced from combusting the biomass is used to produce steam which is in turn used to turn a turbine to produce electricity. In addition to dedicated biomass plants, there is also the potential for using biomass sources as a co-firing fuel with traditional resources such as coal.

Biogas: This category includes the capture of gas naturally produced as a part of biological processes. The most common fuel falling into this category is methane collected from the process of decay at landfills. Another potential source is the methane produced from bacterial digestion of manure.

Biogas resources may be used to produce electricity as part of a dedicated plant in the same manner as a traditional natural gas plant or used as a cofiring fuel.

Transmission and Siting Requirements

Biofuel resources may or may not require significant transmission upgrades depending on the location of the source of fuel. For instance, plants utilizing urban wood waste or gas produced as a part of sewage treatment would likely be located near load centers and require minimal additional transition resources. On the other hand, a plant utilizing agricultural waste or waste from forest thinning would likely be a significant distance from load centers and require transmission upgrades.

Dispatch Characteristics

One of the potential major advantages to the deployment of biomass is that it can be used as a stable, reliable, baseload resource (in contrast to many other renewables). Direct fired biomass facilities typically operate at capacity factors of 85% and above.

Environmental Attributes

The biggest environmental advantage of the use of biofuels is that they are considered to be carbon-neutral. While the process of burning biofuels does release CO_2, a nearly equal amount of CO_2 is absorbed from the atmosphere as the biological source of the fuel grows. While the burning of biofuels is carbon-neutral, it does entail significant emissions of nitrous oxides and particulate matter, requiring the use of scrubbing technology. In addition to some unfavorable emissions, the use of biomass also risks other negative environmental impacts if the fuel is not collected in a sustainable manner. In general, however, biofuels are harvested from waste sources, and sustainability is not a significant issue.

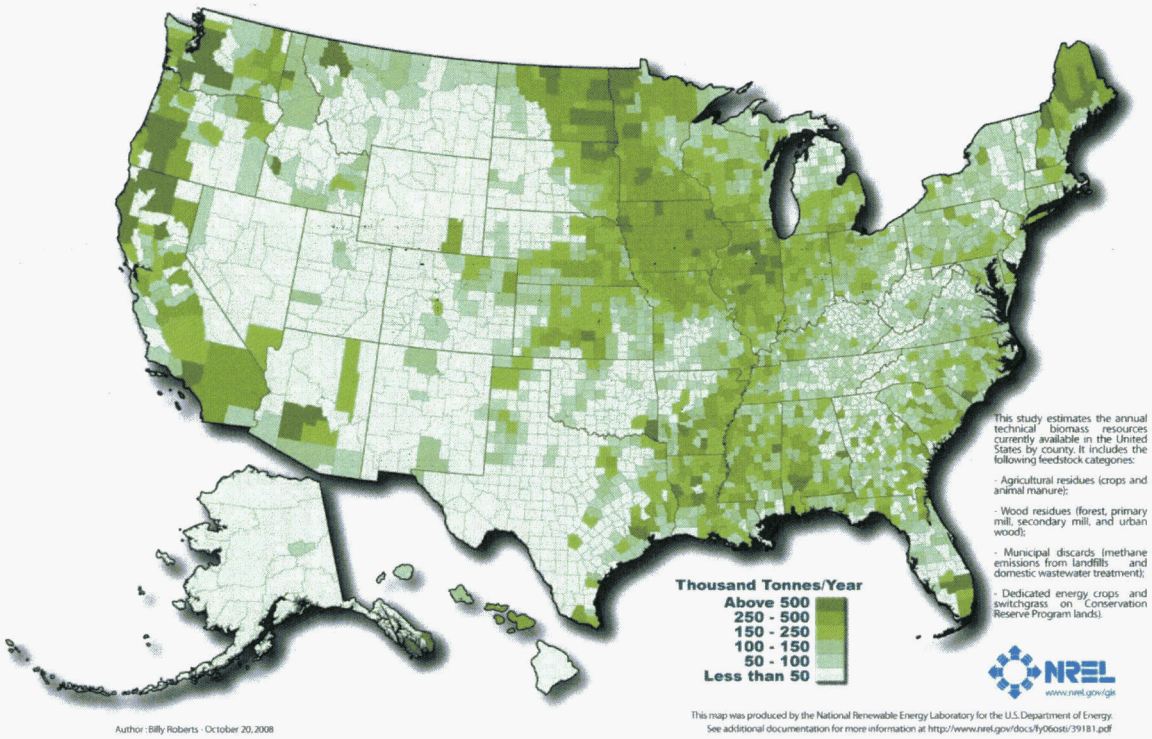
Modeling Assumptions

For the IRP process at UNS Electric, a direct fired biomass facility with the following characteristics was considered.

Coincident System Peak Capacity	100%
Heat Rate Btu/kWh	11,000
Capacity Cost $/kW	$2,950
Fixed O&M Cost $/kW-Year	$85
Annual Capacity Factor, %	85%
CO2 Rate, lbs/MMbtu	Carbon-Neutral
SO2 Rate, lbs/MMbtu	0.0006
NOX Rate, lbs/MMbtu	0.033
HG Rate, Mlbs/MMbtu	2.55
Water, Gal/MWh	90
Levelized Cost $/MWh	$108

U.S. BIOMASS MAP

Map 17 – U.S. NREL Biomass Map



RENEWABLE RESOURCE INTEGRATION COSTS

Table 19 below reflects the renewable integration modeling assumptions used in the 2012 IRP. Integration costs for wind resources were based on the APS Wind Integration Cost Impact Study conducted by NAU, September 2007.(NAU, Northern Arizona University) Integration costs for a solar resource were based on the Solar Integration Study for Public Service Company of Colorado, prepared by Xcel Energy, February 9, 2009. (EnerNex Corporation, 2009). In addition, a study that was completed in mid-2011, titled Large-Scale PV Integration Study conducted by Navigant Energy was used to validate these integration cost assumptions.

Table 19- System Integration Costs

System Integration Costs	
Renewable Technology	2012 $/MWh
NM Wind	$5.00
AZ Wind	$5.00
Solar PV (Fixed)	$4.00
Solar PV (Single Axis)	$4.00
Solar CSP	$2.00
Solar CSP (Storage)	$0.00
Biomass Direct	$0.00

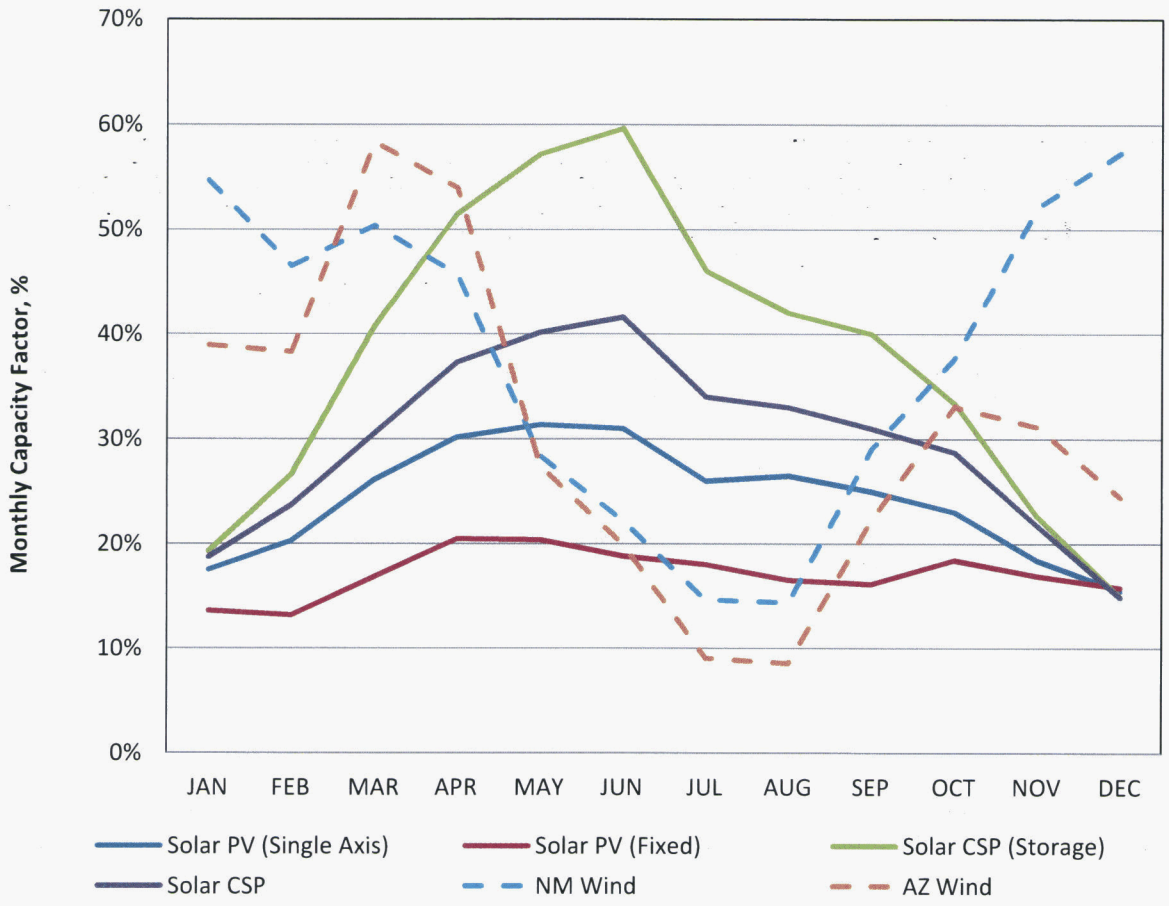
These integration costs represent the additional costs for system regulation, load following and unit commitment to compensate for the intermittent and unpredictable nature of renewable resources. These costs reflect the dollar impact on system incremental dispatch and are based on utility systems with relatively low renewable penetration.

UNS Electric will continue to research and study the cost impacts as renewable integration becomes a larger percentage of the overall UNS Electric portfolio. As described on the next page, a number of more recent studies are providing utilities with additional insights on how the utility of the future will face the challenges of renewable integration.

Seasonal Profiles for Renewable Resources

Chart 25 shown below provides a monthly comparison of the expected capacity factors by renewable technology types. Wind resources provide more output during the winter season whereas solar resources tend to have higher capacity factors during the summer season.

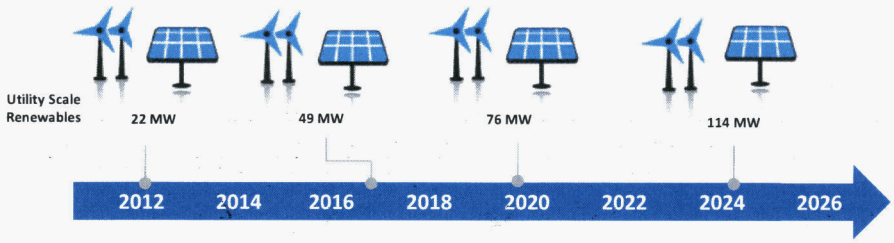
Chart 25 - Renewable Resource Seasonal Profiles



Projected Utility Scale Requirements in the 2012 IRP

The Reference Case plan also includes a diverse portfolio of renewable resources that complies with the Arizona Renewable Energy Standard (RES). The Reference Case plan meets the renewable energy standard goals. The RES requires UNS Electric to utilize renewable energy resources to serve 3.5% of its 2012 retail load requirement, growing to 15% by 2025. By 2020, the Reference Case plan includes approximately 300 MW of renewable nameplate capacity. These utility scale renewable resources are expected to supply over 650 GWh of energy on an annual basis in 2020.

Figure 15 – Utility Scale Renewable Capacity



Below is a forecast summary of the utility-scale renewable resources that comply with the Arizona RES targets.

Table 20 – 2012-2027 Projected Utility Scale Generation

REST Program, Energy	2012	2013	2014	2015	2016	2017	2018	2019
Utility Scale Solar, GWh	24.0	35.5	38.3	43.9	57.3	68.3	79.5	90.8
Utility Scale Wind, GWh	25.9	26.1	26.9	28.8	33.3	37.0	40.6	44.4
Total Utility Scale Renewables, GWh	49.9	61.6	65.2	72.7	90.5	105.4	120.1	135.2

REST Program, Energy	2020	2021	2022	2023	2024	2025	2026	2027
Utility Scale Solar, GWh	102.4	113.6	125.2	137.3	150.2	162.7	169.6	182.6
Utility Scale Wind, GWh	48.3	52.1	55.9	59.9	64.2	68.4	68.5	72.8
Total Utility Scale Renewables, GWh	150.7	165.6	181.1	197.1	214.4	231.2	238.0	255.4

Table 21 – 2012-2027 Projected Utility Scale Resource Costs

REST Program Costs	2012	2013	2014	2015	2016	2017	2018	2019
PPFAC Cost, Renewables, $000	$3,053	$2,601	$4,032	$4,857	$6,198	$7,467	$10,250	$12,126
REST Program - Utility Scale, $000	$2,939	$4,800	$3,716	$3,595	$3,921	$3,921	$2,684	$2,462
Total Utility Scale Renewables, $000	$5,992	$7,401	$7,748	$8,451	$10,119	$11,389	$12,934	$14,588

REST Program Costs	2020	2021	2022	2023	2024	2025	2026	2027
PPFAC Cost, Renewables, $000	$13,895	$15,714	$17,667	$19,776	$22,131	$25,600	$29,025	$33,595
REST Program - Utility Scale, $000	$2,464	$2,442	$2,426	$2,410	$2,383	$1,278	$0	$0
Total Utility Scale Renewables, $000	$16,359	$18,156	$20,094	$22,185	$24,514	$26,878	$29,025	$33,595

CHAPTER 10

Distributed Generation Resources

Overview

Distributed Generation (DG) resources are small-scale renewable resources sited on customer premises. The Renewable Energy Standard requires that a portion of renewable energy requirements be obtained from residential and commercial DG systems. The required DG percentage in 2012 and beyond is 30% of the total renewable energy requirement.

UniSource Electric Power is committed to assisting our customers in developing zero-emission resources that enable customers to supplement their energy usage and reduce their overall monthly energy bills. In order to facilitate the installation of these DG resources, UNS Electric provides incentives through its Renewable Energy Credit Purchase Program (RECPP) to subsidize the cost of these systems. The RECPP provides incentives to customers to set up renewable energy systems at their homes or businesses while allowing UNS Electric to purchase Renewable Energy Credits (RECs) in return. These incentives can be in the form of up-front or production based credits.

Up-Front Incentive (UFI)

Up-Front Incentives (UFI) provides customers a one-time payment based on their system rating, which is in kWh savings. In turn the customer would sign a credit purchase agreement assigning UNS Electric the Renewable Energy Credits (REC) for 20 years. To qualify for the UFI a system must have at least a 10-year manufacturer's warranty; otherwise a system would qualify for the Performance Based Incentive (PBI).

Performance Based Incentive (PBI)

Performance Based Incentives (PBI) provides customers with a long-term payment stream ranging from 10 to 20 years based upon the customer's selected DG technology. In return, the customer signs a credit purchase agreement assigning UNS Electric the Renewable Energy Credits (REC) for the same number of years.

In addition to the UFI and PBI incentives, customers may also qualify for federal and state tax credits to further reduce the cost of their DG systems.

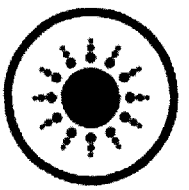
Distributed Generation Resources

For the 2012 IRP, all of UNS Electric's proposed resource plans comply with the RES specified DG targets. For modeling purposes, UNS Electric assumes the majority of DG resources will be based on solar PV and solar hot water systems. This section provides a brief overview on some of the technologies eligible as distributed generating resources in UNS Electric's service territory.

- Photovoltaic Solar Electric Systems
- Solar Hot Water Systems

- Solar Space Heating & Cooling Systems
- Small Hydro Systems
- Small Wind Systems
- Biogas or Biomass Systems

Photovoltaic Solar Electric Systems

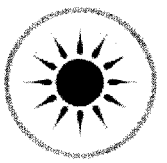


Solar Electric

UNS Electric is offering incentive payments for residential photovoltaic (PV) systems to encourage the installation of solar power. To qualify in this category, systems can be up to 20 kW. Up-Front Incentives are available for both grid-tied and off-grid systems up to 20 kW.

Solar systems are best suited in areas that receive a relatively high amount of solar insolation like Arizona. The productivity of photovoltaic systems is sensitive to the specifics of the installation method and location. In particular, these systems are impacted by shading, photovoltaic panel horizontal tilt angle and azimuth. These factors are particularly important as they relate to systems receiving UFI type incentives both in the amount of incentive received by the customer and in the computation of the capacity reported by UNS Electric.

Solar Hot Water/Space Heating



Solar Hot Water/
Space Heating

UNS Electric is offering incentive payments for residential solar hot water and space heating systems to encourage the installation of solar power. Solar hot water and/or space heating systems are best suited in areas that receive a relatively high amount of annual sunshine.

Small Hydro

Small Hydro

UNS Electric is offering incentive payments to residential and nonresidential customers to encourage the installation of Small Hydro systems. Hydropower is a renewable resource that uses water to create electricity. Location and the source of swift moving water will play a key role in the decision to invest in a hydropower system.

Solar Space Cooling

Solar Space Cooling

UNS Electric offers incentive payments to install solar space cooling systems at a customer's home or business. Solar space cooling systems are best suited in areas that receive a relatively high amount of annual sunshine. The productivity of solar space cooling systems is sensitive to the specifics of the installation method and location. These factors are particularly important as they relate to systems receiving Performance-Based Incentives (PBI) received by the customer.

Small Wind

Small Wind

UNS Electric is offering incentive payments for residential and nonresidential small wind systems to encourage the installation of wind power. Incentives range for both grid-tied and off-grid systems from 1 kW up to 1,000 kW. Systems under 100 kW will have funding priority. Small wind systems are best suited in areas that have a relatively high annual wind speed, low wind intermittency rates and at least a half acre of property to accommodate the wind turbine equipment.

Geothermal Energy Systems

Geothermal

UNS Electric is offering incentive payments to residential and nonresidential customers to encourage the installation of Geothermal Energy Systems. Geothermal energy is a renewable resource that uses the natural heat from the earth. By investing in geothermal energy, you can reduce long-term energy costs and increase energy independence. Qualifying geothermal energy systems include:

Geothermal Space Heating or Cooling

The most common type of space heating or cooling from geothermal energy is a geothermal heat pump. The geothermal heat pump takes advantage of the relatively constant temperature of the earth's interior, using it as a source for both heating and cooling purposes. This type of geothermal energy usually requires low to moderate temperatures ranging between 80 to 150 degrees Fahrenheit.

Geothermal Thermal (Process Heating)

This method uses heat from the earth's interior that is directly used in an application or process such as heating or cooking. An example is the use of geothermal energy to heat water. This is the oldest form of geothermal energy use and is generally practical with low to moderate temperatures of 150 degrees Fahrenheit or more.

Distributed Generation Resources

For the 2012 IRP, all of UNS Electric's proposed resource plans comply with the RES specified DG targets. For modeling purposes, UNS Electric assumes the majority of DG resources will be based on solar PV and solar hot water systems. This section provides a brief overview on both residential PV systems and solar hot water heating technologies.

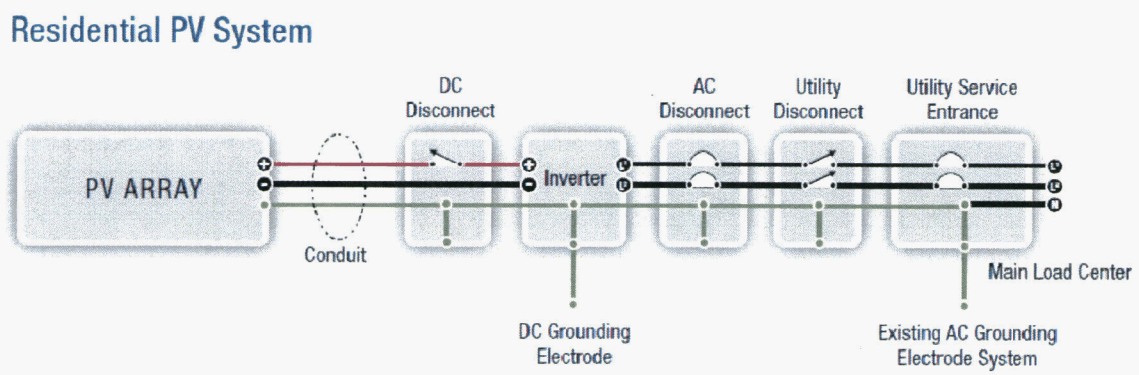
Solar Photovoltaic DG Systems Overview

Solar Photovoltaic DG systems convert sunlight directly into electricity. A residential PV power system enables a homeowner to generate some or all of their daily electrical energy demand on their own roof. The house remains connected to the utility grid at all times, so any power needed above the installed solar capacity can be drawn from the utility. PV systems can also include battery backup or uninterruptible power supply (UPS) capability to operate selected circuits in the residence for hours or days during a utility outage.

Every house that is connected to the electric utility has a main service panel, an electrical meter and a line to the utility grid. Power flows from the grid through the meter to the service panel where it is distributed throughout the house. When PV generation is added to a residence, additional power from that source will also flow to the Main Service Panel to be distributed throughout the house. In the event of a utility outage, the PV system is designed to shut down until utility power is restored.

A simple grid-tied PV system diagram is show below:

Figure 16 – Residential PV System Schematic



Typical System Components:

PV Array: PV systems use solar cells to convert sunlight directly into electricity. The most commonly used solar cells are made from highly purified crystalline silicon. Groups of solar cells are packaged into PV modules, which are sealed to protect the cells from the environment. Modules are wired together in series and parallel combinations to meet the voltage, current, and power requirements of the system. This grouping is referred to as a PV array. The PV array produces DC power, which is then converted to AC power by an inverter to produce electricity. PV modules typically range in size from 5-to-25 square feet and weighs about 3-4 lbs/ft2.

Balance of System (BOS): The remainder of the PV system, aside from the PV modules, is called the balance-of-system. BOS includes mounting systems and wiring systems used to integrate the solar modules into the structural and electrical systems of the home. The wiring systems include disconnects for the DC and AC sides of the inverter, ground-fault protection, and over current protection for the solar modules. Most PV systems include a circuit combiner to integrate each module source circuit. Some inverters include this fusing and combining function within the inverter enclosure.

Configuration of Typical PV Systems

Figure 17 – Typical Grid Tied PV System

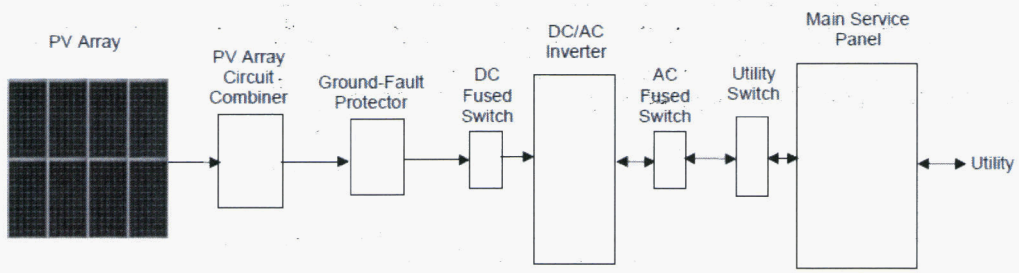
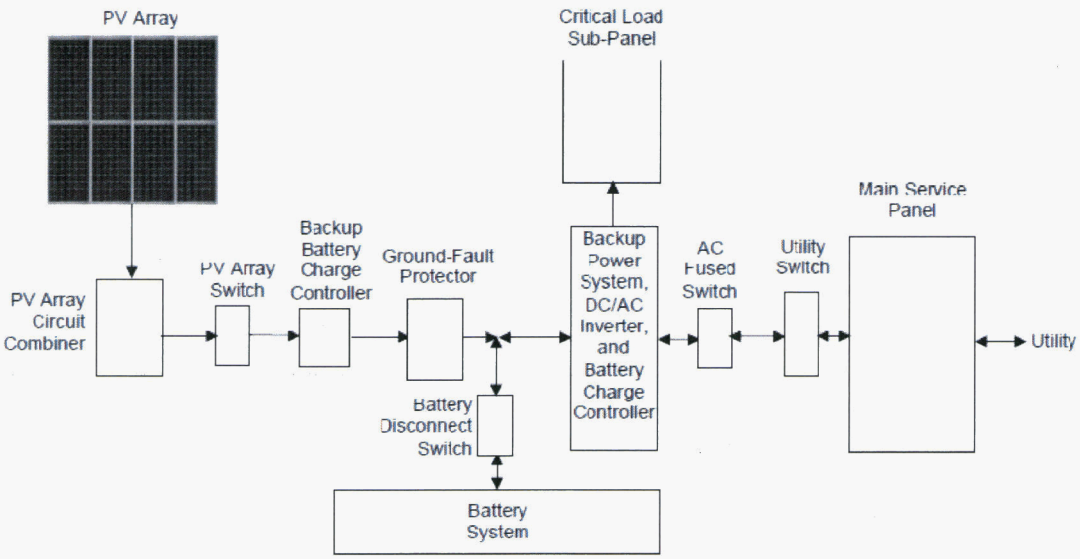


Figure 18 – Typical Grid Tied PV System with Battery Backup



Solar PV Load Profiles

Chart 26 – Typical Summer Customer Load Profile, Net Solar PV

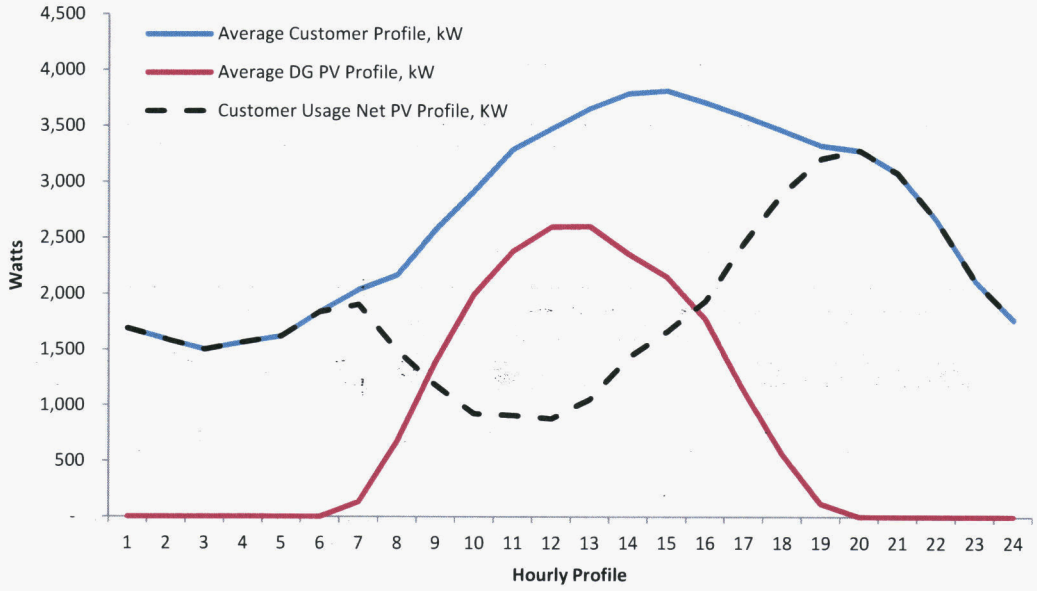
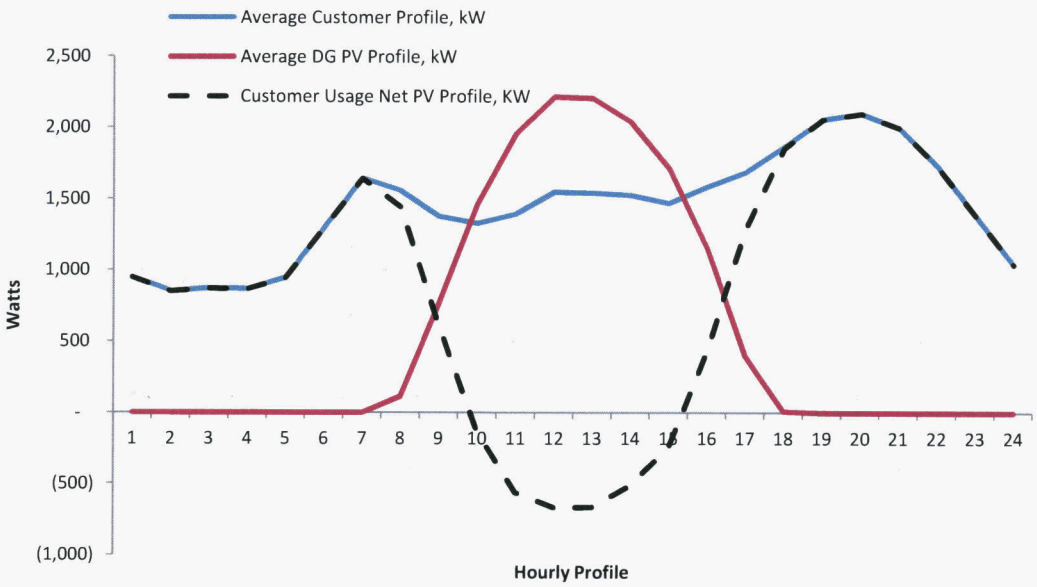


Chart 27 – Typical Winter Customer Load Profile, Net Solar PV



Solar Hot Water Heater Overview

Solar water heating systems include storage tanks and solar collectors. There are two types of solar water heating systems: active, which have circulating pumps and controls, and passive, which don't. Most solar water heaters require a well-insulated storage tank. Solar storage tanks have an additional outlet and inlet connected to and from the collector. In two-tank systems, the solar water heater preheats water before it enters the conventional water heater. In one-tank systems, the back-up heater is combined with the solar storage in one tank. Solar water heating systems are described using four common terms:

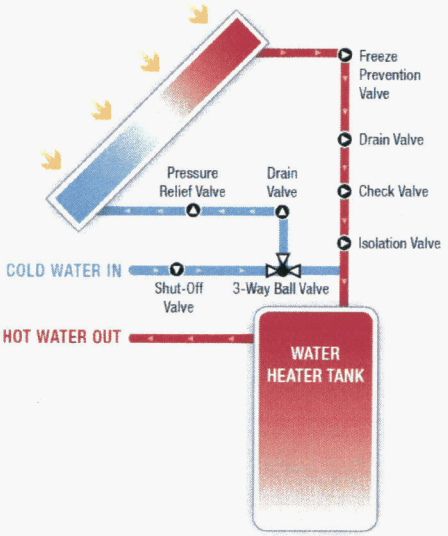
- Active systems use pumps to move fluids through the system.
- Passive systems rely on the buoyancy of warm water and gravity to move fluids through the system without any pumps.
- Direct systems heat water that feeds directly into the domestic hot water system. Direct systems always use potable water as the heat transfer fluid. In areas with dissolved minerals, CO_2, or other water quality problems, these systems may require water softeners or other treatments.
- Indirect systems have independent piping and use heat exchangers to isolate solar fluids from potable domestic hot water. Systems using propylene glycol must use heat exchangers, however, water may also be used in indirect systems with heat exchangers.

The following system descriptions include example illustrations of system designs. In practice, systems may be configured in many different ways.

Integral Collector Storage (ICS) Passive Direct System

ICS systems are passive and direct. The tank and collector are combined. Potable water is heated and stored in the ICS collector. As hot water is used, cold water fills the collector from the bottom. These systems work best when hot water demands are in the late afternoon and evening. Heat gained during the day may be lost at night if not used depending on local weather conditions. A check valve or the arrangement of pipe runs stops reverse thermosiphoning where heat is lost from the domestic hot water system to the night sky. These systems are the least expensive of solar thermal options and one of the most popular systems on the world market. However, they may only be used in areas that do not experience many hard freezes. ICS collectors have more depth than flat plate collectors to accommodate integral tanks. Some builders have placed these collectors directly on the roof deck and built up around them with parapets or tile roof systems.

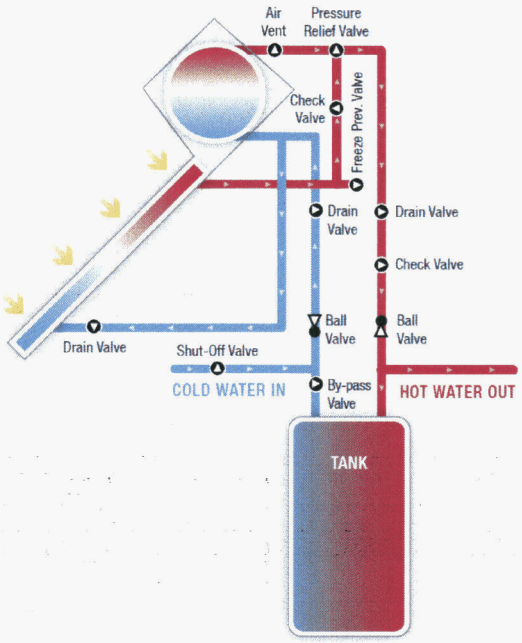
Integral Collector Storage (ICS) Passive Direct System



Source: NREL – Department of Energy

Thermosiphon Passive Direct System

Thermosiphon systems are passive with a storage tank located higher than the solar collector. Some systems come prepackaged with tanks pre-mounted to collectors. In these systems the tank sits on the outside of the roof. Other systems have tanks located inside attic spaces above the collectors. These systems are direct, using potable water as the heat transfer fluid. Water pipes and tanks containing water must be protected from freezing or located in a conditioned space in climates that freeze.



Source: NREL – Department of Energy

Typical Installations

In general, SHW systems are mounted on a south-facing roof, or adjacent to the house at ground level. In either case, the SHW system is generally remote from the backup and supplementary storage water heater and its tank. This distance, or the amount of finished space the loop must traverse in a retrofit installation, impacts the method and cost of installation. The most fundamental distinction is between systems that must resist freezing (closed-loop systems), and those located in climates where freezing is very rarely severe enough to threaten the integrity of the system (open-loop systems). Because closed-loop systems require either drain-back provisions or a separate freeze-protected loop to indirectly heat water in the storage tank, they generally have active components (pumps) and are more complex.

Solar Hot Water Heating Load Profiles

Chart 28 – Typical Summer Customer Load Profile, Net Solar Hot Water Heating

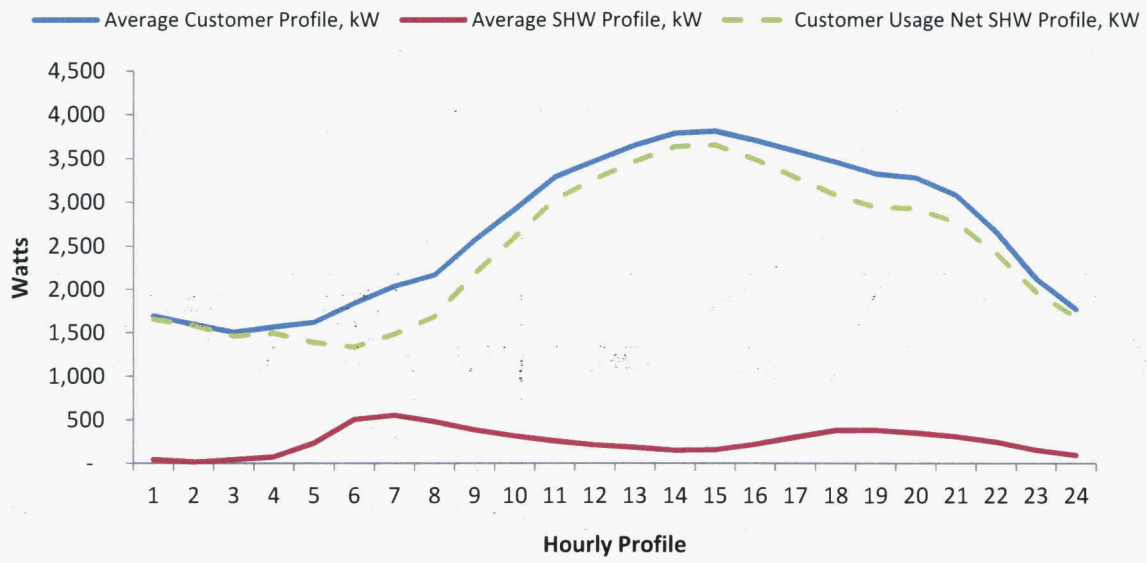
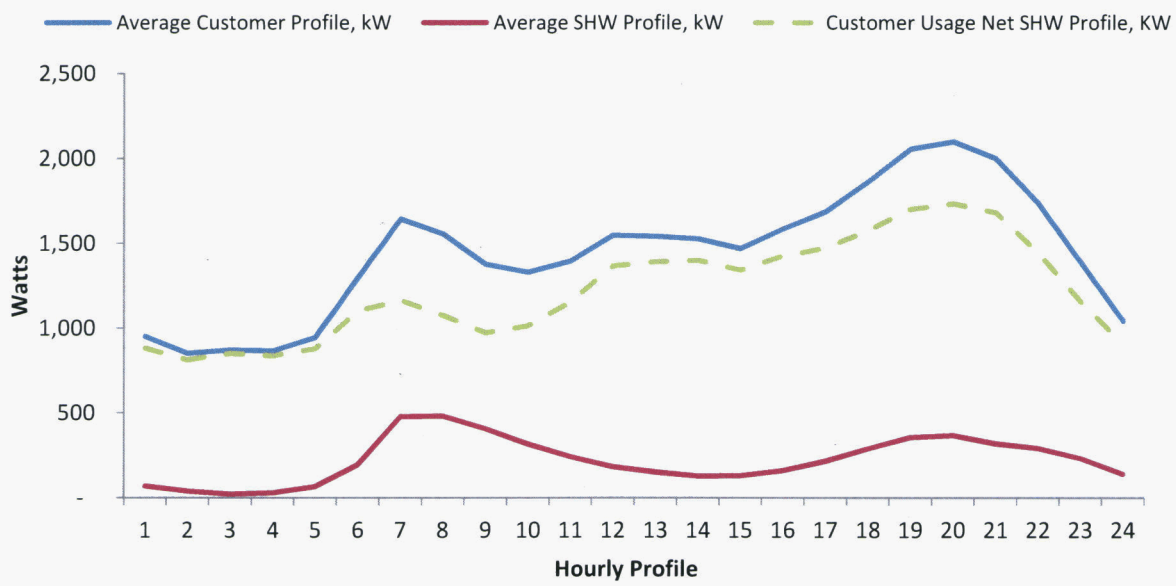


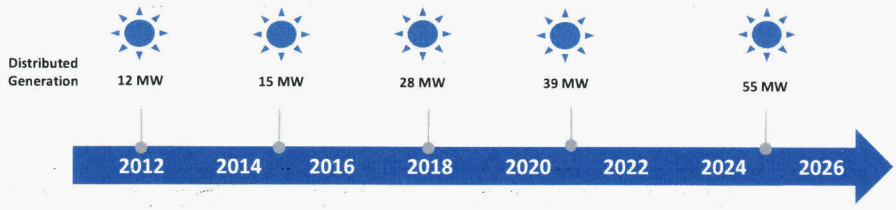
Chart 29 – Typical Winter Customer Load Profile, Net Solar Hot Water Heating



Projected Distributed Generation Requirements in the 2012 IRP

The Reference Case resource plan meets the DG requirement based on Arizona's Renewable Energy Standard. The annual DG requirement is 30% of the total renewable energy standard starting in 2012. By 2015, the Reference Case plan will include 150 MW of DG nameplate capacity. DG resources are expected to supply at least 200 GWh of energy on an annual basis in 2019. Figure 19 below shows the expected cumulative nameplate capacity to be installed under the DG programs from 2012 through 2027.

Figure 19 - Distributed Generation Resource Capacity



Below is a forecast summary of the estimated grid offsets related to customer-sited DG systems that comply with the Arizona RES targets.

Table 22 – 2012-2019 Projected Distributed Generation Program Schedule

DG Program (Energy)	2012	2013	2014	2015	2016	2017	2018	2019
Solar PV, GWh	18.1	21.0	23.7	26.5	32.0	37.6	43.2	48.8
Solar Hot Water, GWh	2.0	2.3	2.6	2.9	3.6	4.2	4.8	5.4
Program Energy, GWh	20.1	23.3	26.3	29.5	35.6	41.8	48.0	54.3

DG Program (Capacity)	2012	2013	2014	2015	2016	2017	2018	2019
Nameplate MW	12	14	15	17	21	24	28	31
System Coincident Peak MW	3	4	4	5	5	6	7	8

DG Program Costs ($000)	2012	2013	2014	2015	2016	2017	2018	2019
Solar PV, $000	$5,453	$4,867	$4,337	$4,247	$7,880	$7,530	$7,158	$7,294
Solar Hot Water, $000	$952	$145	$129	$126	$235	$224	$213	$217
Total Program Costs, $000	$6,406	$5,012	$4,467	$4,374	$8,115	$7,754	$7,371	$7,511

Table 23 – 2020-2027 Projected Distributed Generation Program Schedule

DG Program (Energy)	2020	2021	2022	2023	2024	2025	2026	2027
Solar PV, GWh	54.5	60.3	66.4	72.6	79.1	85.7	92.4	99.3
Solar Hot Water, GWh	6.1	6.7	7.4	8.1	8.8	9.5	10.3	11.0
Total Program Energy, GWh	60.6	67.0	73.7	80.7	87.9	95.2	102.7	110.3

DG Program (Capacity)	2020	2021	2022	2023	2024	2025	2026	2027
Nameplate MW	35	39	43	47	51	55	60	64
System Coincident Peak MW	9	10	11	12	13	15	16	17

DG Program Costs ($000)	2020	2021	2022	2023	2024	2025	2026	2027
Solar PV, $000	$7,341	$7,439	$7,837	$8,241	$8,517	$8,949	$9,247	$9,670
Solar Hot Water, $000	$218	$221	$233	$245	$253	$266	$275	$288
Total Program Costs, $000	$7,560	$7,660	$8,070	$8,486	$8,770	$9,216	$9,522	$9,958

Chart 30 – UNS Electric's Distributed Generation by Technology Type

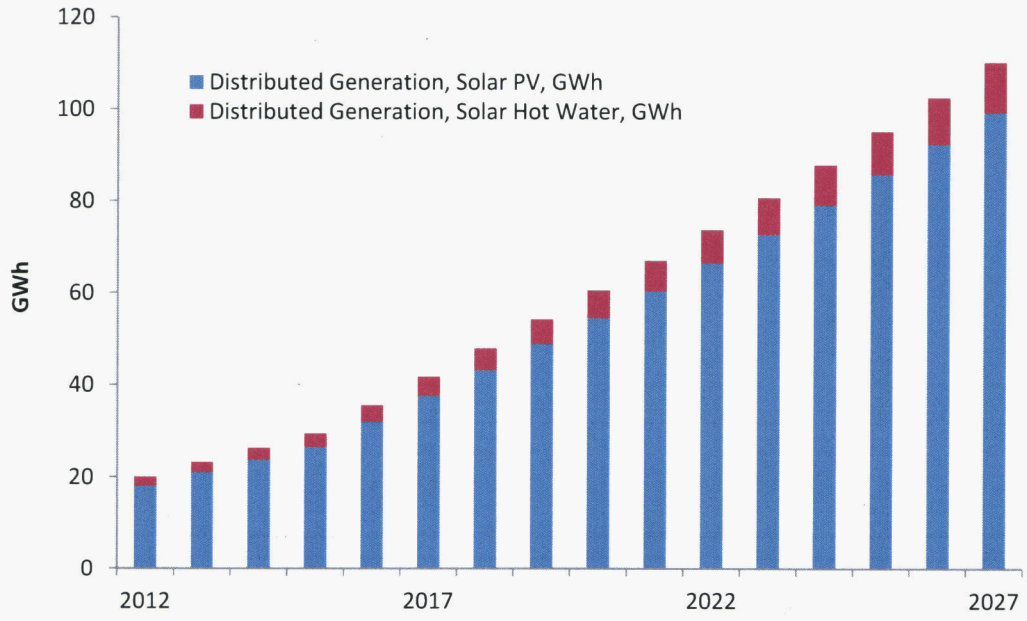
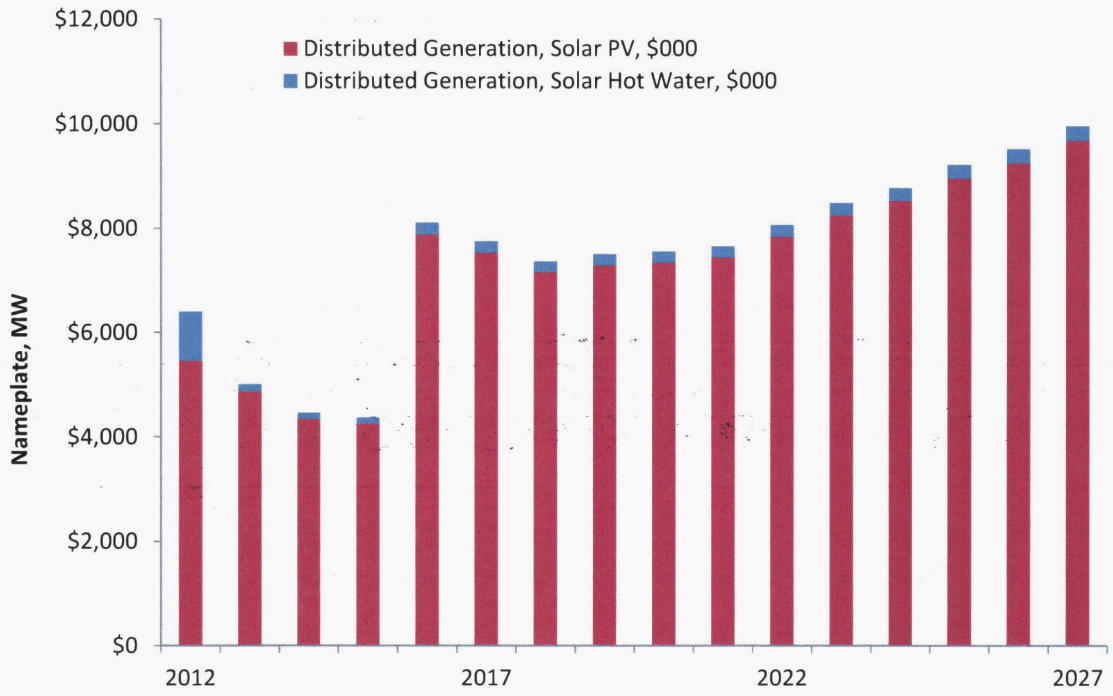


Chart 31 – UNS Electric's Distributed Generation DG Technology Budget



CHAPTER 11

CONVENTIONAL RESOURCE TECHNOLOGIES

Overview

In developing the input assumptions for the conventional resources, the resource planning team relied on a number of sources, including Ventyx's Power Market Advisory Service, Wood Mackenzie and PACE Global to provide a comprehensive set of data inputs such as capital, O&M, and operational assumptions.

For the 2012 resource plan, the following conventional technologies were modeled as viable future resources:

- Combustion Turbine (CT)
- Combined Cycle Plant (CC)
- Compressed Air Energy Storage (CAES)
- Integrated Gasification Combined Cycle (IGCC)
- Pulverized Coal
- Nuclear

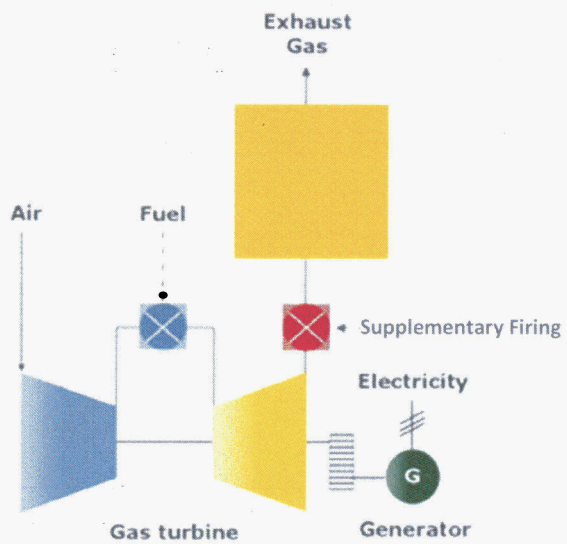
Combustion Turbine (CT)

CT power plants are a mature generation technology and have been used to generate electricity for several decades. CTs play a significant role in supporting UNS Electric's summer peak load obligations and annual operating reserve requirements. CTs are designed to be dispatched quickly to meet changes in load and provide backup for other generation resources that are intermediate in nature or when other units are unexpectedly forced out of service. UNS Electric expects that CTs will play a larger role in its future resource mix as UNS Electric integrates a larger share of renewable resources into its portfolio. Some of the key features of CTs include flexibility in siting, low emission levels with natural gas fuel, low capital cost, and short construction time. The primary risk associated with CTs is related to fuel cost risk which is the result of the uncertain price volatility associated with natural gas.

Technology Overview

CTs essentially bring together compressed air and natural gas that are then ignited in a combustor stage. The resulting gases are expanded through a power turbine that drives a compressor and electrical generator. The turbine's shaft continues to rotate and drive the compressor which is on the same shaft, and operation continues.

Figure 20- Combustion Turbine Diagram



There are two classes of gas turbine designs, heavy-duty and aero-derivative. The heavy-duty class utilizes a single shaft for the compressor and the power turbine. The aero-derivative utilizes a two shaft design in which one shaft drives the compressor and another shaft drives the generator. The aero-derivative tends to be 10% more efficient to operate than the heavy duty class but costs about 25% more to construct.

Transmission & Siting Requirements

CT power plants tend to have small land requirements and are usually sited close to load centers. This relatively small construction footprint allows CT projects to take advantage of existing natural gas and transmission infrastructure, reducing the development time and cost of a project. In addition, as a utility's resource

requirements change over time, a CT site configuration can be designed to allow for a future conversion to a combined cycle facility through staged development.

Dispatch Characteristics

CTs can respond quickly to changes in system loads or unit contingencies, giving them a high degree of operating flexibility. CT generating units can go from a cold start to full operation in less than 10 minutes. CTs are used to meet peak load requirements and provide standby capacity for system reliability purposes.

Environmental Attributes

Control technologies are used to eliminate most, but not all emissions of SO2 and NOx. However, CO2 production remains a major concern.

Modeling Assumptions

The simple-cycle combustion turbines considered for the IRP included one heavy duty class unit and two aero-derivatives. These resources ranged in size from 45MW to 160 MW. The cost and operating characteristics are summarized below.

Table 24 - Combustion Turbine Modeling Assumptions

Unit Description	GE 7FA	GE LMS100	GE LM6000
Dispatch Capacity MW	160	90	45
Heat Rate Btu/kWh	10,500	9,000	9,800
Capacity Cost $/kW	$750	$1,151	$954
Fixed O&M $/kW-yr	$13.60	$11.95	$15.00
Annual Capacity Factor, %	7%	18%	10%
CO2 Rate, lbs/MWh	1,248	1,070	1,165
SO2 Rate, lbs/MWh	0.006	0.005	0.006
NOX Rate, lbs/MWh	0.347	0.323	0.297
HG Rate, lbs/MWh	2.70E-06	2.30E-06	2.50E-06
PM10 Rate, lbs/MWh	0.078	0.067	0.073
Water, Gal/MWh	150	150	150
Levelized Cost $/MWh	$293	$185	$262

Combined Cycle (CC)

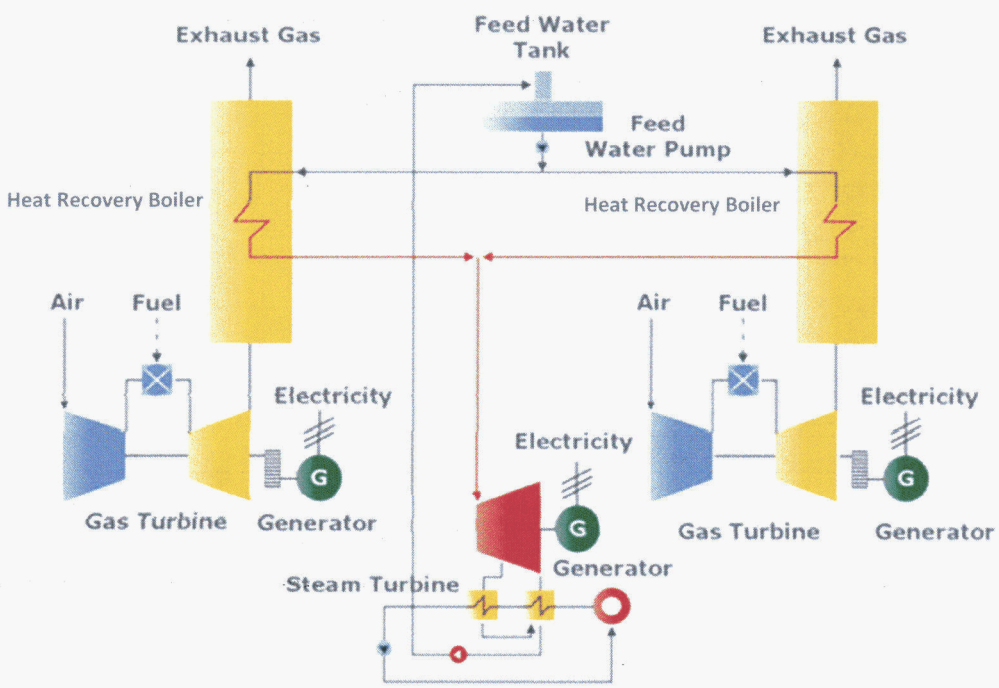
Combined cycle combustion turbine (CC) power plants representing about one-third of the electricity generated in the United States.

Technology Overview

The CC plant is a hybrid of the simple cycle gas turbine and steam turbine technologies. Combined cycle generating units are designed to capture the waste exhaust heat from a CT, generating additional electricity in a heat recovery steam generator (HRSG). This steam drives a steam turbine generator (STG), which provides an increase in plant efficiency and capacity output. This capture of waste heat increases efficiency compared to a CT by about 35%. The combined cycle add-on increases plant output by approximately 50% of the gas turbine rating. Usually about two-thirds of the power is produced from the CTs and one-third from the STG. In addition, the CC plant has the flexibility to be operated either with or without the steam cycle, which allows the unit to better match a utility's resource requirement. In addition, the steam generator of combined-cycle units can be fitted with fuel burners ("duct firing") to boost peak power output.

The primary risk associated with CCs is related to fuel cost risk which is the result of the uncertain price volatility associated with natural gas.

Figure 21 - Combined-Cycle Diagram



Transmission & Siting Requirements

CC power plants tend to have small land requirements and are usually sited close to load centers.

Dispatch Characteristics

Similar to a CT, CCs can be dispatched quickly if operated without the steam cycle. However, in order to achieve maximum operating efficiency, CCs require longer start up and shut down times and are usually committed on a day-ahead basis. This efficiency benefit over CTs enables CCs to be dispatched to serve both base load and intermediate capacity requirements. Once on-line, CCs have quick ramping capabilities and are often relied on to meet system load following requirements.

Environmental Attributes

Control technologies are used to eliminate most, but not all emissions of SO2 and NOx. However, CO2 production and high water usage remains a major concern.

Modeling Assumptions

The cost and operating characteristics for the CC are summarized below.

Table 25 - Combined Cycle Modeling Assumptions

	Intermediate	Baseload
Dispatch Capacity MW	570	570
Heat Rate Btu/kWh	7,200	7,200
Capacity Cost $/kW	$1,161	$1,161
Fixed O&M Cost $/kW-yr	$16.50	$16.50
Annual Capacity Factor, %	40%	80 %
CO2 Rate, lbs/MWh	850	850
SO2 Rate, lbs/MWh	0.004	0.004
NOX Rate, lbs/MWh	0.094	0.094
HG Rate, lbs/MWh	1.80E-06	1.80E-06
PM10 Rate, lbs/MWh	0.054	0.054
Water, Gal/MWh	350	350
Levelized Cost $/MWh	$115	$83

Integrated Gasification Combined Cycle (IGCC)

Integrated gasification combined cycle (IGCC) is an up and coming concept that takes several technologies that have been successfully applied commercially and combines them for the generation of electricity. These processes produce synthetic natural gas (syngas) from coal or petroleum coke then use the syngas as a generation fuel. There are many advantages to IGCC generation including:

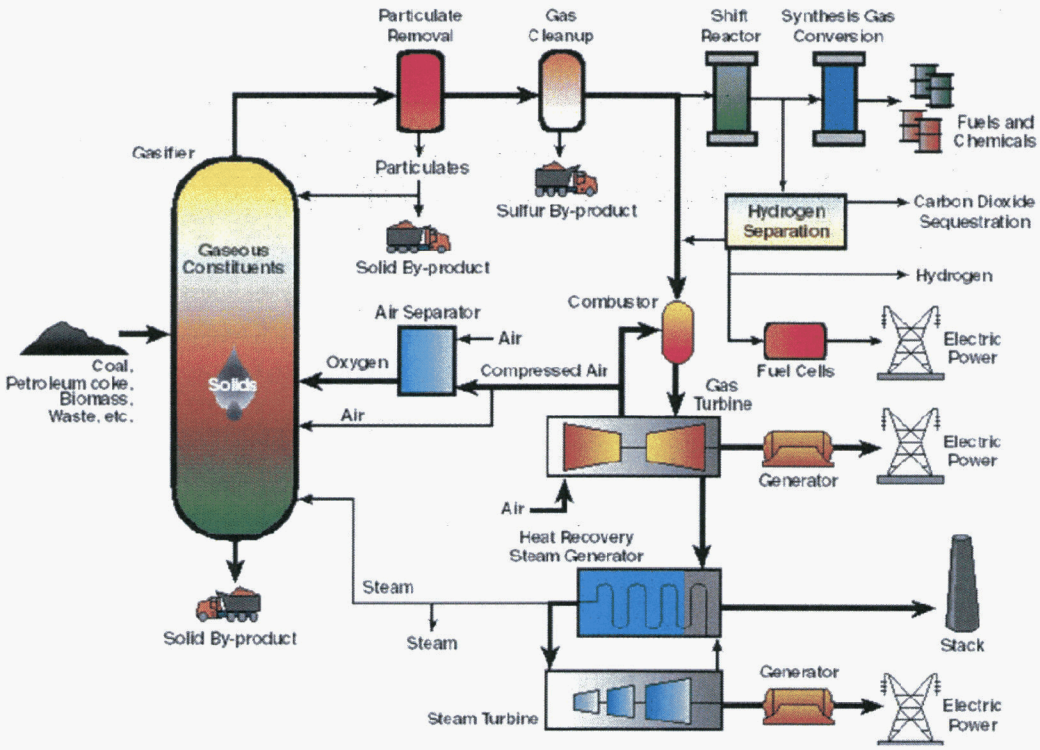
- High thermal efficiency - less fuel is needed to produce a MWh of energy
- Less solid waste – IGCC produces about half the solid waste of traditional coal generation
- Lower water requirements – IGCC generation uses 20-40% less water than conventional coal generation
- Lower emissions – IGCC emits less Nitrogen and Sulfur than traditional coal plants and it lends itself to simpler, less expensive carbon capture. However, currently no commercial IGCC plant captures CO2.
- The U. S. Dept of Energy has reported utility scale IGCC plants utilizing carbon capture technologies that showed a 90% reduction of carbon release when compared to the same plants without carbon capture and sequestration technology.

The disadvantages are that while operating costs are lower for IGCC as compared to conventional coal, the upfront capital costs are higher largely due to the very custom designs needed. Every plant must be specifically designed to the fuel to be burned. There are no "off the shelf" packages available. It should also be emphasized that while this technology has many expected advantages there are very few such plants operating worldwide.

Technology Overview

The IGCC begins with atmospheric air which is split into oxygen and nitrogen. A device called a "gasifier" combines the separated oxygen with a slurry of water and pulverized coal, coke or biomass at extremely high temperatures and pressures. The gasification of the slurry produces a hydrogen, carbon monoxide synthesis gas or syngas. After a multi-step cleanup process the syngas is used to power a CT generator to generate electricity. Frequently, the excess heat from the gasifier and from the turbine generator is used in a second stage to produce steam that is used to power a steam turbine generator producing more electricity for added efficiency.

Figure 22 - Integrated Gasification Combined Cycle Diagram



(NREL, National Renewable Energy Laboratory)

Transmission & Siting Requirements

Transmission requirements for an IGCC project are similar to that of baseload or traditional coal generation.

IGCC power plants generally require less land than traditional coal plants. However, sequestration of carbon may require a specialized location with underground storage nearby.

Dispatch Characteristics

Because IGCC uses a CT generator its dispatch characteristics are similar to a traditional CT.

Environmental Attributes

The syngas cleanup process removes a large percentage of the particulates, sulfur and mercury normally found in coal emissions. Because IGCC lends itself well to carbon sequestration it has a further environmental advantage. Finally, IGCC has the environmental benefit of requiring about one half the water of coal generation.

Modeling Assumptions

The cost and operating characteristics for an IGCC are summarized below.

Table 26 - IGCC Modeling Assumptions

CCS Capability	No	Yes
Dispatch Capacity MW	600	380
Heat Rate Btu/kWh	9,200	11,000
Capacity Cost $/kW	$4,448	$5,931
Fixed O&M Cost $/kW-yr	$50.80	$57.90
Annual Capacity Factor, %	75%	70%
CO2 Rate, lbs/MWh	1,886	226
SO2 Rate, lbs/ MWh	0.117	0.094
NOX Rate, lbs/ MWh	0.406	0.450
HG Rate, lbs/MWh	4.25E-06	4.59E-06
PM10 Rate, lbs/ MWh	0.007	0.007
Water, Gal/MWh	800	900
Levelized Cost $/MWh	$145	$200

Pulverized Coal

Coal has been used to generate low-cost electricity in the United States for more than a century. Pulverized coal generation technology was developed in the 1920s and since then has been the most common form of coal-fired generation. Examining the outlook for pulverized coal generation in the United States reveals sharply contrasting considerations. On one hand, pulverized coal generation is a proven, reliable technology that has relatively low direct costs and uses a domestic fuel supply that is readily available in large quantities.

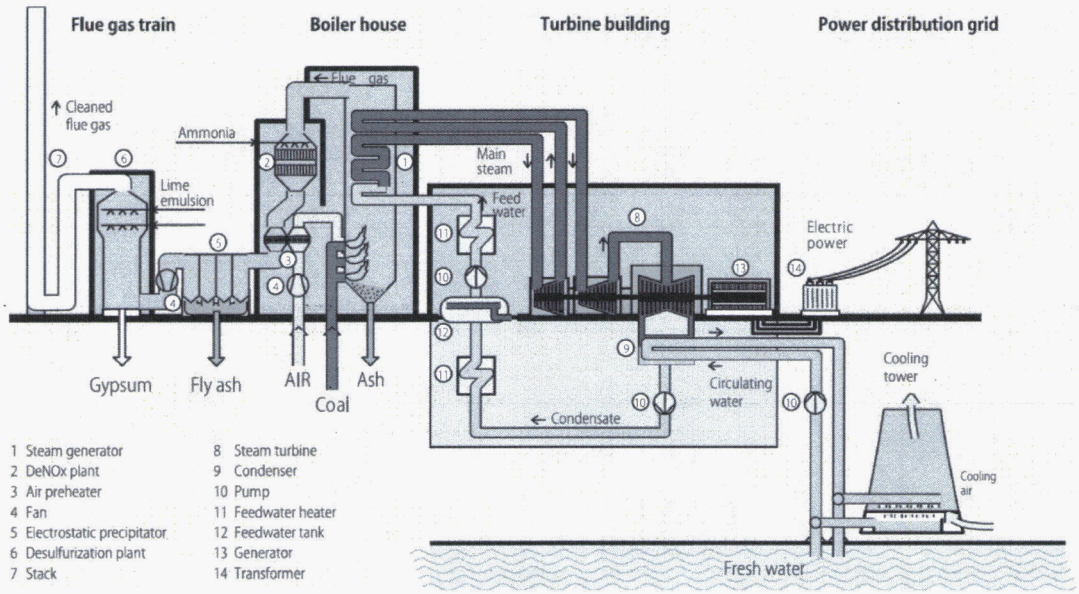
On the other hand, it produces larger and more damaging environmental impacts than most other generation resources. In the future, advances in pulverized coal generating technologies may become commercially successful. For example, supercritical combustion technologies are being developed that operate at higher temperature and pressure conditions, allowing higher thermal efficiency. However, future costs for CO_2 emissions represent a large source of risk and uncertainty.

Technology Overview

Pulverized coal power plants are fueled by coal that is either extracted from an on-site mine or delivered via railroad or truck. The coal is crushed and ground to a fine powder in a pulverizer. The pulverized coal is then blown, along with heated air as the oxidant, into the furnace of a boiler. The resulting thermal energy is used to heat water in boiler pipes, which line the furnace walls, into high-temperature, high-pressure steam. The high-pressure steam is forced through a steam turbine causing the turbine blades to rotate, which in turn drives an electric generator.

Figure 23 shows a pulverized coal (PC) unit that meets today's lower, permitted emissions levels. The three main components of a PC unit are: (1) the boiler block where coal is burned to generate steam in the boiler tubes; (2) the generator block, which contains the steam turbine/electric generator set and manages the steam, condenser, and cooling water; and (3) the flue gas clean-up train, which removes particulates and pollutants from the flue gas.

Figure 23 - Pulverized Coal Diagram



The flue gas clean-up section contains Selective Catalytic Reduction (SCR) for NOx removal, followed by electrostatic precipitation (ESP) to remove particulate matter, and wet flue gas desulfurization (FGD) to remove SOx. The choice of coal, and the design and operation of the flue gas units is to assure that emissions are below the permitted levels.(Massachusetts Institute of Technology, 2007)

There are various types of steam cycles that can be implemented in a PC unit, with a tradeoff between operating efficiency, operational flexibility and cost. Sub-critical steam cycle plants have heat rates in the 9,800 Btu/kWh range, whereas super-critical steam cycle plants may have a heat rate of 9,000 Btu/kWh. The most efficient steam cycle is the ultra super-critical cycle, which may have a heat rate in the range of 8,200 Btu/kWh.

Transmission and Siting Requirements

Pulverized coal facilities typically require large amounts of land and are built at a significant distance away from load centers. As a result, significant investment in additional transmission resources is also typically required when building a new facility.

Dispatch Characteristics

Pulverized coal generating plants operate most efficiently at high capacity factors as base load resources. Coal-fired units are typically designed to operate at a capacity factor between 80-90 percent. Coal units contribute to system ramping capabilities and are often relied on to meet a portion of the system load following requirements. Coal units do not turn down overnight due to long start up requirements that range from 24 to 36 hours. If required, coal units will operate at a minimum capacity state during low load hours to be available for on-peak load obligations.

Environmental Attributes

The most significant drawback of pulverized coal plants is their environmental impacts. Pulverized coal generation is a major source of CO_2 emissions and other greenhouse gases and pollutants, emitting more CO2 per megawatt-hour than most other forms of fossil-fueled generation. There is currently no commercially viable technology for capturing the CO2. At new pulverized coal generating plants, control technologies are used to remove most but not all emissions of sulfur oxides and nitrogen oxides. Other emissions from coal plants include mercury and carbon monoxide. Pulverized coal generation also consumes large amounts of water, and coal mining has significant impacts on land, water and wildlife.

Pulverized Coal Modeling Assumptions

The cost and operating characteristics for the coal resource model in the IRP are summarized below.

Table 27 - Pulverized Coal Modeling Assumptions

Dispatch Capacity MW	400
Heat Rate Btu/kWh	10,250
Capacity Cost $/kW	$3,300
Fixed O&M Cost $/kW-yr	$30.45
Annual Capacity Factor, %	85%
CO2 Rate, lbs/MWh	2,101
SO2 Rate, lbs/ MWh	1.046
NOX Rate, lbs/ MWh	0.656
HG Rate, lbs/ MWh	1.17E-05
PM10 Rate, lbs/ MWh	0.21
Water, Gal/MWh	750
Levelized Cost $/MWh	$107

Nuclear Power

Nuclear power plants have not been seriously considered as resources in the U.S. for over 30 years due to safety concerns and public opposition as a result of the Three Mile Island, Chernobyl and Fukushima Daiichi accidents. There is also a serious concern over the unresolved issue of long-term storage of nuclear waste. Nevertheless, in recent years, there has been a growing interest in the possibility of building new nuclear power units in order to reduce CO2 emissions. Simply put, consideration of nuclear resources has transitioned from being completely out of the question in the mid-1990s, to something that is at least being discussed as a viable alternative.

One sign of renewed interest in nuclear development is a process where a party can pursue the approval of a plant design, without getting into an approval process for a particular plant. There are over a dozen approved designs that have pursued this approval path, with three designs currently being certified by the Nuclear Regulatory Commission.

Current Status

Nuclear power plants have provided a significant portion of the electricity generated in the United States and throughout the world for the last several decades. Table A-1 outlines the percentage of electricity generation provided by nuclear sources by country in 2009.

Table 28 - Electricity Generation from Nuclear Sources

Country	2009 % of Electricity from Nuclear Sources
USA	19.70%
Japan	24.90%
South Korea	35.60%
France	76.20%
World	15.00%

As illustrated in Table 22, while nuclear power already provides a significant percentage of the electricity generation in the United States, it represents an even higher proportion of the generation in other major industrialized economies. However, nuclear power also has a large number of associated risks and barriers to adoption. Most significantly, nuclear technologies require a large amount of startup capital and long lead times due primarily to regulatory delays. In addition, nuclear reactors produce radioactive waste which represents an environmental and potential security risk.

Technology Overview

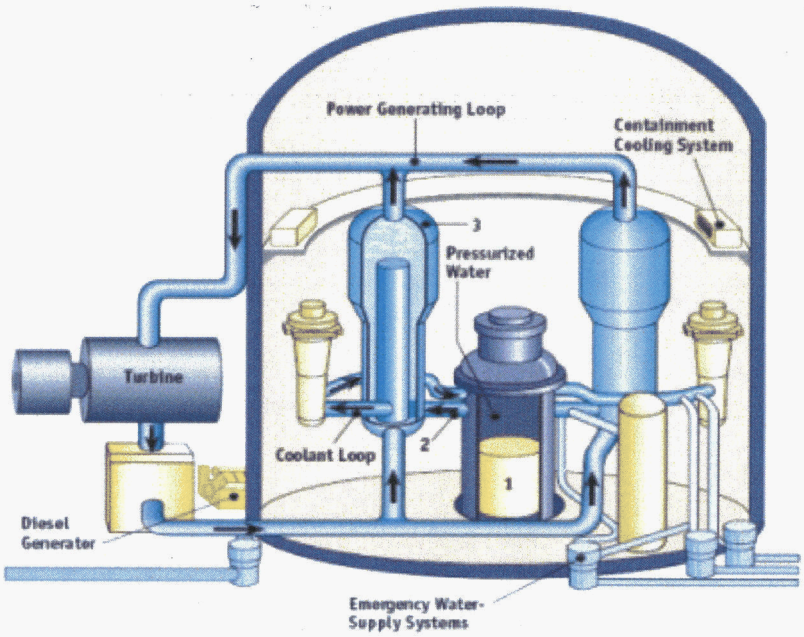
In general, current nuclear power plants utilize a controlled nuclear fission reaction to generate steam which is in turn used to turn turbines and produce electricity. The process requires extensive cooling achieved through the use of a pumped water system and cooling tower.

More specifically there are two types of nuclear reactors currently in operation in the United States: Pressurized Water Reactors (PWRs) and Boiling Water Reactors (BWRs).

Pressurized Water Reactors:

In a PWR, the fission reaction is cooled via pumped water which is held in a liquid state even at very high temperatures through the maintenance of constant high pressure. Approximately 2/3 of the existing nuclear plants in the United States are of this type.

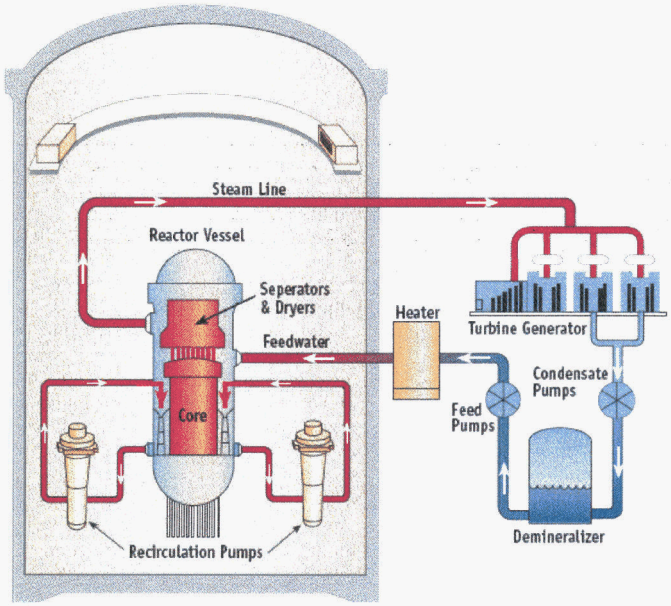
Figure 24 - Pressurized Water Reactor



Boiling Water Reactors:

In a BWR, the fission reaction is cooled via pumped water which is held at slightly lower pressure than in a PWR. As a result, the water is allowed to boil in the system. Reactors of this design are able to achieve a higher thermal efficiency than PWR designs, but the boiling process may also put added stress on system components. Approximately 1/3 of the existing nuclear plants in the United States are of this type.

Figure 25 - Boiling Water Reactor



While all current domestic nuclear plants operate on either the PWR or BWR design, a number of other systems are employing alternate methods of cooling, generation, and containment are in use in other countries. These include Gas Cooled Reactors (GCRs), Pressurized Heavy Water Reactors (PHWRs), and Liquid Metal Cooled Fast Breeder Reactors (LMCFBRs). In addition, a number of theoretical designs are currently being researched and moved toward commercialization. Depending on regulatory approval and the underlying economics that emerge as additional technologies become available, future IRP processes may also require consideration of additional technologies beyond those currently in domestic usage.

Transmission and Siting Requirements

Nuclear facilities typically require large amounts of land and are built at a significant distance away from load centers. As a result, significant investment in additional transmission resources is also typically required when building a new facility.

Dispatch Characteristics

Nuclear plants are dispatched as baseload resources, typically operating at capacity factors of approximately 85% and above.

Environmental Attributes

The generation of electricity from nuclear resources has both positive and negative environmental impacts. The major potential environmental benefit of the use of nuclear resources is that the greenhouse gas (GHG) emissions from nuclear plants are virtually zero. The zero carbon emissions attribute also means that generation costs are unaffected by potential increases in carbon prices. The major environmental disadvantages to the use of nuclear resources are the generation of radioactive waste, and high water usage.

Modeling Assumptions

The cost and operating characteristics used to model nuclear resources in the IRP process are summarized below.

Table 29 - Nuclear Modeling Assumptions

Dispatch Capacity MW	1,000
Heat Rate Btu/kWh	10,400
Capacity Cost $/kW	$7,532
Fixed O&M Cost $/kW	$75.55
Annual Capacity Factor, %	85%
CO2 Rate, lbs/ MWh	0
SO2 Rate, lbs/ MWh	0
NOX Rate, lbs/ MWh	0
HG Rate, lbs/ MWh	0
PM10 Rate, lbs/MWh	0
Water, Gal/MWh	1,000
Levelized Cost $/MWh	$136

The Next Generation of Advanced Nuclear Reactors

Snapshot of Advanced Reactors

Unlike today's nuclear plants, the reactors proposed for new plants have standardized designs with innovative safety features. Two reactors being considered for construction—the Westinghouse AP1000 and General Electric's Economic Simplified Boiling Water Reactor (ESBWR)—are advanced, "passive safety" designs that rely on natural forces such as gravity for plant safety, rather than on pumps or fans. Both employ a modular design. Three other reactors under consideration—Areva's Evolutionary Power Reactor (EPR), General Electric's Advanced Boiling Water Reactor (ABWR), and Mitsubishi's U.S. Advanced Pressurized Water Reactor (US-APWR)—are evolutionary designs. Although based on current plants, these reactors have enhanced safety features.

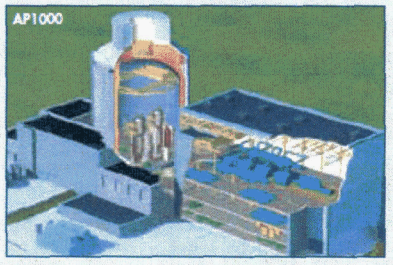
The Westinghouse AP1000, a 1000-MW pressurized water reactor (PWR), has significantly fewer components than today's PWRs. It has 50% fewer valves, 35% fewer pumps, 83% less pipework, and 87% less control cable. In addition, the design reduces by 45% the amount of building materials required. The reactor's safety system uses gravity, natural circulation, and compressed gas to ensure emergency core cooling and employs no pumps, fans, diesels, chillers, or other rotating machines in safety applications that could malfunction or lose power in an emergency.

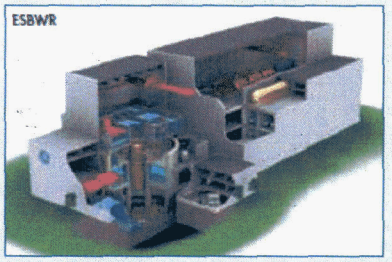
General Electric's ESBWR, a 1500-MW boiling water reactor (BWR), has reduced the number of systems by 25% and contains 25% fewer pumps and valves and 25% less piping and cabling than conventional designs. Its natural circulation and passive safety features eliminate the need for safety system pumps and safety diesel generators. For example, the ESBWR has a gravity-driven cooling system for the reactor and a passive containment cooling system that removes heat by means of four low-pressure natural circulation loops, each with a heat exchanger.

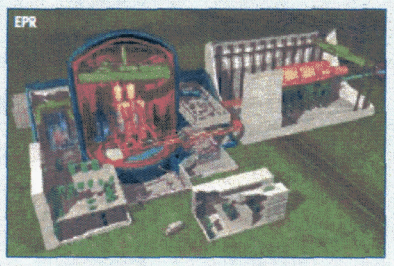
Areva's EPR, an evolutionary PWR designed by Framatome ANP, incorporates simplified safety systems that improve accident prevention and protection against external hazards. It features a robust containment structure consisting of two cylindrical walls—an inner prestressed wall with a steel liner and an outer reinforced-concrete wall, each with a separate dome. The EPR being deployed in the U.S. market has been designed to use 7% less uranium fuel per kilowatthour, reducing the cost of electricity generation. The first EPR is under construction in Finland; construction of a second EPR will begin in France by the end of 2007.

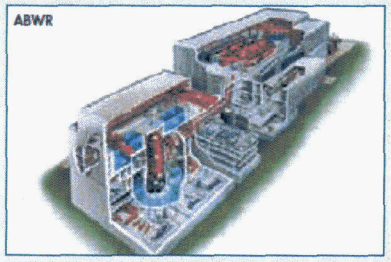
General Electric's ABWR employs a more compact design than the current BWR, increasing safety and reducing construction costs. All major equipment and components have been engineered for improved reliability and ease of maintenance—including such features as vessel-mounted reactor internal pumps and fine-motion control rod drives. This design was certified by the NRC in 1997. The first two ABWRs went into commercial operation in Japan in 1996 and 1997 at the Kashiwazaki-Kariwa site. Two ABWRs are under construction in Taiwan at the Lungmen site.

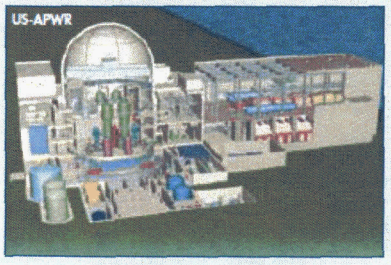
Mitsubishi's US-APWR, an evolutionary design with active safety features, is a 1700-MW reactor. Twenty-three versions of the basic Mitsubishi design are now operating in Japan.











Source: EPRI Journal 2007

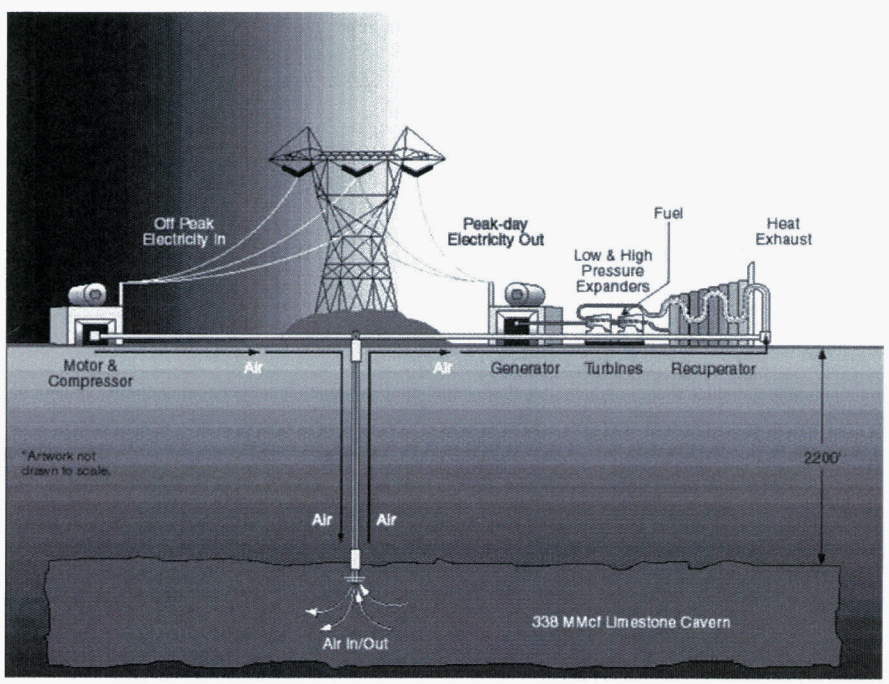
Compressed Air Energy Storage (CAES)

Compressed Air Energy Storage (CAES) works on the concept of the favorable trade of low cost off-peak generation for higher priced on-peak generation. The use of off-peak energy, to compress the stored air, makes CAES an ideal match to a wind generation system since wind generation frequently occurs during off- peak periods. CAES is advantageous in that it can provide relatively large capacity generation (>100MW) for a relatively low capital cost and low O & M costs. It has the effect of converting off-peak generation into an on-peak resource. The disadvantages are in order to take full advantage of its abilities there needs to be a low cost source of off-peak power available and the CAES system must be located in close proximity to a storage medium that is large enough to store the volume of air needed to make a utility scale project viable. The storage volume should be in the 10s of millions of cubic feet. And it should have sufficient geologic integrity for very high pressure containment of air.

Technology Overview

In a CAES system off peak energy is used to power air compressors. The air compressors pump ambient air into large storage containers, typically an underground cavern or salt mine, usually to several hundreds of pounds per square inch of pressure. Later, when energy prices rise or when energy needs increase, the compressed air is released from storage to power a generator providing an energy source that can be controlled by the air release. The efficiency of the system is enhanced by passing the air through intercoolers as it goes into storage and by inserting a small flame burning natural gas between the storage chamber and the generator as the air is released from storage.

Figure 26 - Compressed Air Energy Storage (CAES)



Transmission & Siting Requirements

Transmission requirements for a CAES project are similar to that of baseload generation. Because CAES must be located near a large mine or cavern, its locating options are accordingly limited. Depending on where the storage is and hence the location all determine the extent of needed transmission.

CAES power plants generally require more land than traditional coal plants. Location is driven by the availability of underground storage. Most of Arizona and New Mexico have geologies that support the necessary underground storage in the scale needed for practical applications.

Dispatch Characteristics

Because CAES uses a CT generator its dispatch characteristics are similar to a traditional CT.

Environmental Attributes

The environmental effects of CAES generation are minimal. The effects of generating power for the off-peak storage of the air depend on that energy source. When the stored air is used to power the turbine generator a small natural gas flame is used to excite the air coming out of storage.

Modeling Assumptions

The cost and operating characteristics of CAES are summarized below.

Table 30 - Compressed Air Energy Storage Modeling Assumptions

Dispatch Capacity MW	100
Heat Rate Btu/kWh	4,500
Capacity Cost $/kW	$1,593
Fixed O&M Cost $/kW	$29.00
Annual Capacity Factor, %	15%
CO2 Rate, lbs/ MWh	267
SO2 Rate, lbs/ MWh	0.001
NOX Rate, lbs/ MWh	0.173
HG Rate, lbs/ MWh	1.35E-06
PM10 Rate, lbs/MWh	0.039
Water, Gal/MWh	75
Levelized Cost $/MWh	$227

CHAPTER 12

REFERENCE CASE ASSUMPTIONS

Reference Case Market Assumptions

In developing its fifteen year market forecast, the resource planning team relied on PACE Global to provide a comprehensive set of correlated market, fuel, and emission price forecasts. These forward price projections for wholesale power, coal, natural gas and emission prices were based on a comprehensive set of market fundamentals for the WECC Region. As a general planning rule, UNS Electric compares its input assumptions against multiple third party sources to validate the range of potential forecast values for developing its Reference Case and sensitivities.

- 2011 PACE Global Long Term Forecast
- 2011 Spring Reference Case, Electricity and Fuel Price Outlook, WECC Region
- 2011 Wood MacKenzie Long Term View (Fall 2011)

Market Reference Case Assumptions

This section details the reference case market assumptions for the following IRP inputs.

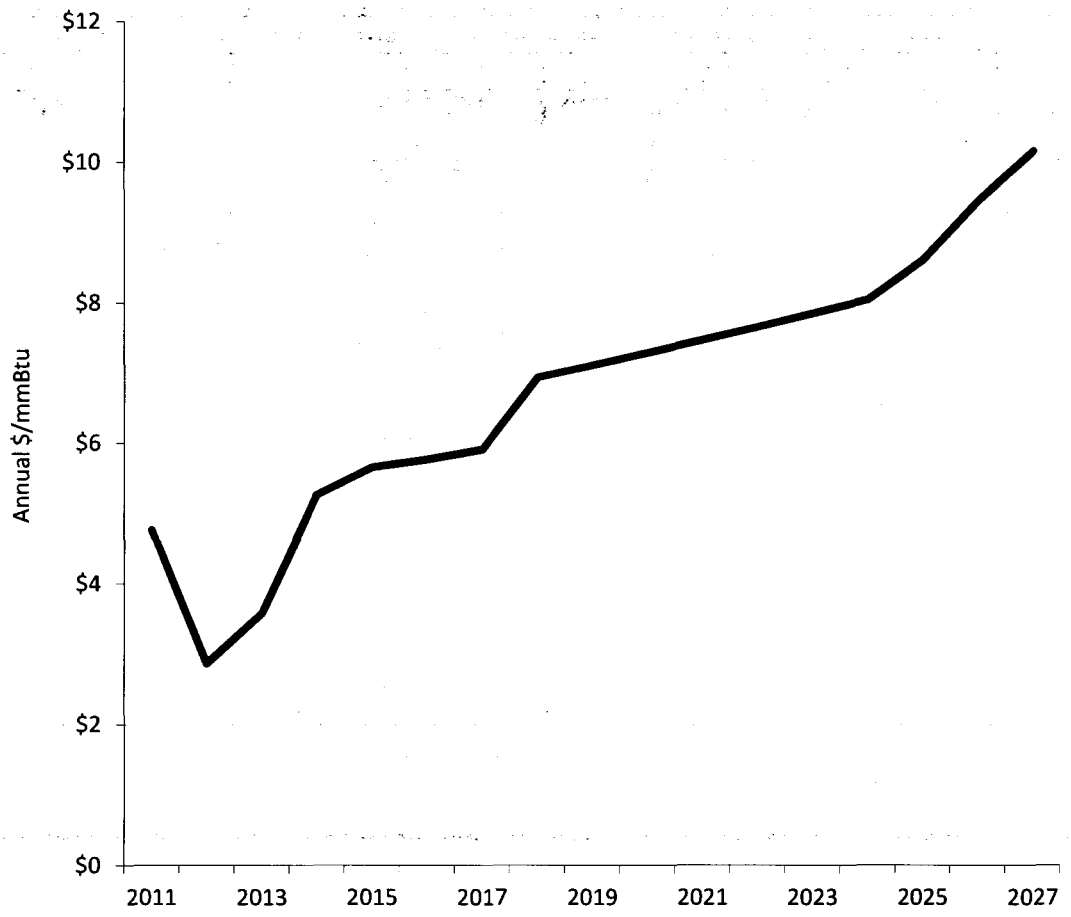
- Natural Gas Prices
- Wholesale Power Prices
- Delivered Coal Prices
- Emissions Prices

NATURAL GAS PRICE FORECAST

Permian Natural Gas

The PACE Global forecast for Permian natural gas starts at $2.86/MMbtu in 2012, and escalates to $10.14/MMbtu in 2027. Chart 32 - Permian Basin Natural Gas Prices shows the 15 year natural gas price projections in nominal dollars.

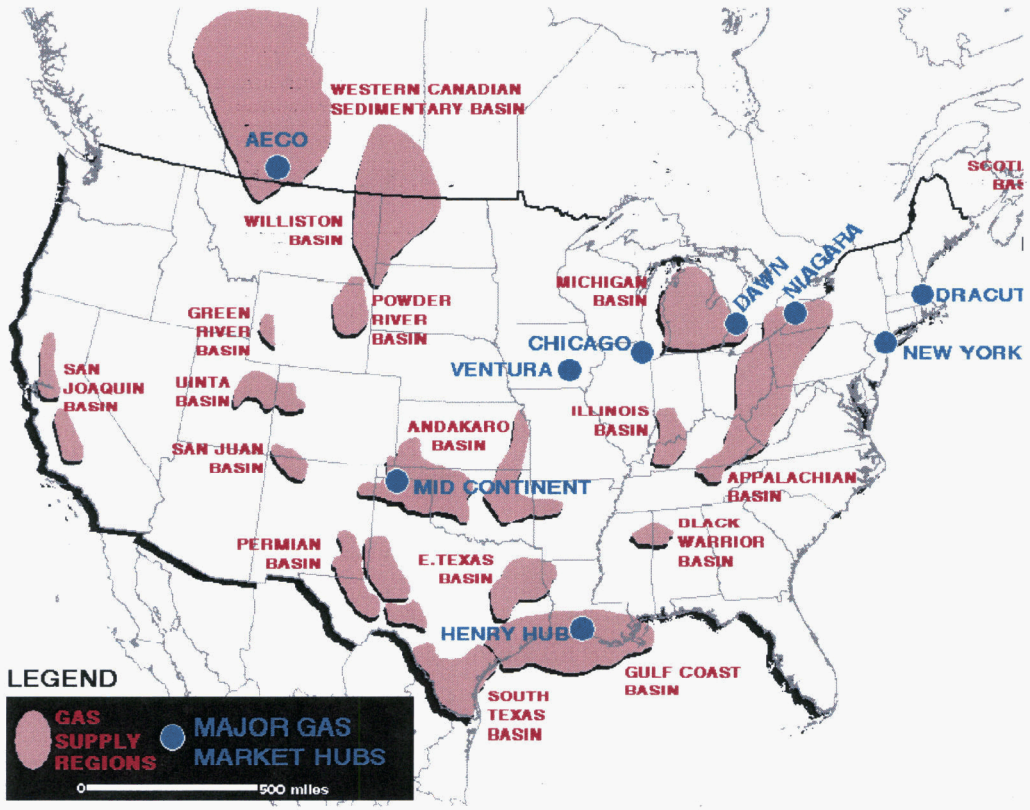
Chart 32 - Permian Basin Natural Gas Prices



Natural Gas Supply Basins

UNS Electric's forward natural gas price projections are based on deliveries from the Permian and San Juan Basins. Primary and secondary supply basins are shown along with key market hubs in Map 18.

Map 18 - Natural Gas Supply Basins and Major Market Hubs of U.S. and Canada

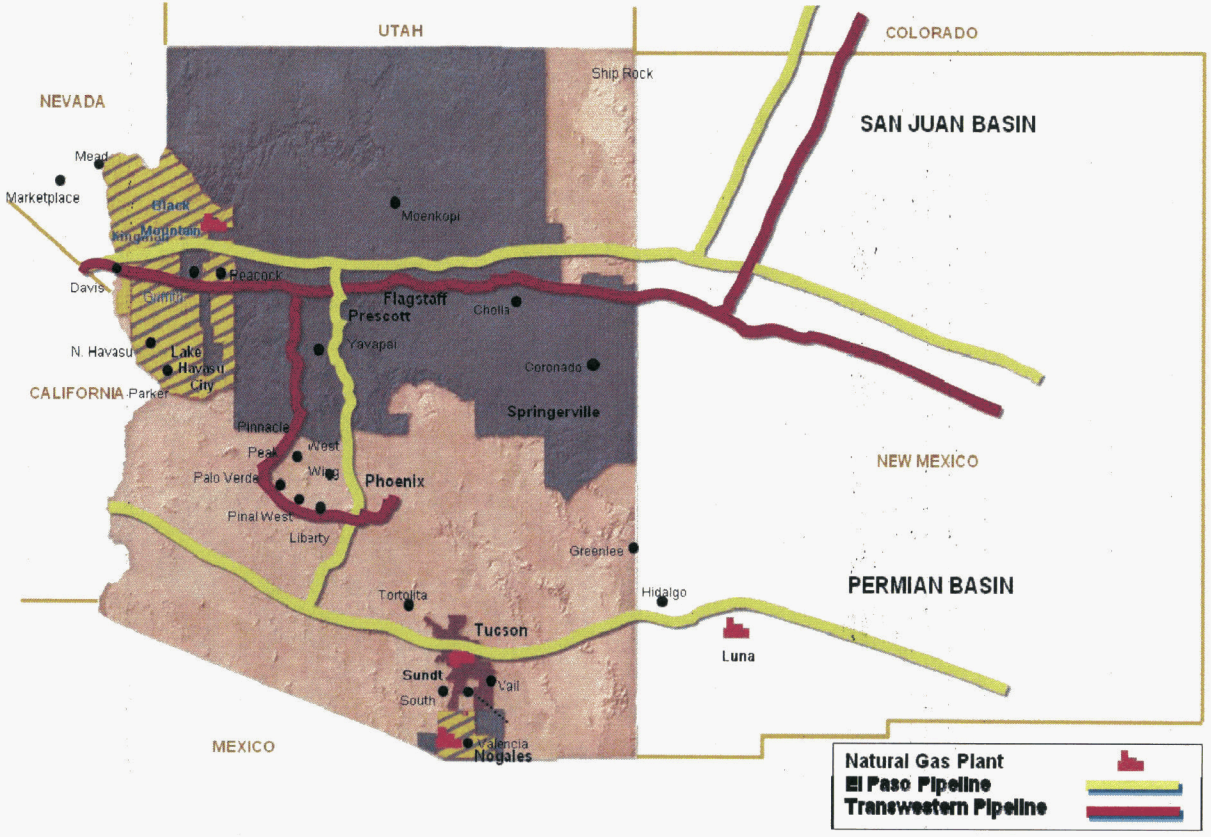


SOURCE: Ventyx.

NATURAL GAS PIPELINE INFRASTRUCTURE

Map 19 - Natural Gas Pipeline Infrastructure below provides an overview of UNS Electric's natural gas fired generation facility in relationship to both theEl Paso and Transwestern pipeline infrastructure.

Map 19 - Natural Gas Pipeline Infrastructure

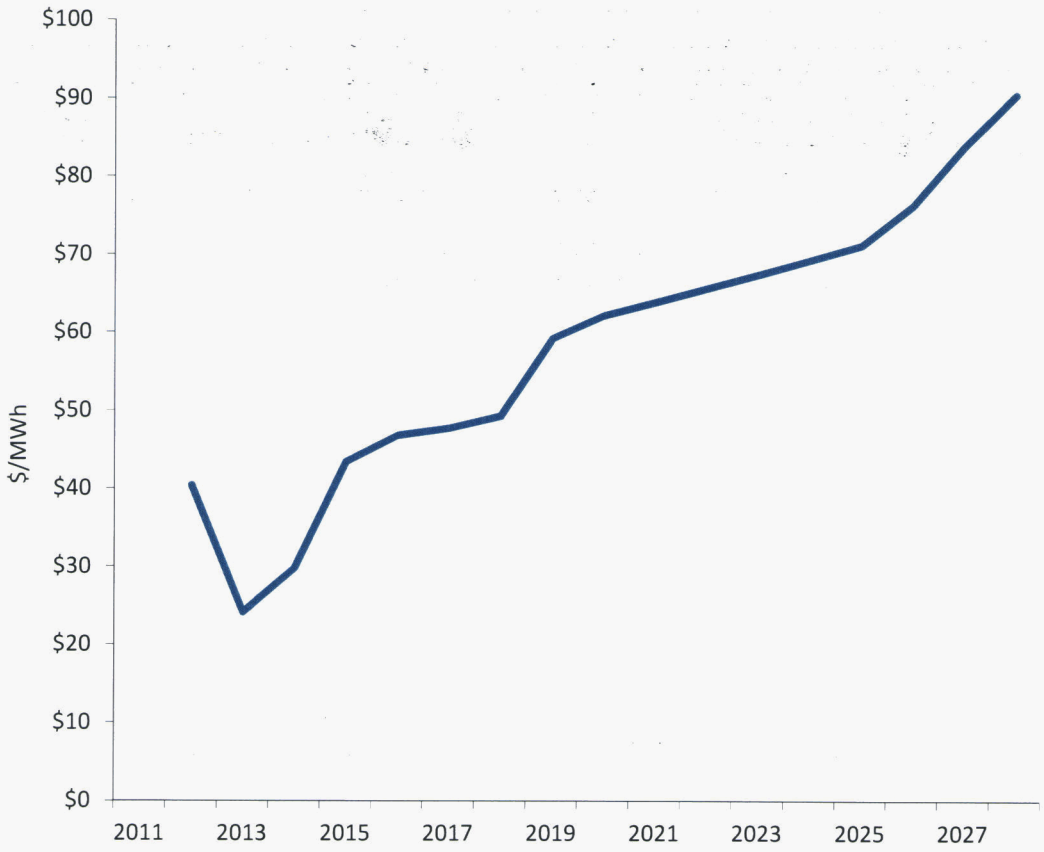


WHOLESALE MARKET PRICE FORECAST

Palo Verde (On-Peak) Market Prices

The PACE Global forecast for 7x24 Palo Verde market prices starts at $25.85/MWh in 2012, and escalates to $98.23/MWh in 2027. Chart 33 - Palo Verde (On-Peak) Market Prices shows the 15 year wholesale power price projections in nominal dollars.

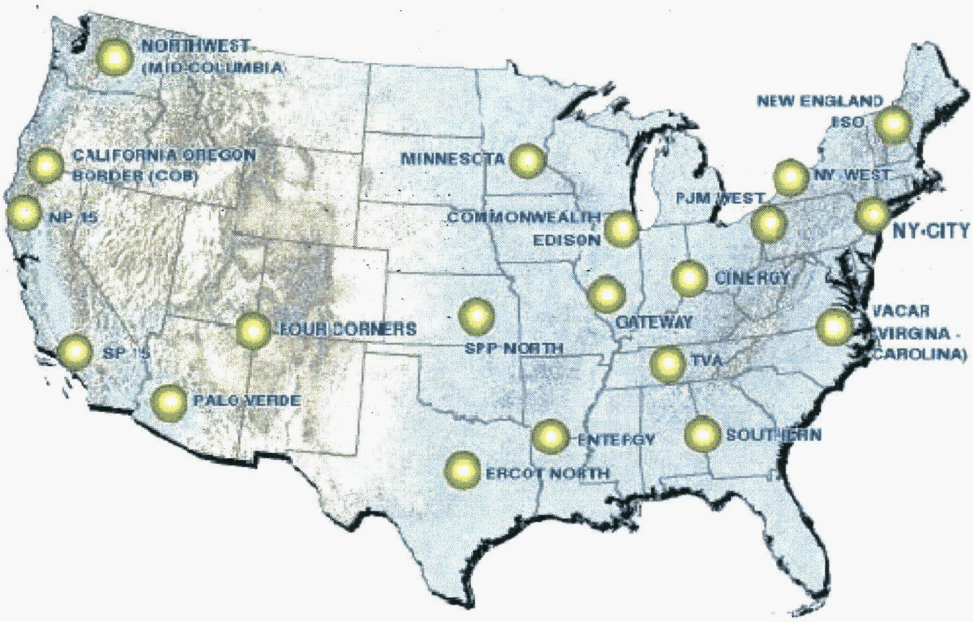
Chart 33 - Palo Verde (On-Peak) Market Prices



Wholesale Power Market Price Zones

UNS Electric's forward wholesale market power price projections are based on Palo Verde and Four Corner market hubs as shown below in Map 20 - Wholesale Power Market Price Zones.

Map 20 - Wholesale Power Market Price Zones



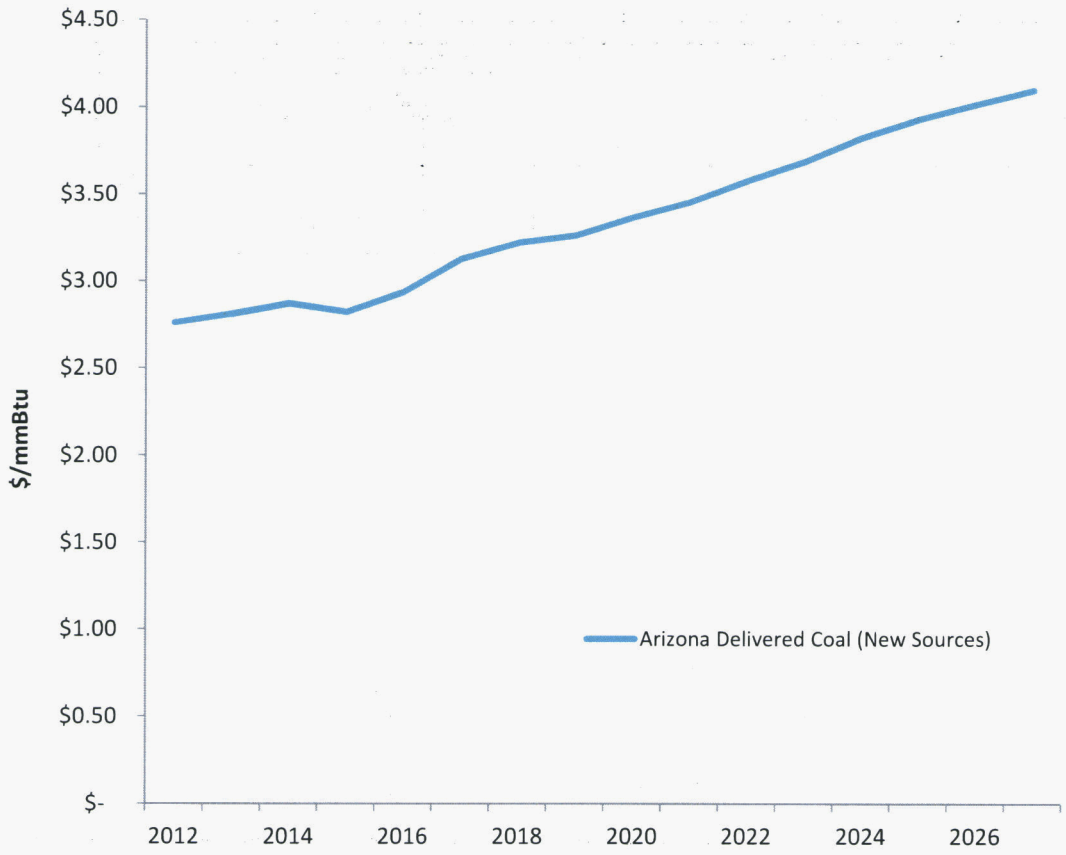
SOURCE: Ventyx.

COAL PRICE FORECAST

Coal Market Prices

For purposes of modeling new coal-fired facilities, the assumed forecast for Arizona delivered coal in the 2012 Reference Case starts at $2.76/MMbtu in 2012, and escalates to $4.10/MMbtu in 2027. Chart 34 shows the 15 year spot coal price projections in nominal dollars.

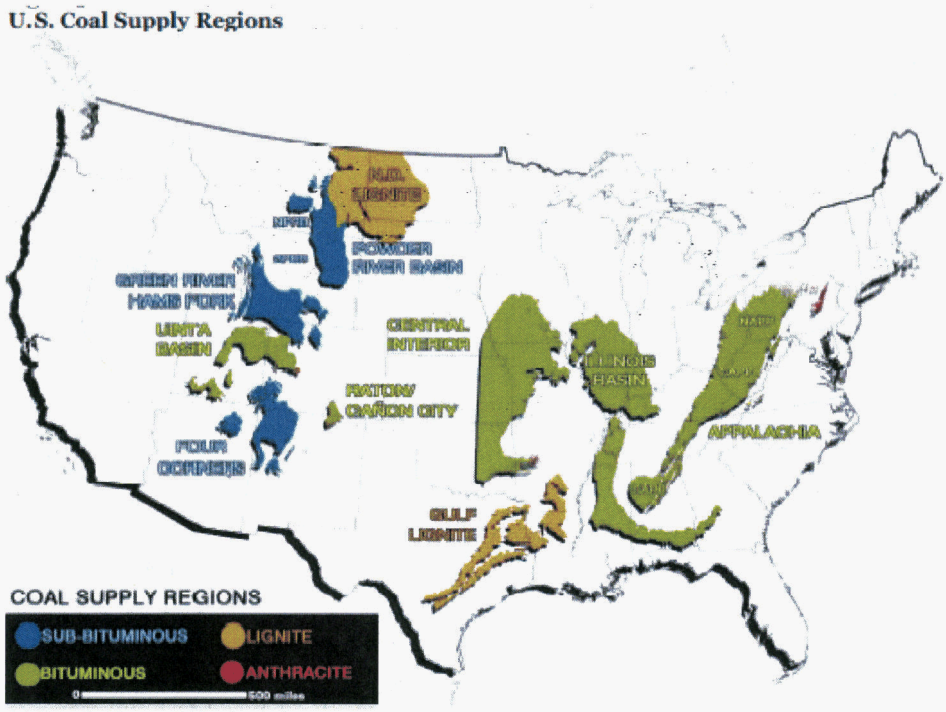
Chart 34 - Coal Price Forecast



Coal Supply Regions

For purposes of the resource planning process, it was assumed that any new resources which required a coal fuel supply (Pulverized Coal or Integrated Gasification Combined-Cycle (IGCC)) would be based on price projections from the Four Corners region. The U.S. Coal Supply Regions are shown in Map 21 below:

Map 21 - U.S. Coal Supply Regions



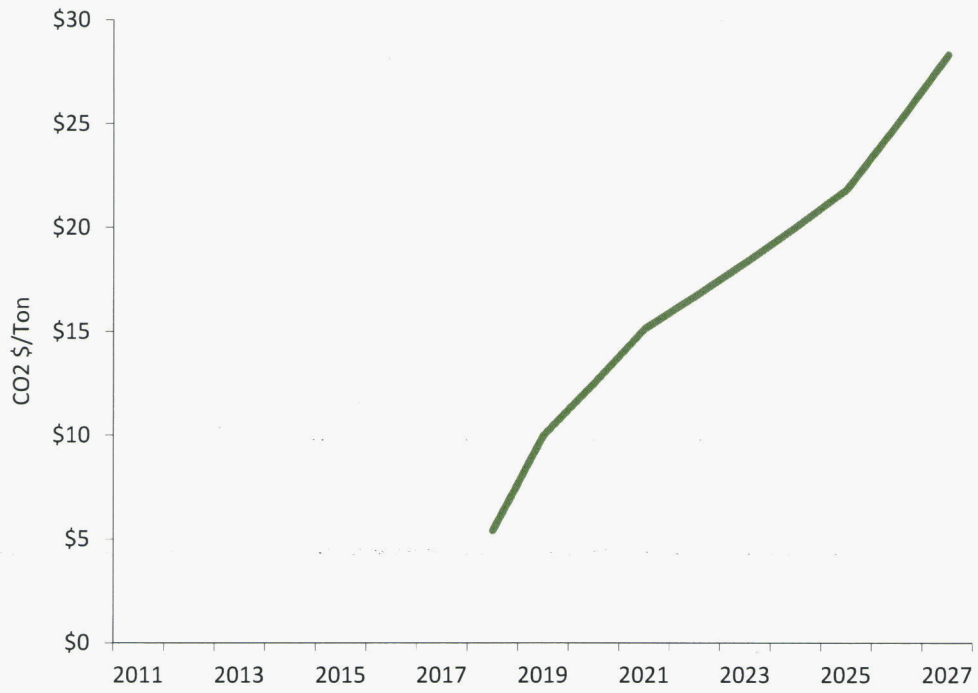
SOURCE: Ventyx Velocity Suite.

EMISSION PRICES

Carbon Price Assumptions Used in the 2012 IRP

In the past several years, the United States Congress has considered bills that would regulate domestic GHG emissions. However, there have been no attempts by the 112th Congress to pass legislation that would regulate GHG emissions. With Congress's focus on the economy, it is unclear when it will again consider a climate change bill. While the eventual form and timing of GHG regulation remains uncertain, the 2012 IRP process references the CO_2 price projections by PACE Global to formulate its assumptions around future CO_2 legislation. For the 2012 IRP, it is assumed that a federal program which places a cost on CO_2 emissions will be implemented across all sectors beginning in 2018. The 2012 forecast for CO_2 emissions in the Reference Case starts at $5/ton in 2018, and escalates to $28/ton in 2027. The chart below shows the 15 year emission price projections in short tons in nominal dollars.

Chart 35 - CO_2 Emission Prices, $/Ton



Financial and Capital Structure Assumptions

Table 31 below details the financial and capital structure assumptions used for the 2012 IRP. The weighted average cost of capital is based on assumptions from UNS Electric's last approved rate order in September 2010.

Table 31 - Financial and Capital Structure Assumptions

Cost Of Capital	
Debt	7.05%
Common Equity	9.75%
Composition	
Debt	54.24%
Common Equity	45.76%
Average Cost Of Capital	
Weighted Average Cost of Capital (WACC)	8.28%
Inflation, Insurance & Property Taxes	
Inflation Rate	2.50%
Property Taxes & Insurance	1.90%
Federal & State Income Tax Rates	
Federal Tax Rate	35.00%
State Tax Rate	7.10%
Composite Rate	39.60%

SENSITIVITY ANALYSIS

For the 2012 IRP, UNS Electric developed a range of sensitivities and scenarios to evaluate its potential resource portfolios. The goal of the sensitivity analysis was to determine to what degree the optimal resource portfolio might change given different forecast projections related to customer demand, wholesale power prices, natural gas prices, and carbon emission prices. The sensitivities relative to the Reference Case are summarized below.

IRP Sensitivities

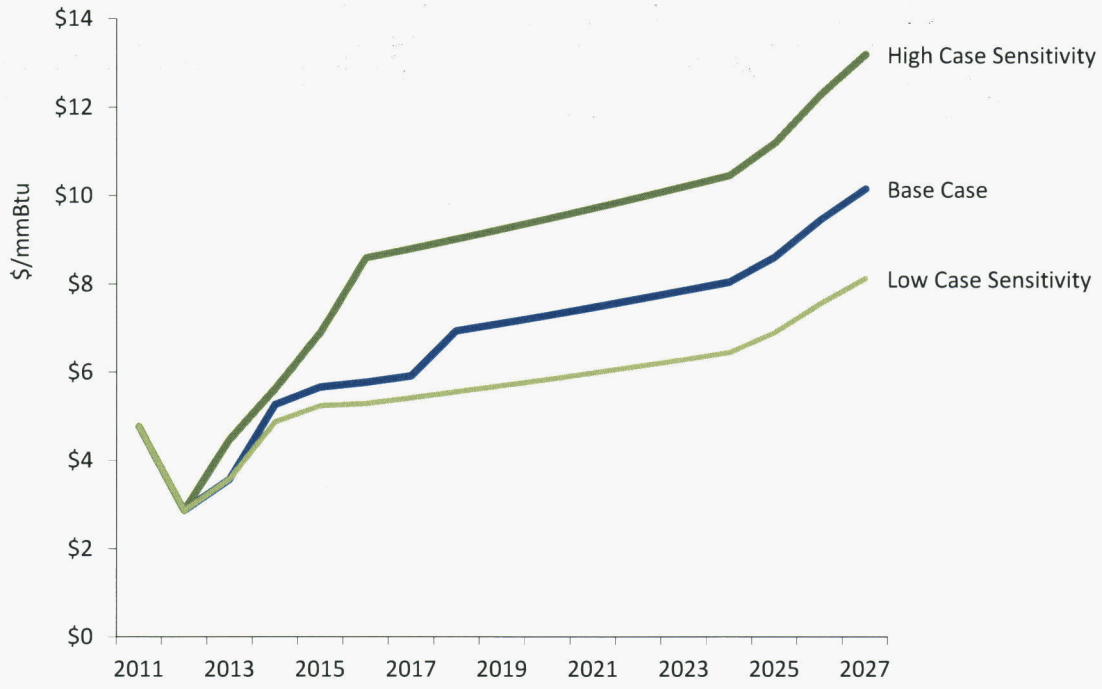
- Natural Gas Prices
- Wholesale Power Prices

NATURAL GAS AND WHOLESALE POWER SENSITIVITIES

Permian Natural Gas

The PACE Global forecast for Permian natural gas starts at $2.86/MMbtu in 2012, and escalates to $10.14/MMbtu in 2027. Chart 36 - Permian Basin Natural Gas Price Sensitivities shows the high and low gas sensitivities that were analyzed as part of this resource planning process.

Chart 36 - Permian Basin Natural Gas Price Sensitivities



Palo Verde (7x24) Market Prices

The PACE Global forecast for 7x24 Palo Verde market prices starts at $25.85/MWh in 2012, and escalates to $98.23/MWh in 2027. Chart 37 - Palo Verde (7x24) Market Price Sensitivities shows the high and low power market sensitivities that were analyzed as part of this resource planning process.

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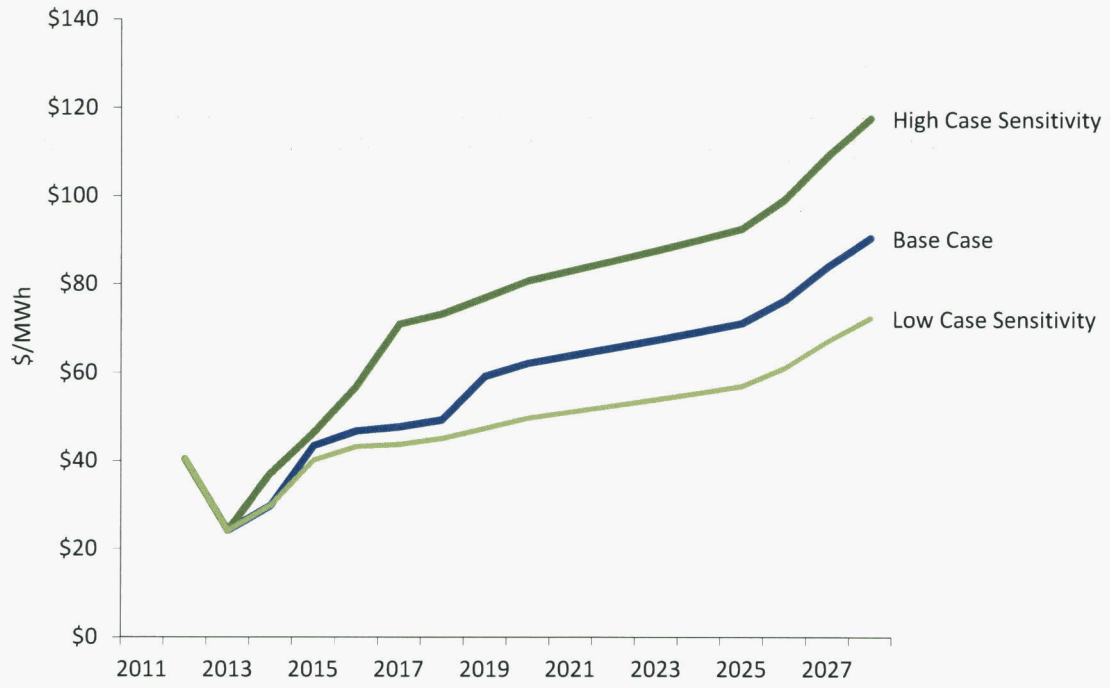
Chart 37 - Palo Verde (7x24) Market Price Sensitivities



CHAPTER 13

FUEL SUPPLY

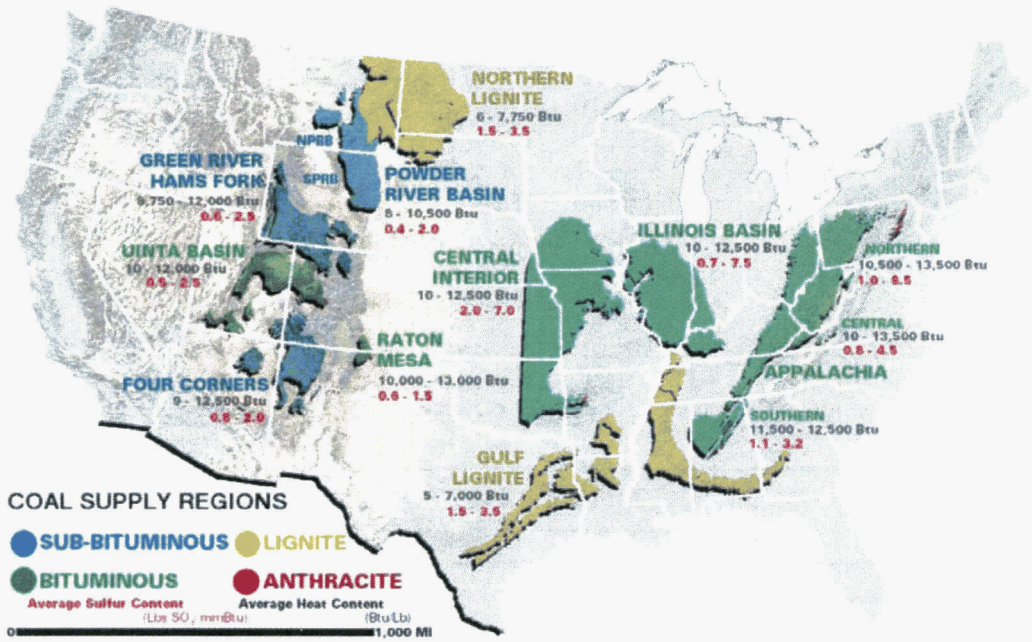
Coal Supply

Due to its low cost and ample supply, coal remains the dominant fuel source for power generation in the U.S. For the 2012 IRP, UNS Electric relied on publicly available data related to projected recoverable coal reserves to quantify future coal supply. These data sources included reports compiled by the U.S. Energy Information Administration and British Petroleum (BP).

- U.S. Energy Information Administration, 2011 Annual Coal Report (March 2012)
- BP Statistical Review of World Energy (June 2010)

Domestic coal for electricity generation is produced throughout the country. The major producing regions are Central Appalachia (CAPP), Northern Appalachia (NAPP), and the Illinois Basin (ILLB), jointly described as Eastern coal; the Powder River Basin (PRB) and the Rocky Mountain Basin (RCKY), jointly described as Western coal. Lignite is produced in Texas and neighboring states (Gulf Lignite). Production of Northern Lignite is centered in North Dakota. The quality of coal is heterogeneous within each producing region and even more so among producing regions. Map 22 - Domestic Coal Producing Regions depicts U.S. coal producing regions and typical qualities of the coal produced.

Map 22 - Domestic Coal Producing Regions



SOURCE: Ventyx.

There are four major ranks of coal in the U.S. classification scheme. In the United States, coal rank is classified according to its heating value, its fixed carbon and volatile matter content, and, to some extent, its caking properties during combustion. The coal ranks from highest to lowest in heating value are:

- anthracite
- bituminous
- sub bituminous
- lignite

Of the four ranks, bituminous coal accounts for over half (53.1 percent) of the demonstrated reserve base (DRB). Bituminous coal is concentrated primarily east of the Mississippi River, with the greatest amounts in Illinois, Kentucky, and West Virginia. All sub bituminous coal (36.5 percent of the DRB) is west of the Mississippi River. Most sub bituminous coal is in Montana and Wyoming. Lignite, the lowest-rank coal, accounts for about 8.8 percent of the DRB. Lignite is found mostly in Montana, Texas, and North Dakota. Anthracite, the highest-rank coal, makes up only 1.5 percent of the DRB. Anthracite is concentrated almost entirely in northeastern Pennsylvania.

U.S. Energy Information Administration

As of January 1, 2011, the DRB was estimated to contain 485 billion short tons. In the United States, coal resources are larger than remaining natural gas and oil resources. Annually, Energy Information Administration (EIA) reports remaining tons of coal in the demonstrated reserve base (DRB), which is comprised of coal resources that have been identified to specified levels of accuracy and may support economic mining under current technologies.

Between 1990 and 1999, EIA obtained updated coal reserves information and data largely through its Coal Reserves Data Base (CRDB) program. That program encouraged State agencies to revise coal resource and reserves estimates in their respective States. These revised coal reserve estimates include improved analyses of coal quality, accessibility, and recoverability in the study areas. EIA used these new data to revise the DRB.

EIA initiated a new coal reserves project in 2008 to incorporate existing reserves data into a geographic information system (GIS) based program. This system will include existing data, plus U.S. Geological Survey data, particularly for the Powder River Basin area of Montana and Wyoming. Recovery rates vary greatly between underground and surface mining. The actual proportion of coal resources that can be recovered economically from undisturbed deposits varies from less than 40 percent in some underground mines to more than 90 percent at some surface mines. In some underground mines, by design a portion of the coal is left intact as pillars to protect against surface collapse. Adverse geologic features in a mining area, such as folding, faulting, and inter-layered rock strata, can limit the amount of coal recovered at some underground and surface mines.

Access to some coal is limited. Because of property rights, land use conflicts, and physical and environmental restrictions, EIA has estimated that only about 50 percent of the demonstrated reserve base (DRB) may be available or accessible for mining. EIA annually estimates recoverable coal reserves by adjusting the DRB to reflect accessibility and recovery rates in mining. As of January 1, 2011, EIA estimated that the remaining U.S. recoverable coal reserves totaled over 259 billion short tons (a short ton is a unit of weight equal to 2,000 pounds), from a demonstrated reserve base of 485 billion short tons.

Recoverable coal reserves at producing mines represent the quantity of coal that can be recovered (i.e. mined) from existing coal reserves at reporting mines. These reserves essentially reflect the working inventory at producing mines. In 2010, the recoverable reserves at producing mines were 17.9 billion short tons. EIA conducts an annual survey, "Coal Production and Preparation Report," to gather and report the quantity of recoverable coal reserves at producing mines.

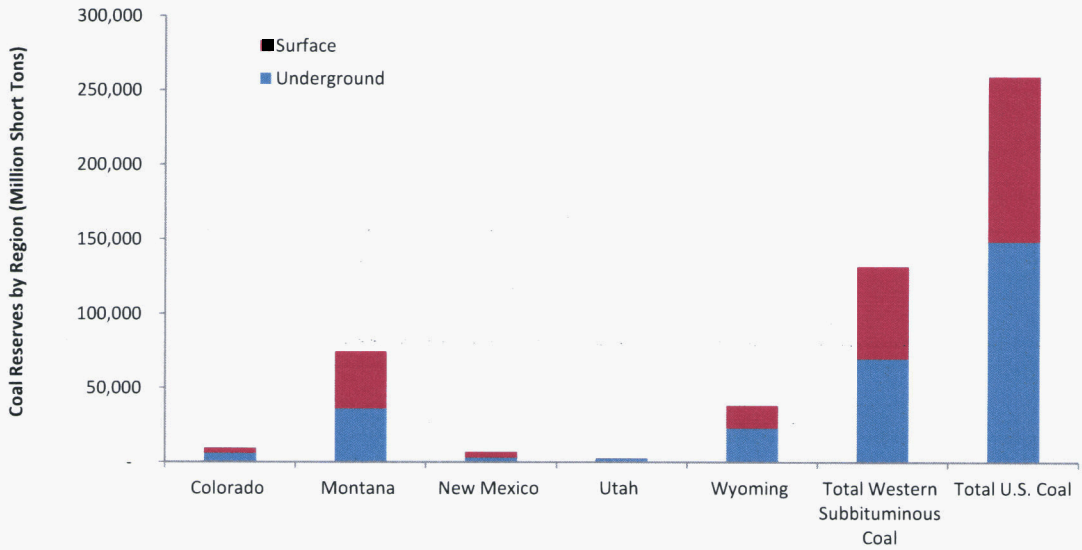
Table 32 – EIA Coal Reserves Data, 2010 Annual Coal Report

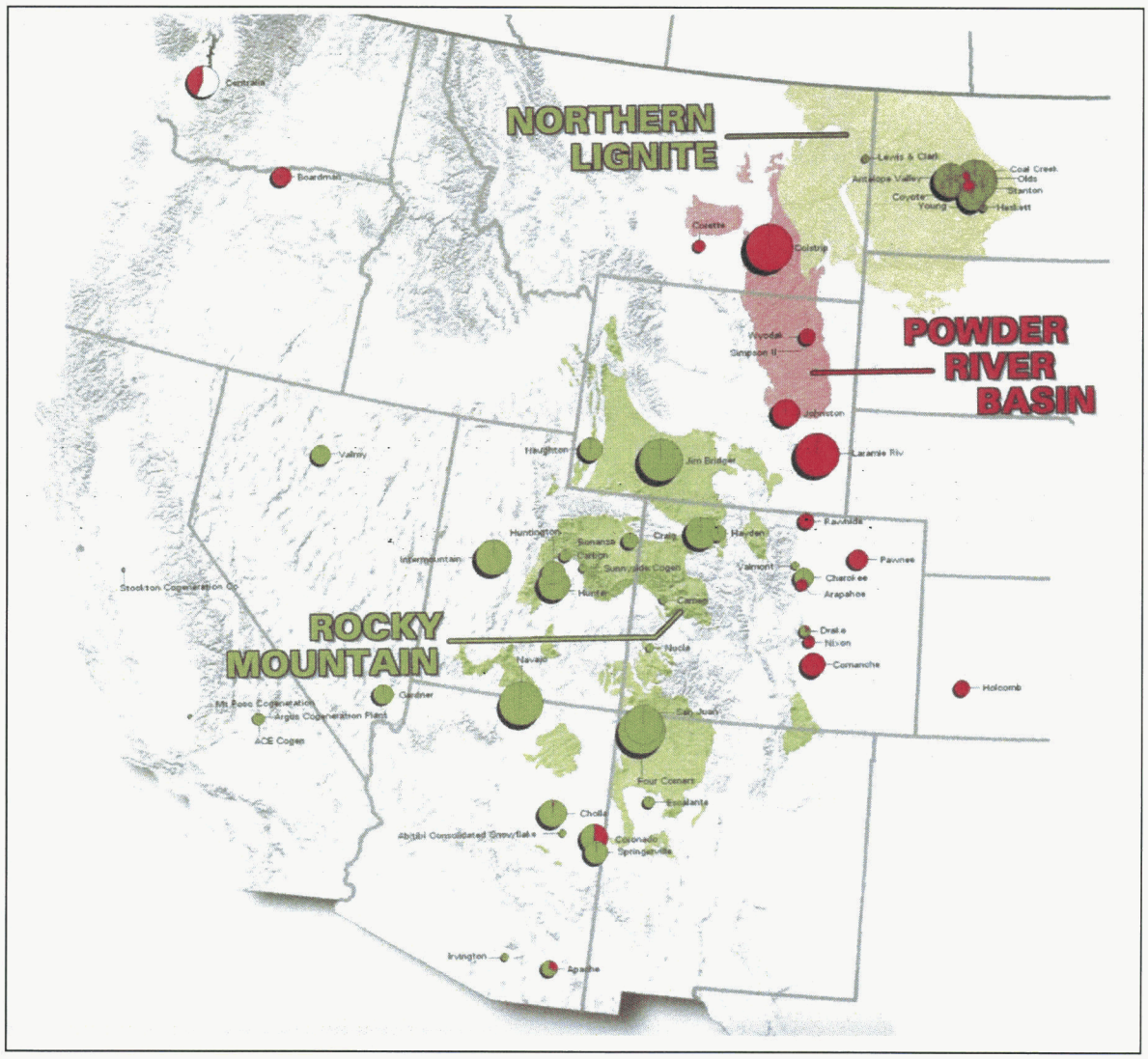
	Underground - Minable Coal			Surface - Minable Coal			Total		
Coal-Producing Region (Million Short Tons)	Recoverable Reserves at Producing Mines	Estimated Recoverable Reserves	Demonstrated Reserve Base	Recoverable Reserves at Producing Mines	Estimated Recoverable Reserves	Demonstrated Reserve Base	Recoverable Reserves at Producing Mines	Estimated Recoverable Reserves	Demonstrated Reserve Base
U.S. Total	6,452	148,427	331,202	11,485	111,091	153,309	17,937	259,518	484,511

	Underground - Minable Coal			Surface - Minable Coal			Total		
Coal-Producing State (Million Short Tons)	Recoverable Reserves at Producing Mines	Estimated Recoverable Reserves	Demonstrated Reserve Base	Recoverable Reserves at Producing Mines	Estimated Recoverable Reserves	Demonstrated Reserve Base	Recoverable Reserves at Producing Mines	Estimated Recoverable Reserves	Demonstrated Reserve Base
Arizona	-	-	-	W	-	-	W	-	-
Colorado	W	5,865	11,175	W	3,745	4,759	253	9,609	15,935
Montana	W	35,917	70,946	W	38,808	48,012	894	74,724	118,958
New Mexico	W	2,771	6,091	W	4,110	5,863	340	6,881	11,954
Utah	210	2,401	4,897	-	212	268	210	2,612	5,164
Wyoming	W	22,935	42,472	W	15,349	18,535	6,610	38,284	61,007
Western Sub-bituminous Coal	210	69,889	135,581	-	62,224	77,437	8,307	132,110	213,018
Percentage of U.S. Total		47.09%	40.94%	0.00%	56.01%	50.51%	46.31%	50.91%	43.97%

- = No data are reported.
W = Data withheld to avoid disclosure.

Chart 38 – EIA Coal Reserve Report (2012)





Source: Ventyx

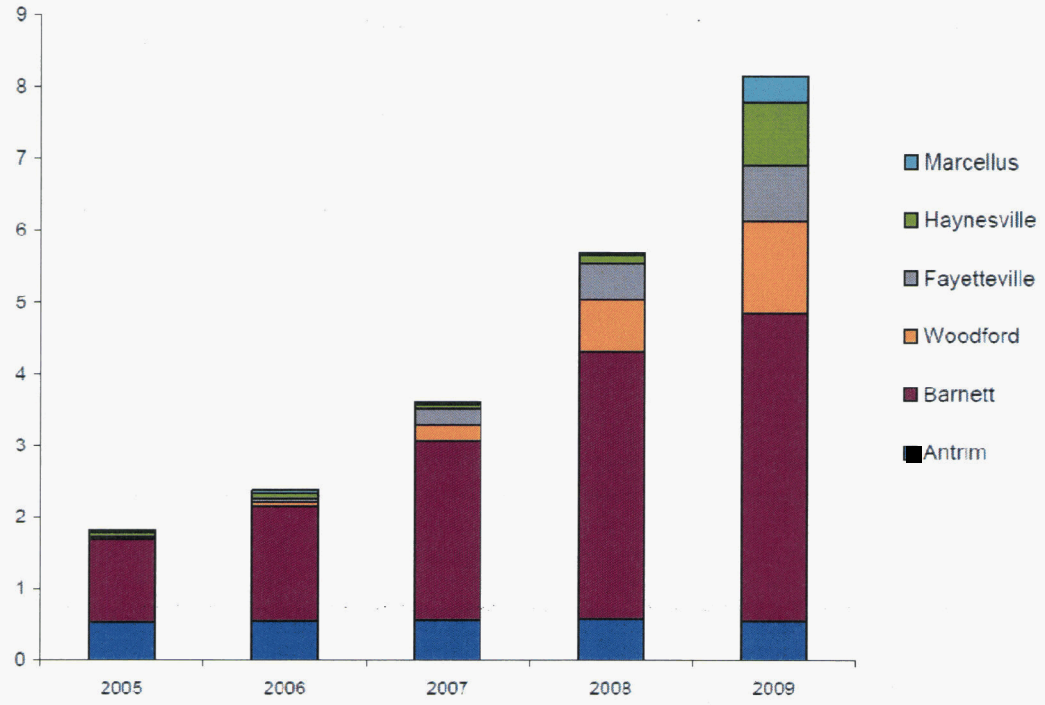
Natural Gas Supply

For the 2012 IRP, UNS Electric relied on a number of data sources to compile the supply and demand fundamentals related to natural gas supply. These data sources included reports compiled by:

- Pace Global, Regional Supply Assessment - 2011
- Ventyx, Power Market Advisory Service - 2011
- Wood Mackenzie, Regional Gas and Power Service Insight - 2011

The sharp growth in unconventional gas production in North America has changed the supply dynamics on a global basis. In addition to making North America increasingly self sufficient in gas, it has removed the need to import LNG and, in so doing, has contributed to the surplus of LNG available for export markets. This has helped depress spot prices globally. Unconventional gas (coal bed methane (CBM), tight gas and shale gas) is present in large volumes throughout the U.S. and the world. Production from these new sources could have far reaching consequences for global gas trade and pricing, by reducing import requirements and providing additional export sources. This has helped depress spot prices globally. The primary cause for the downward trend in U.S. natural gas prices is the robust production growth from several emerging shale gas plays. Natural gas production from shale increased by over 6 Bcfd from 2005-2009, as illustrated in Chart 39.

Chart 39 - U.S Shale Natural Gas Production, (Bcfd)

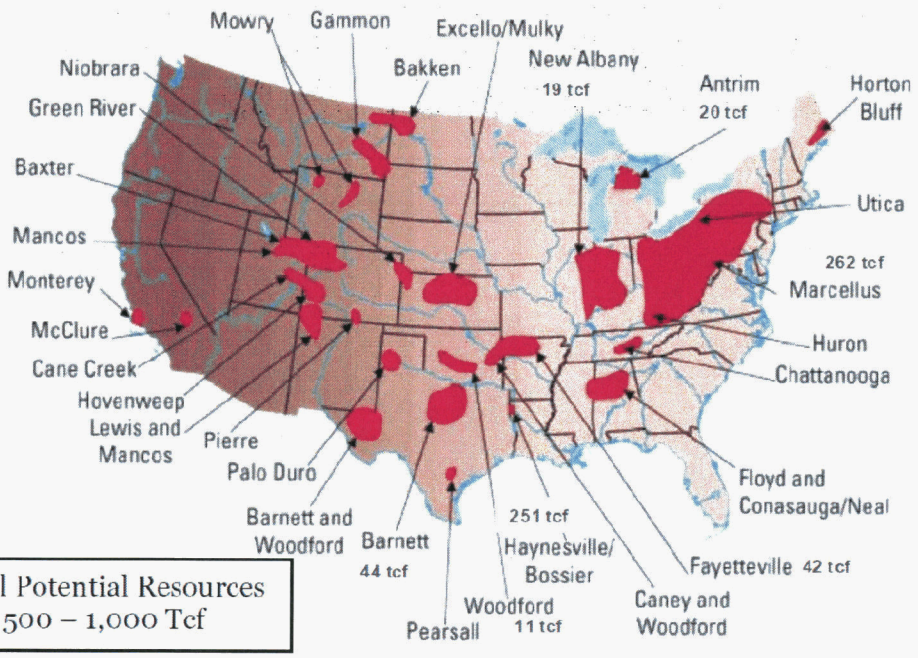


SOURCE: Adapted from Lippman Consulting, Inc. (LCI).

U.S. Shale Gas Plays

While production from the Antrim shale in Michigan had been under way for years, it was the rapid growth of the Barnett shale near Dallas-Fort Worth through the combination of hydraulic fracturing and horizontal drilling that excited producers. During the last several years, a growing number of primarily independent gas producers rushed to lock down leases across hundreds of thousands of acres in Oklahoma (Woodford), Arkansas (Fayetteville), Pennsylvania-to-southern New York (Marcellus), and northwest Louisiana (Haynesville), where they believed prodigious amounts of natural gas were in place in shale rock similar to the Barnett shale in Texas. The Barnett, Fayetteville, Marcellus, and Haynesville Shales may represent world-class size natural gas fields, but there are dozens of other potential shale gas plays in the United States as illustrated in Map 23.

Map 23 - U.S. Shale Gas Plays



SOURCE: Adapted from Schlumberger.

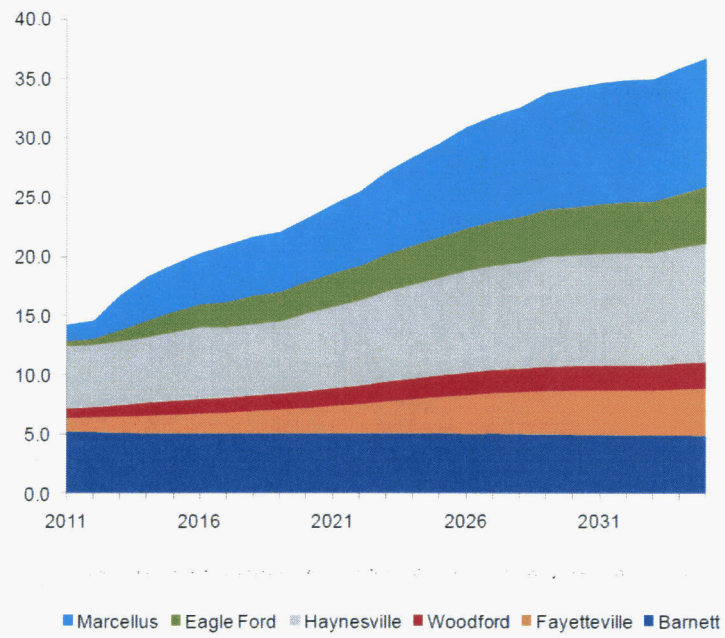
In order to bring the burgeoning shale gas supplies to market, over 5 Bcfd of new pipeline capacity has been added out of the Midcontinent and eastern Texas/northern Louisiana region over the past three years and many of the new pipelines have current plans for additional expansion with a total incremental planned capacity of approximately 1 Bcfd. Almost all of this new shale supply-driven pipeline capacity is targeting Perryville Hub in northern Louisiana and downstream markets on Transcontinental Gas Pipe Line (Transco Station 85) or into other pipelines serving the U.S. Southeast and Mid-Atlantic markets.

In addition, the rapid growth in Marcellus shale production is also driving new pipeline development. Virtually all of the major interstate pipelines in the region are looking for the expected surge in gas production to support significant infrastructure projects. While shale gas production continues to expand, there are some risks to its continued growth. Some environmental interests remain skeptical of shale gas and concerned about water quality and the local impacts of drilling activity. Hydraulic fracturing, which is critical to successful shale gas play development, raises concerns in some areas about water access and water disposal issues.

Chart 40 shows forecasted U.S. shale gas production for the six major shale plays in the lower 48. As can be seen from the figure, total shale gas production is propelled by production growth in the Marcellus, Haynesville and Eagle Ford shale's pushing total shale gas production to over 32 Bcfd by the 2026 to 2028 time frame. Production in the older more established shale plays such as the Barnett, Woodford and Fayetteville shale plays is more muted with total production from these three plays increasing at a slower rate over this time period. Beyond 2028, total shale gas production grows at a slower CAGR rate of 1.4%.

Currently, the core parts of the emerging shale plays represent the least cost production resource for domestic producers. The longer term profile is more uncertain given potential regulatory impacts and cost pressures; particularly around issues of fracturing, water access and disposal. The shale gas production forecast shown below results in a total cumulative shale gas production of about 240 Tcf which represents approximately 37% of the estimated technically recoverable resource for these six plays.

Chart 40 – Shale Plays Forecast (Bcfd)



(Source: Ventyx Advisors.)

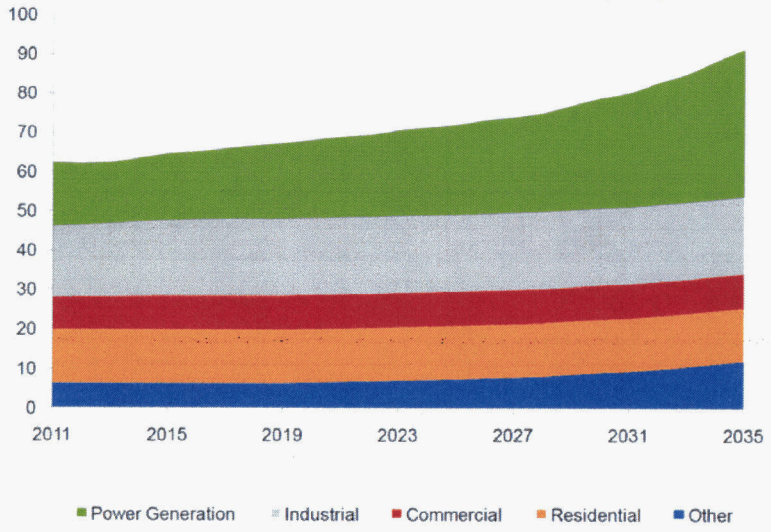
Over the time period 2011 to 2020, conventional gas production is expected to decrease from current levels of about 37% of the domestic supply to about 22% of domestic supply as lower cost shale gas production continues to displace higher cost conventional production. As prices recover above $7/MMBtu post 2030, conventional production begins to grow slightly. Production levels from CBM and tight gas are less responsive to changes in price levels and are relatively constant over time, dropping slightly during the period of rapid growth in shale gas production and increasing modestly in the later years of the forecast period.

While total import levels are expected to increase over the forecast period the modest increases are disproportional to market growth and result in a 2.4% decrease in market share for total imports. This forecast for total imports is consistent with a robust domestic production outlook, and increasing Canadian demand levels. In total U.S. gas imports are expected to account for approximately 11% or 10 Bcfd of domestic supply by 2035 representing an aggregate increase of 1.7 Bcfd but a decrease in market share of 2.4%. Several of the U.S. Gulf Coast LNG import terminals including Freeport LNG and Sabine Pass LNG are currently seeking regulatory approval for the export of domestically produced shale gas. Realization of either of these two export facilities, which are not included in the current reference case, would have a significant downward impact on the outlook for net imports.

Market Forecast

The 2011 Reference Case forecast for U.S. natural gas demand (by sector) is depicted in Chart 41. As shown, gas demand for power generation increases by over 100% over current levels during the 25-year forecast period at a compound annual growth rate of 3.5%. Growth in gas consumption by the power sector is most accelerated in the post 2028 period when gas is expected to be increasingly used to meet incremental base load power demand. Gas demand for the residential and commercial sectors is expected to be essentially flat over the forecast period. This is largely due to efficiency gains in gas use in these sectors offsetting moderate increases in demand. Demand in the industrial sector grows by about 1.25% through 2018 due to low gas price levels and a gradual economic recovery. Beyond 2018 industrial demand remains essentially flat.

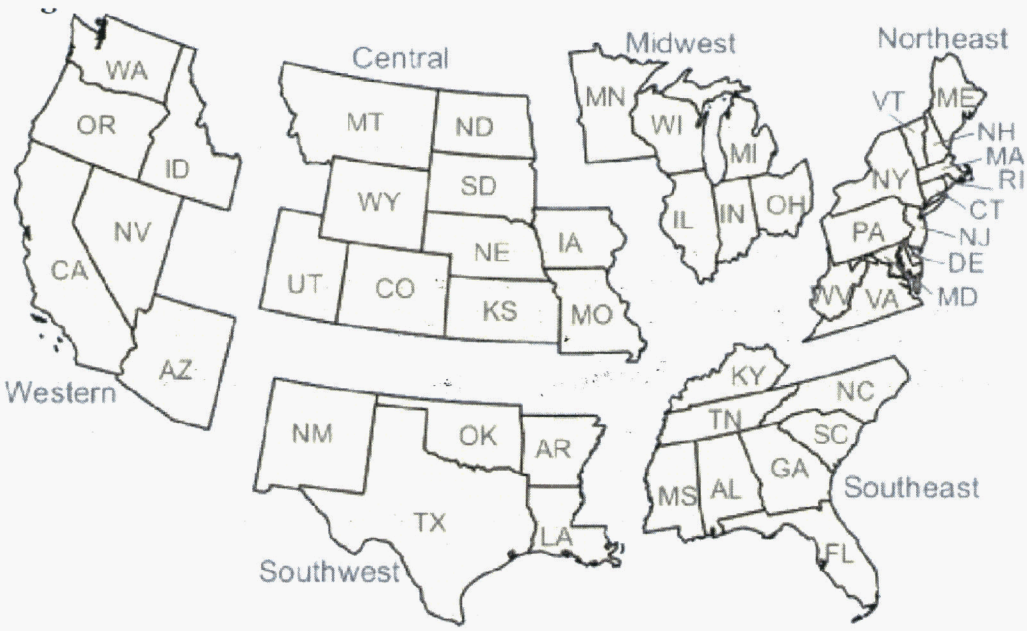
Chart 41 - U.S. Natural Gas Demand Forecast (Bcfd)



(Source: Ventyx Advisors.)

The power generation sector forecast is built up from projections for unit-level dispatch in five regions; namely, ERCOT, Southeast, Northeast, Midwest and WECC. These regions are depicted in the Map 24 - Regional State Groupings.

Map 24 - Regional State Groupings



Statistics for power generation growth rates for each of these regions can be seen in Table 33. Increases in power sector gas consumption are modest for the period 2011 to 2020 with about 1.3 Bcfd of incremental consumption which is expected to mostly occur in the WECC and Midwest regions. The relatively slow growth rates for power sector gas consumption during these years is largely a result of state level renewable energy mandates that are expected to meet a large portion of incremental power demand over this period. Beyond 2020, power sector gas consumption is expected to grow at a much quicker pace with approximately 19 Bcfd of incremental gas use. During this period, all regions are projected to have higher rates of power sector gas consumption growth with the largest gains occurring in the Southeast and Midwest.

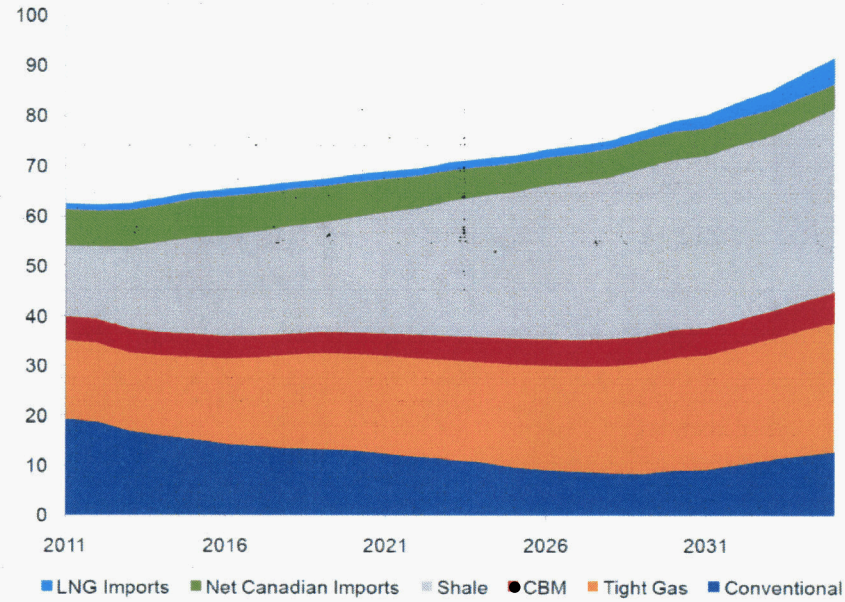
Table 33 - Regional U.S. Gas Demand Forecast

	ERCOT		Midwest		Northeast		Southeast		WECC	
	CAGR	Bcfd	CAGR	Bcfd	CAGR	Bcfd	CAGR	Bcfd	CAGR	Bcfd
2011 to 2020	2.8%	0.6	4.6%	1.3	1.1%	0.3	1.2%	0.6	3.0%	1.3
2021 to 2035	2.2%	1.0	7.1%	6.6	3.9%	2.2	5.3%	6.1	3.0%	2.9

(Source: Ventyx Advisors.)

Chart 42 illustrates the 2011 natural gas supply forecast for the U.S by major supply type while Table 34 Forecast shows changes by major supply source in Bcfd and the compound annual growth rate for the periods 2011 to 2020 and 2021 to 2035. As can be seen from the figure and table, shale gas production represents the largest incremental supply source for the U.S. market with production growing at a rate that displaces conventional production. Shale gas production is estimated to grow from current levels of about 26% of domestic supply to about 49% of domestic supply by 2030. This represents an increase of about 20 Bcfd over current levels of shale gas production.

Chart 42 - U.S. Natural Gas Supply Forecast (Bcfd)



(Source: Ventyx Advisors.)

Table 34 - Regional U.S. Supply Forecast by Type

		Conventional	Tight Gas	Coal Bed Methane	Shale	Net Canadian Imports	LNG Imports
2011 to 2020	CAGR	-4.2%	2.2%	-1.3%	5.6%	-0.3%	2.0%
	Bcf/d	-6.2	3.4	-0.5	8.9	-0.2	0.2
2021 to 2035	CAGR	0.2%	2.1%	2.3%	3.0%	-2.4%	9.6%
	Bcf/d	0.4	6.4	1.7	12.4	-1.9	3.8

(Source: Ventyx Advisors.)

Overview of Arizona's Regional Gas Supply Sources

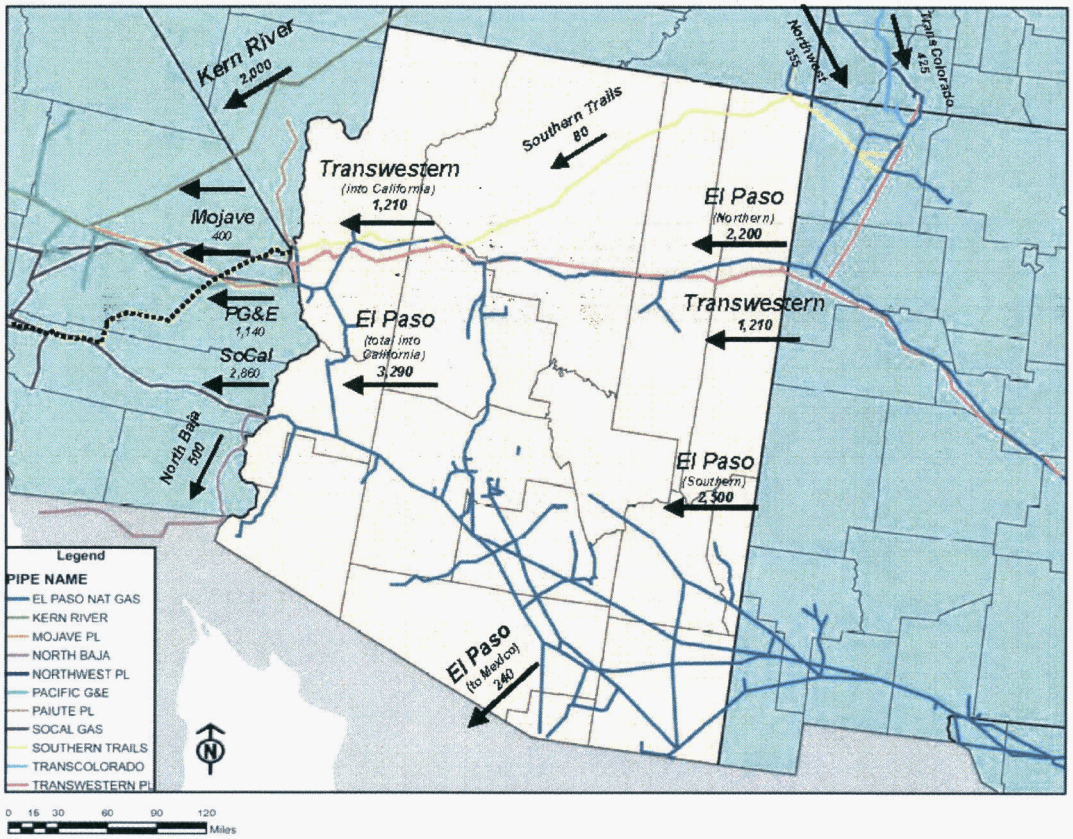
Arizona is in close proximity three major gas supply basins. This includes the San Juan, Permian, and Rockies basins. These regional basins are three of the top five largest gas supply sources in the United States. Combined, these three sources have a daily production capacity 18.7 billion cubic feet a day (Bcf/d). Based on studies conducted by Pace Global, the total technically recoverable resources are estimated at 240 Tcf. Table 35 below breaks out each regional gas supply source.

Table 35 - Arizona Regional Gas Supply Sources

Rank	Regional Gas Supply Source	Current Production (MMcf/d)	Technically Recoverable Resources (Tcf)	Area (Square Miles)
1	Rockies*	10,632	148.9	95,240
2	Permian	4,563	40.5	75,000
3	Barnett Shale	3,668	26.7	26,327
4	San Juan	3,480	50.5	15,200
5	Anadarko	2,931	14.2	44,354

Arizona has an extensive pipeline network comprised of a dual system served by El Paso and Transwestern. The El Paso system is the largest gas capacity network in the Western US, with total transport capacity of up to 6.2 billion cubic feet a day. Transwestern's 2.4 Bcf/d natural gas pipeline system accesses gas in the Anadarko, San Juan and Permian basins for delivery to California and Arizona.

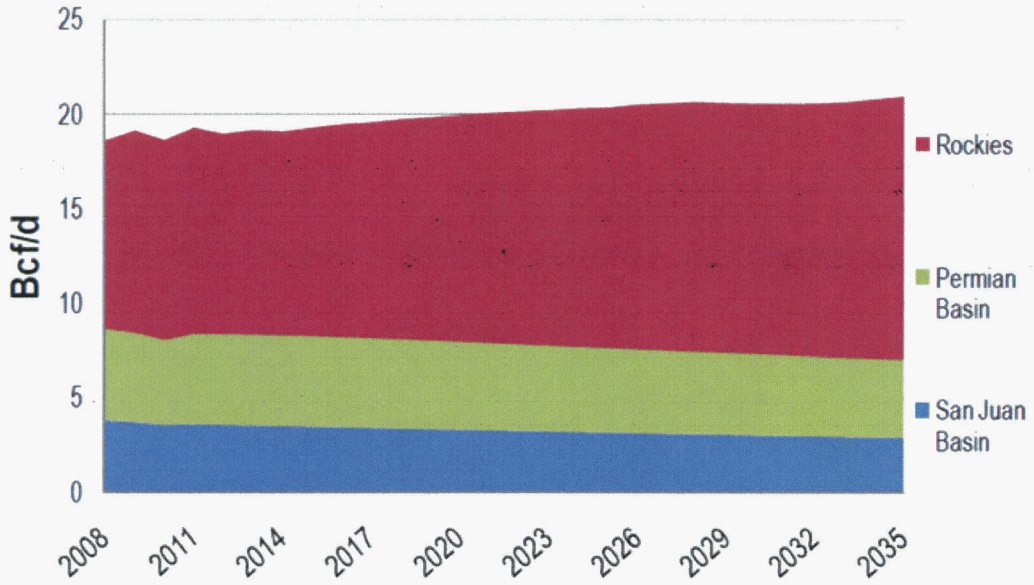
Map 25 - Arizona Natural Gas Pipeline Network



Future Regional Natural Gas Production

As shown in Chart 43, regional gas supply sources with access to the Arizona markets will maintain current production levels of approximately 19 Bcf/d over the forecast period. The San Juan and Permian production levels are expected to decline slightly with the San Juan basin declining at 0.8% per year and the Permian Basin declining at 0.5% per year. In contrast, the Rockies region is expected to increase production at 1.1% per year.

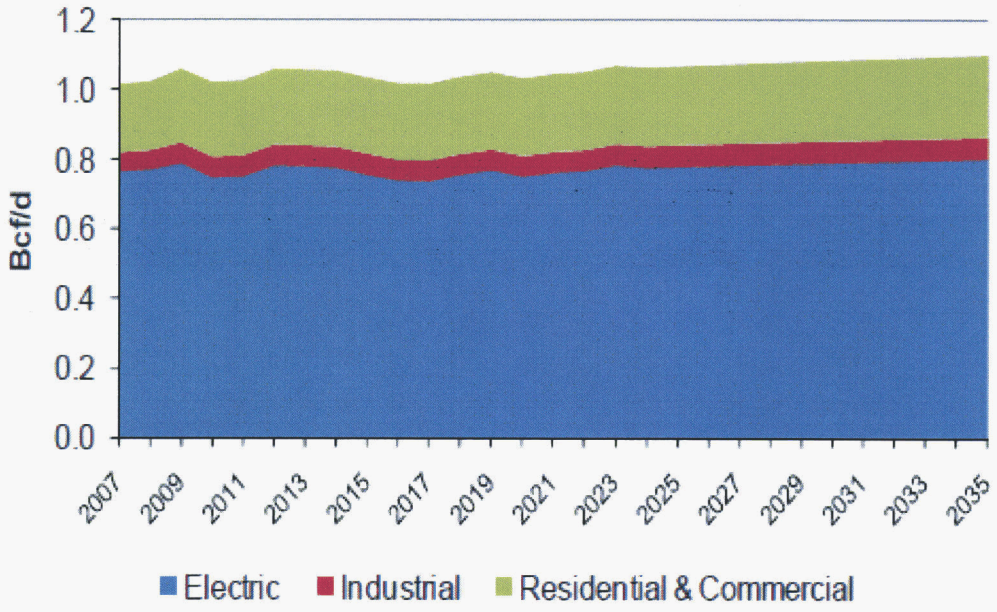
Chart 43 - Future Regional Natural Gas Production



Target Market End-Use Demand for Arizona

End-demand in Arizona is expected to rise from 1.0 Bcf/d in 2010 to 1.1 Bcf/d in 2035. Residential and gas-fired power generation demand represents the principal drivers of demand growth. Residential demand is forecast to grow at a compound annual growth rate (CAGR) of 0.4% over the study period, to approximately 233 MMcf/d in 2035. Gas-fired power demand is forecast to grow at a 0.3% CAGR, reaching approximately 800 MMcf/d in 2035. Chart 44 below shows the Arizona natural gas demand by three major use sectors.

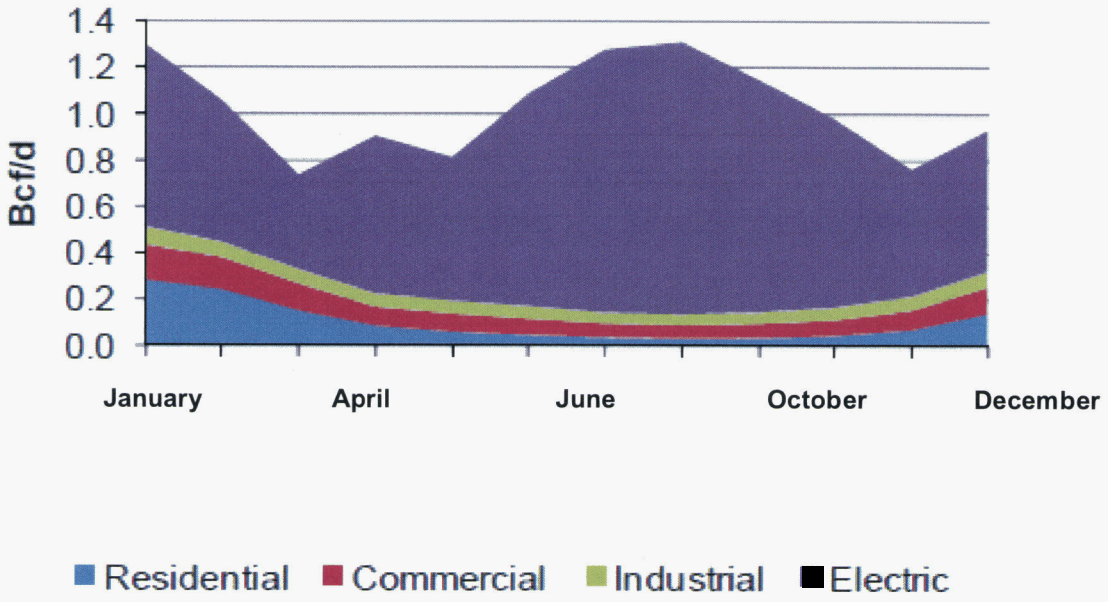
Chart 44 - Arizona Natural Gas Demand by Sector



Arizona Seasonal Natural Gas Demand

Arizona experiences a dual-peaking annual demand, with the highest rate of natural gas demand occurring in the summer (June – September) as a result of increased gas-fired generation. A slightly smaller peak in occurs in the winter (December – February) spurred by residential demand for heating coupled with gas-fired generation. Chart 45 below show the seasonality demand for Arizona natural gas.

Chart 45 - Arizona Seasonal Natural Gas Demand



CHAPTER 14

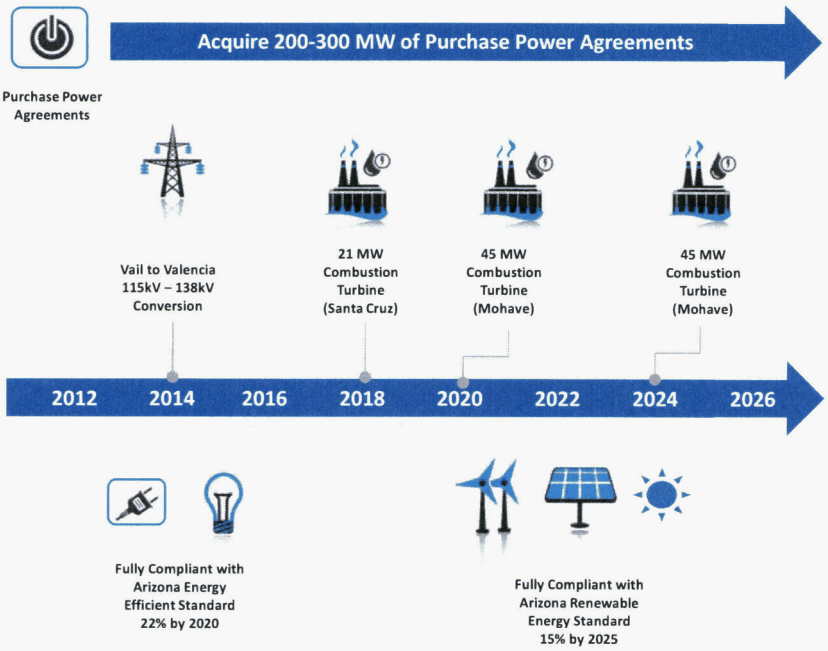
INTEGRATED RESOURCE PLANNING RESULTS

Introduction

The resource planning process starts with a set of input assumptions. These assumptions include a forecast of customer demand, costs and operating characteristics for new and existing resource options, and assumptions on future regulatory and environmental policies. These assumptions are run through detailed planning simulation models to develop an understanding of the financial requirements and risk factors associated with each resource portfolio. The goal of the planning process is to develop a resource acquisition strategy that balances a number of objectives, such as affordability, system reliability, and environmental compliance. The goal of this process is a resource planning strategy that balances competing objectives while allowing for flexibility to execute contingency plans as future uncertainties become known.

Overview of the 2012 Reference Case Plan

The 2012 IRP presents the Reference Case Plan as its base case resource plan. This Reference Case plan provides a starting point for comparisons against other resource portfolio alternatives. The 2012 Reference Case plan emphasizes continued operations based on our existing market based portfolio strategy which results in lower annual customer energy costs with a focus on the future development of EE, renewables, and natural gas resources.



Energy Efficiency and Demand Response

Energy Efficiency

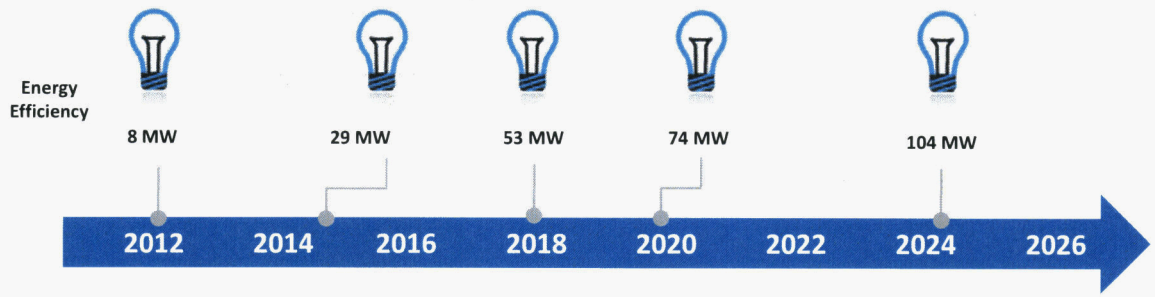
The most cost-effective resource option is EE. UNS Electric proposes to pursue the most cost-effective and reliable programs available. The proposed EE portfolio targets a 22% cumulative energy reduction by 2020. This offset to future retail load growth is expected to reduce UNS Electric's annual energy requirements by 370 GWh in 2020. The EE programs will also reduce UNS Electric's system peak demand by 74 MW by 2020.

Demand Response

The Reference Case plan currently doesn't include any DR programs. UNS Electric is currently in the process of exploring possible DR opportunities. UNS Electric expects that these efforts will determine the potential of DR for UNS Electric and these programs will be considered in future planning studies.

Figure 1 shows the equivalent capacity reductions to be installed under future EE programs for the Reference Case plan from 2012 through 2027.

Figure 27 - Energy Efficiency Resource Capacity



Utility Scale Renewables and Distributed Generation

Utility Scale Renewables

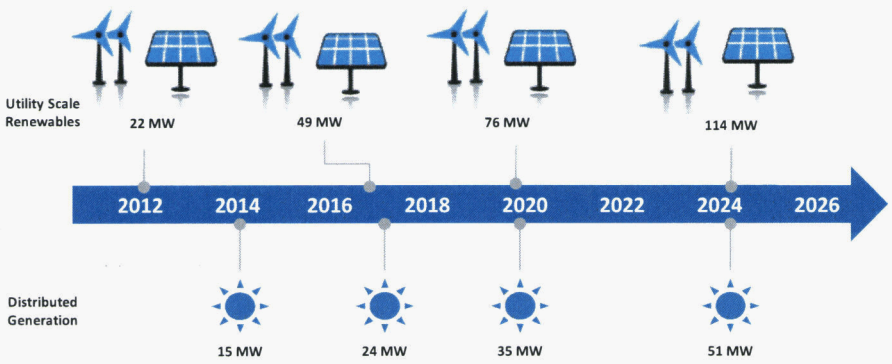
The Reference Case plan also includes a diverse portfolio of renewable resources that complies with the Arizona Renewable Energy Standard (RES). The Reference Case plan meets the renewable energy standard goals, which requires UNS Electric to obtain renewable energy which is equivalent to 3.5% of its 2012 retail load requirement, growing to 15% by 2025. By 2020, the Reference Case plan will include over 76 MW of renewable nameplate capacity. These utility scale renewable resources are expected to supply over 151 GWh of energy on an annual basis in 2020.

The 2012 Reference Case plan places emphasis on a diversified renewable resource portfolio. UNS Electric plans to acquire a diverse mix of renewable technologies and short-term REC market purchases when opportunities become available. Finally, as part of this IRP process, UNS Electric's short term action plan includes plans to conduct a series of on-going RFPs in conjunction with Tucson Electric Power to acquire adequate renewable resource to meet future REST requirements.

Distributed Generation

The Reference Case plan meets the DG requirement based on Arizona's Renewable Energy Standard. The annual DG requirement is 30% of the RES requirement in 2012. By 2020, the Reference Case plan will include 35 MW of DG nameplate capacity. DG resources are expected to supply at least 461 GWh of energy on an annual basis in 2020. Figure 28 below shows the expected cumulative nameplate capacity to be installed under future utility-scale renewable and DG programs from 2012 through 2027.

Figure 28 - Utility Scale Renewables and Distributed Generation Resource Capacity

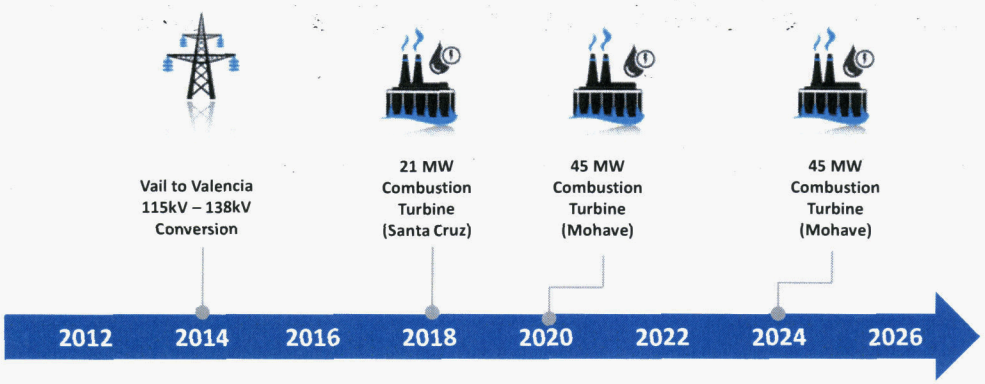


Future Local Area Generation and Transmission Upgrades

Based on current load growth projections, the Reference Case plan assumes that the Vail to Valencia 115kV to 138kV conversion is completed in 2014 and for purposes of maintaining continuity of service, a new 21 MW CT will be sited at the Valencia Power Plant located within the City of Nogales in 2018. In addition, natural gas turbines are also needed to support UNS Electric's renewable resources and two 45 MW gas turbines are shown in 2020 and 2024.

Figure 3 below shows the capacity and the timing associated with UNS Electric's generation and transmission resources.

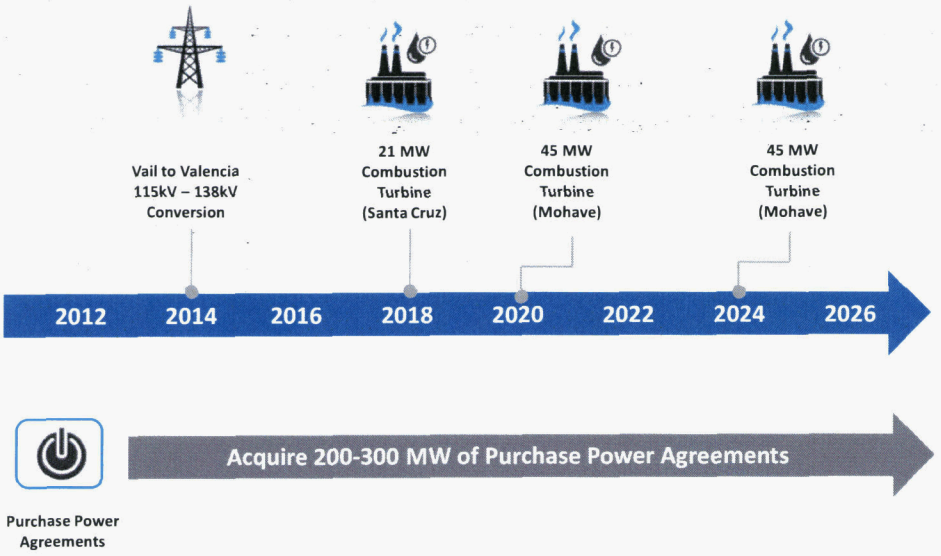
Figure 29 – Local Area Generation and Transmission Resources



The Reference Case Plan – Market Based Portfolio

For the balance of UNS Electric's supply portfolio, the Reference Case Plan selected for UNS Electric is based on the Market Based Portfolio Strategy. Through UNS Electric's competitive procurement process, UNS Electric will execute a number of purchase power contracts to meet future supply obligations. UNS Electric will place emphasis on reliable low cost purchase power agreements that are diversified across a wide-range of resources and counterparties.

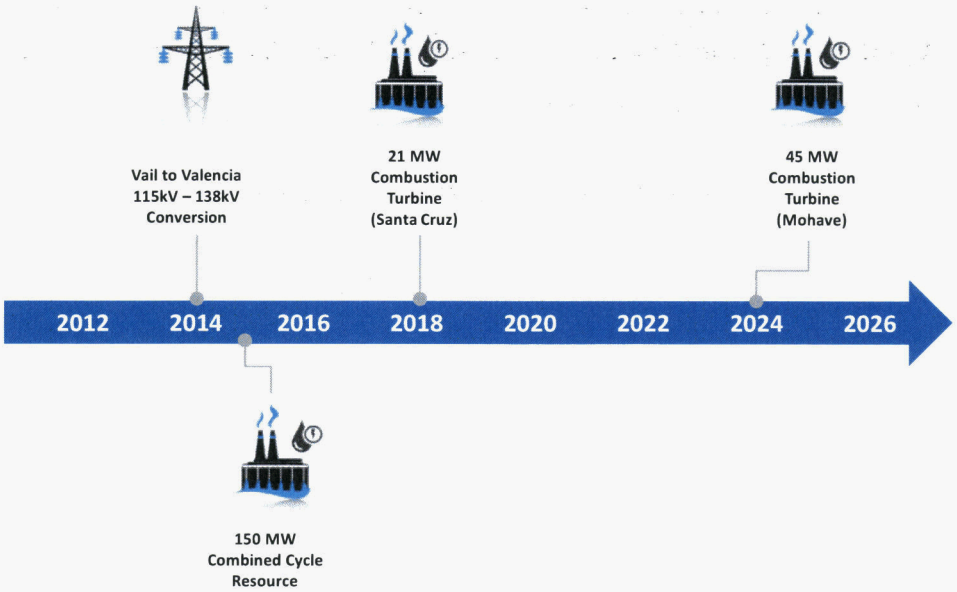
Figure 30 - The Reference Case Plan – Market Based Portfolio



Combined Cycle Resource Plan

Given UNS Electric's need for future base load and intermediate resources as well as firming capacity for intermittent generation resources, the 2012 IRP looked at potential ownership scenarios where UNS Electric owned a portion of a new combined-cycle plant. The 2012 IRP assumptions estimated these ownership costs to be approximate $1,320/kW including transmission. However, with the economic downturn, market activity for merchant plant acquisitions has increased with plant valuations coming in below the cost of new construction. UNS Electric will continue to monitor market activity for potential natural gas resource acquisitions that are economically attractive. A low cost, multi-owner acquisition of an existing Arizona CC plant would enable UNS Electric to firm up its longer-term capacity needs while realizing economies of scale through a multi-owner plant configuration.

Figure 31 - Contingency Plan 1 – Combined Cycle Acquisition



Market Exposure

Resource Plan Comparison – Market Exposure Figure 32 shown below provides a comparison of the future market-based capacity needs under the Reference Case and the Combined Cycle Resource Plan. As shown on the top portion of Figure 32, UNS Electric's market capacity exposure is about 350 MW over the next five years. With the addition of EE and renewable resources, future market exposure is reduced to 150 MW by 2027. In comparison, the Combined Cycle Resource Plan assumes that UNS Electric is able to acquire a portion of combined-cycle resource that reduces its reliance on market based purchase power contracts. In this scenario market capacity exposure is reduce from 350 MW in 2012 to 50 MW by 2027.

Figure 32 – Market Exposure by Resource Plan

	2012	2013	2014	2015	2016	2017	2018	2019
Market Based Portfolio	350	350	350	350	325	325	300	275
Combined Cycle Resource Plan	350	350	350	200	175	175	150	125

	2020	2021	2022	2023	2024	2025	2026	2027
Market Based Portfolio	225	225	225	225	150	150	150	150
Combined Cycle Resource Plan	125	125	125	100	50	50	50	50

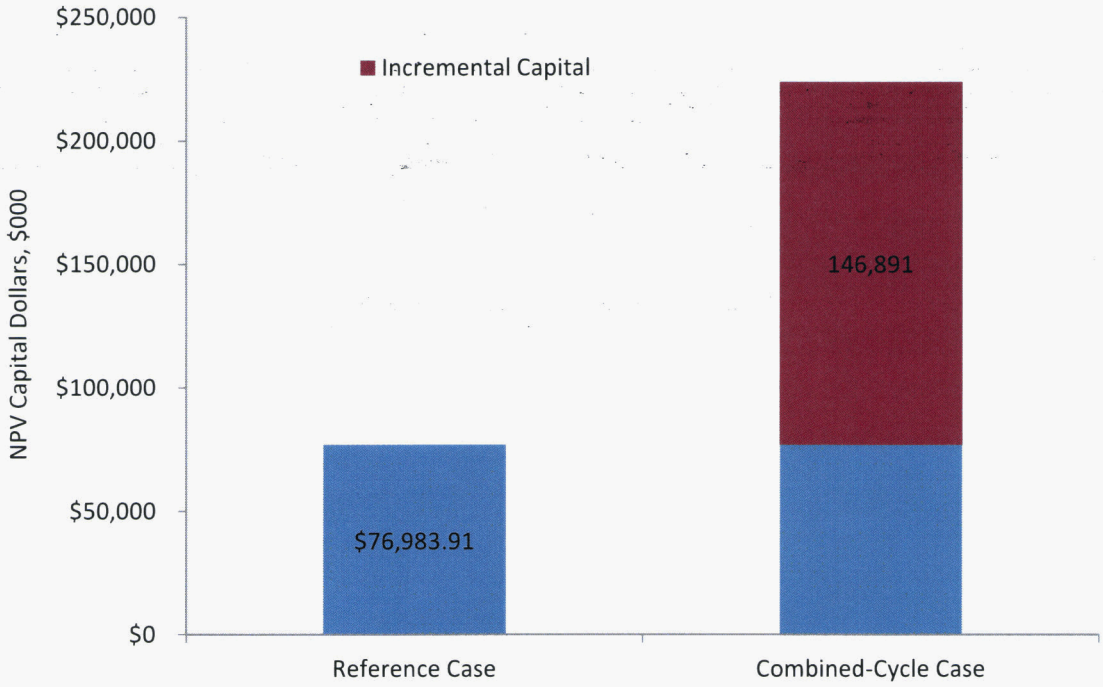
Through the use of annual NERC assessments and other sources of market intelligence, UNS Electric plans to monitor the availability of regional merchant generation capacity. In the case where regional loads increase faster than expected or available capacity starts to decline due to retirements or increased demand, UNS Electric will consider firming up future capacity requirements with plant ownership to reduce market exposure over time.

Since the IRP is done, every two years, UNS Electric will adjust its market based portfolio strategy to accommodate these changes in available regional capacity as needed. Furthermore, UNS Electric will continue to monitor the merchant plant market for economically attractive plant acquisition opportunities. Since UNS Electric's future capacity needs are relatively small compared to size of a full CC plant, a low cost, acquisition of an existing combined cycle gas fired plant would enable UNS Electric to firm up its longer-term capacity needs while realizing economies of scale through a multi-owner plant configuration.

Portfolio Capital Comparison

Under the Reference Case portfolio where UNS Electric relies on a market based portfolio to serve its future load obligations, UNS Electric customers on a net present value basis will pay 91% less in capital expenditures versus having to invest in a new combined cycle asset. This reduction in capital expenditures equates to a $147 million in net present value savings from 2012-2027.

Chart 46 – Reference Case versus Combined Cycle Resource, NPV of Capital



Total Portfolio Cost Comparison

Table 36 compares the net present value of the total resource portfolio costs over the 15-year planning horizon from 2012-2027. In terms of net present value, a market based portfolio approach reduces UNS Electric's customer revenue requirements by $137 million versus investing in a new build combined cycle resource.

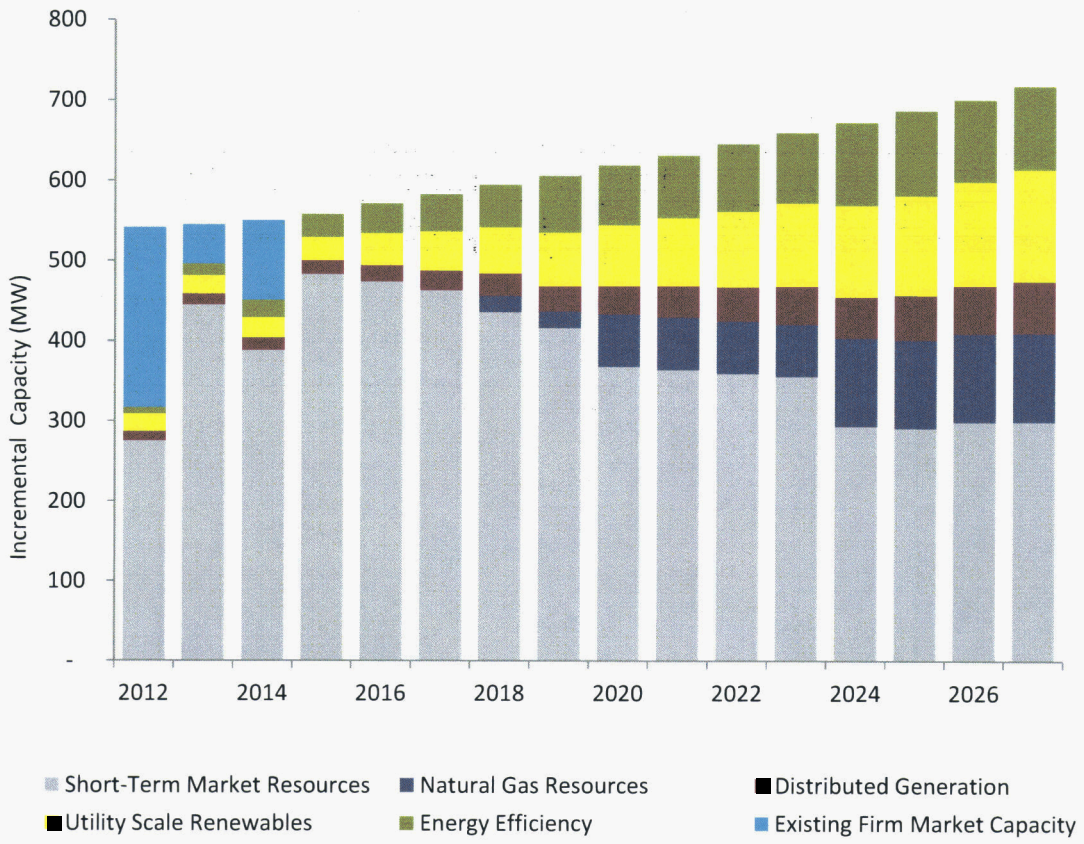
Table 36 – Reference Case Portfolio versus Combined Cycle Case, NPV of Portfolio Costs

NPV Portfolio Costs, $000	Reference Case Portfolio	Combined Cycle Case
NPV Portfolio Costs (2012-2027)	$1,598,377	$1,735,019
NPV Delta to Reference Case Portfolio		($136,642)
% Delta to Reference Case Portfolio		-9%
NPV System Portfolio Costs, $/MWh	$44.56	$48.37

Reference Case Resource Plan - Future Capacity Additions

The Reference Case plan identifies the need for approximately 718 MW of new nameplate capacity through 2027. Chart 2 below shows the incremental nameplate capacities installed by year and resource type.

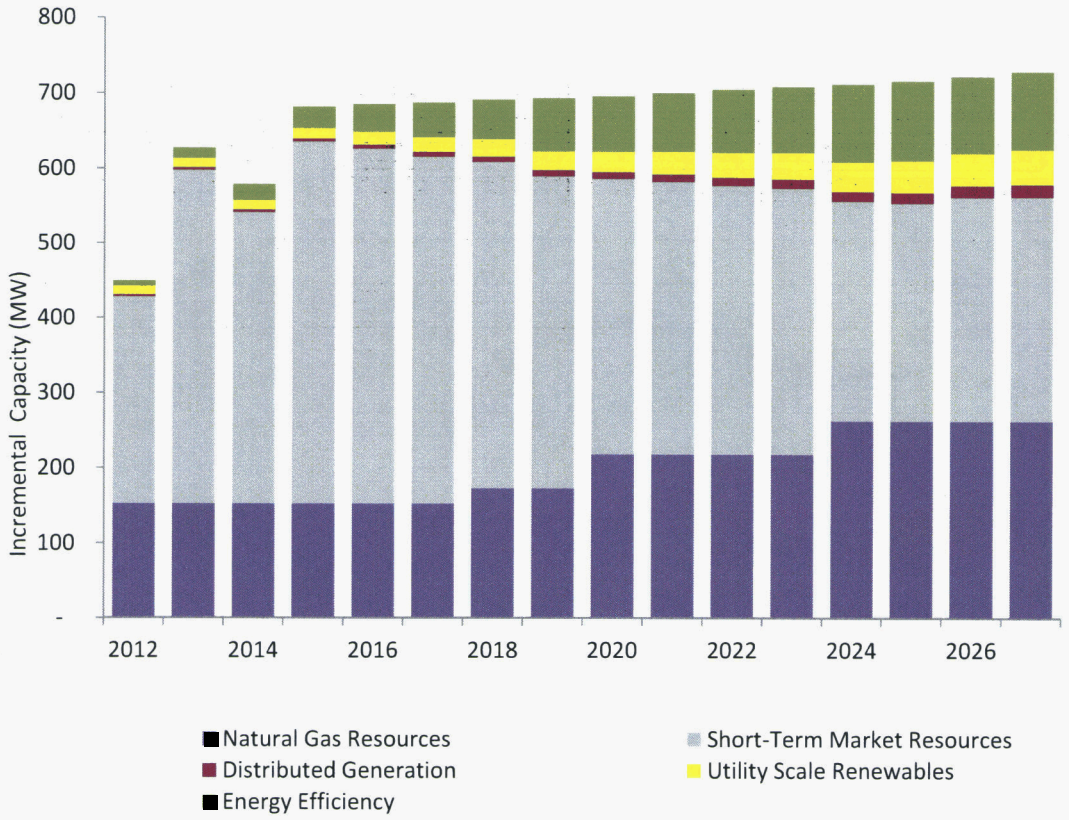
Chart 47 – Reference Case Plan Capacity Additions, Future Nameplate Capacity (MW)



Reference Case Resource Plan – System Coincident Peak Capacity

Chart 48 provides an aggregate summary of UNS Electric's resource capacity including its existing generation resources. In 2012, the resource capacity mix is made up of natural gas and merchant resources. Based on the recommended resource plan, the UNS Electric portfolio is further diversified to include additional capacity resources such as renewables, DG, and EE.

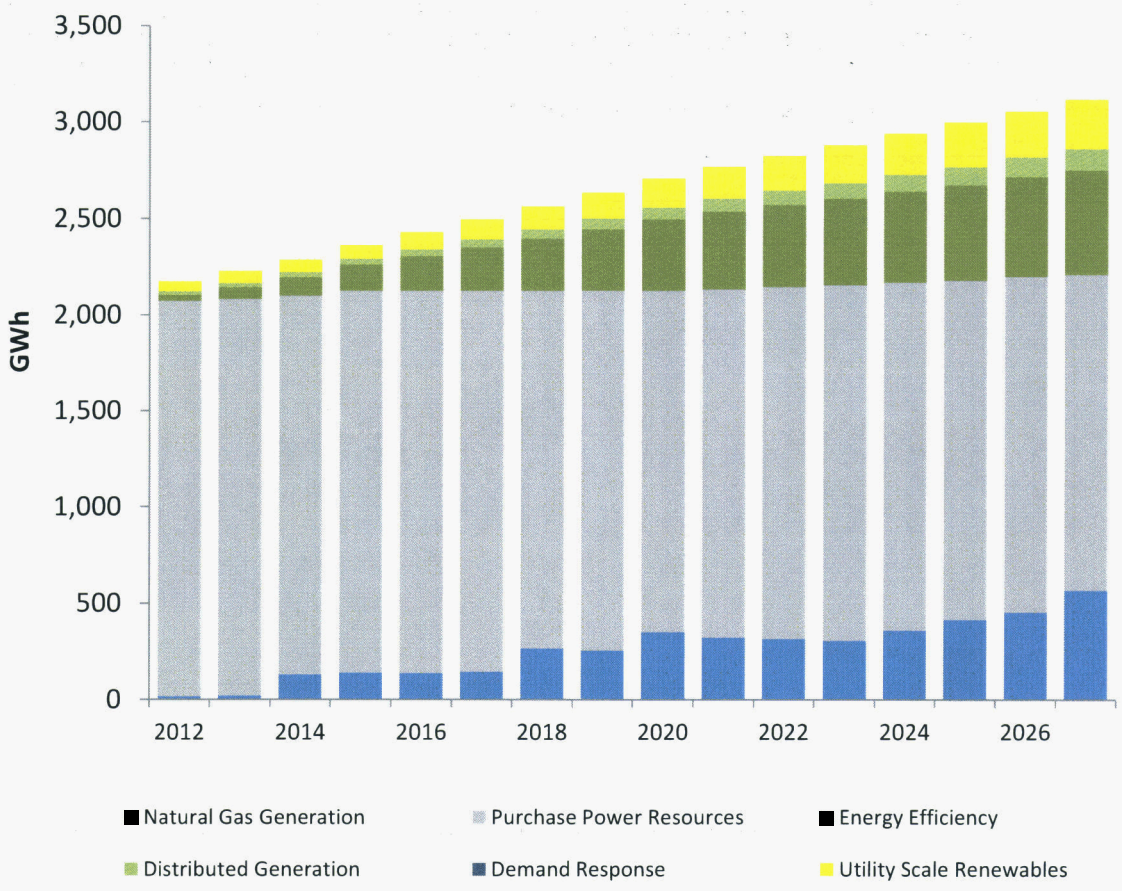
Chart 48 – Reference Case Plan (Total Capacity - Coincident to System Peak MW)



Reference Case Resource Plan – Expected Annual Generation Output

Chart 5 shows the expected energy contribution required to meet UNS Electric's firm load obligations by year and resource type. In 2012, UNS Electric's resource portfolio is comprised of 97% purchase power and natural gas resources. By 2027, it is projected that UNS Electric's resource portfolio will be comprised of 71% natural gas and purchase power resources with 18% made up of EE and 11% renewable resources.

Chart 49 – Reference Case Resource Plan, Expected Annual Generation Output (GWh)



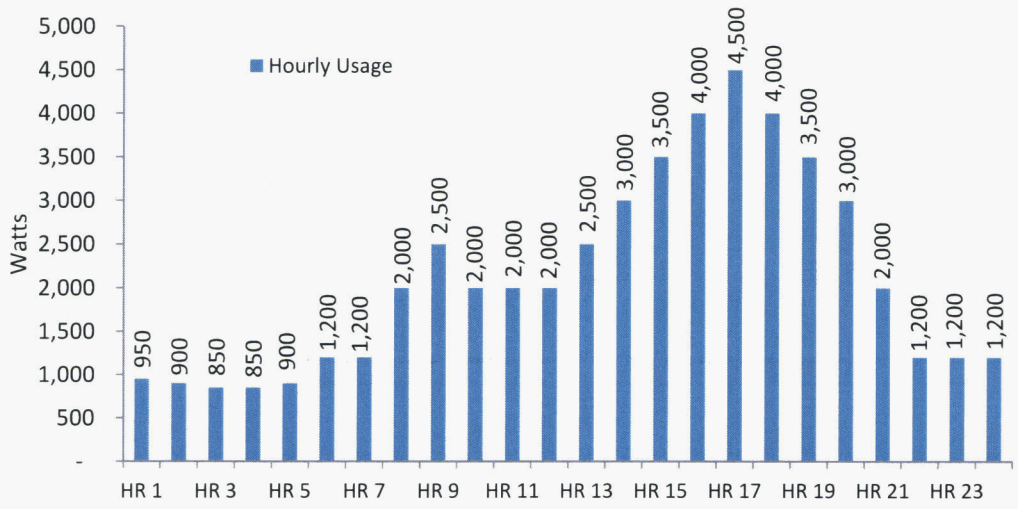
Appendix A

Demand versus Energy

Two utility concepts that relate to resource planning and to ratemaking are demand and energy. Both are measurements of electricity usage. Demand, often referred to as capacity is an instantaneous measurement while energy is a measurement over time. To understand the differences of these measurements, think about measurements made when driving an automobile. Each time that you look at the speedometer you are being told how fast the car is traveling at that instant in time. This compares to a measurement of demand. A second measurement is made by the car's odometer which tells us the distance traveled over time. This compares to the concept of energy. Energy describes how much electricity was used during an hour, day or year. Typical measurements of demand are expressed as kilowatts (KW) or megawatts (MW). Energy measurements include a time reference: kWh or megawatt hours (MWh). The terms demand and capacity are somewhat synonymous. Demand typically is used to measure instantaneous use or consumption while capacity measures instantaneous supply of power.

Chart 50 shows a hypothetical customer's energy usage in watt hours over a 24 hour period. The values along the top of the graph represent the demand values for each hour. The peak demand is the highest measured demand, for this day it is 4,500 watts s at hour 17. The area under the curve is the amount of energy used. The actual energy used is the sum of all hours during this 24 hour period, which is 50,950 watts.

Chart 50 – Customer Energy Usage



Demand and Energy Significance in Resource Planning.

To quantify the resources needed to serve its customers, a utility looks at the peak demand of their system and determines the minimum future resource needs. If customer demand for a utility peaks at 3,000 MW, the company must procure resources either as generators or through purchased power to supply at least 3,000 MW or risk possible shortages and interruptions in customer service. The IRP begins with a long term forecast of system peaks. The system peak forecast is then a guide of what level of supply the company will require over time.

Demand and Energy in the Rate Making Process

Ratemaking for a modern utility is a complicated process with various combinations of pricing formulae. One philosophy of pricing utility services is strictly variable in which the customer is given a price per KWh and they are charged that price times the KWh consumed during a month. If the customer is given a price of $0.10/KWh and they consume 1,000 KWh in a month, their bill is $100. This is a very simplified formula that ignores taxes and other costs that may be in a tariff.

Another philosophy looks at the customers' demand. As stated earlier the utility must have resources that it rarely uses to satisfy the system peaks which result from total customer demand. Some ratemaking formulae look at the cost of the total resources needed to meet this demand. They then look at how much each customer's demand contributes to that total capacity cost. Each customer's share of the total capacity is called the customers Load Ratio. Total Capacity cost is then allocated to each customer on their load ration to define an amount billable to the customer. Most customer billing formulae are a combination of these methods and others to arrive at bills that are fair and equitable for customers and utilities.

List of Acronyms

ACRONYMS

APS – Arizona Public Service Company
BTA – Biennial Transmission Assessment
Btu – British Thermal Unit
CAES - Compressed Air Energy Storage
CC – Combined Cycle; Combined Cycle Combustion Turbine
CFL - Compact Fluorescent Light Bulb
CO2 - Carbon Dioxide
CSP - Concentrating Solar Power
CCS - Carbon Capture and Sequestration; Carbon Capture and Storage
CT - Combustion Turbine
DG - Distributed Generation
DOE – U.S. Department of Energy (Federal)
DLC – Direct Load Control
DR – Demand Response
EE – Energy Efficiency
EIA - Energy Information Administration
EPRI - Electric Power Research Institute
FERC - Federal Energy Regulatory Commission
GW- Gigawatt,
GWh - Gigawatt-Hour
HAPS - Hazardous Air Pollutants
HRSG – Heat Recovery Steam Generator
IGCC - Integrated Gasification Combined Cycle
IRP - Integrated Resource Plan
ITC - Investment Tax Credit
kW - Kilowatt
kWh - Kilowatt-Hour
kWyr - Kilowatt-Year
LNG - Liquefied Natural Gas
MACRS - Modified Accelerated Cost Recovery System
MACT - Maximum Available Control Technology
MMbtu - Million British Thermal Units, also shown as MBtu
MBtu - Million British Thermal Units, also shown as MMbtu
MW - Megawatt

MWh - Megawatt-Hour
NERC - North American Electric Reliability Council
NOX - Nitrogen Oxide
NPV – Net Present Value
NTUA - Navajo Tribal Utility Authority
OATT - Open Access Transmission Tariff
O&M - Operations and Maintenance
PM - Particulate matter
PNM – Public Service Company of New Mexico
PPA - Purchased Power Agreement
PTC - Production Tax Credit
REC - Renewable Energy Credit
REC - Renewable Energy Standard
RFP - Request for Proposal
ROW- Right of Way
RTP – Renewable Transmission Project
SRSG - Southwest Reserve Sharing Group
SO2 - Sulfur Dioxide
STG - Steam Turbine Generator
SWEEP - Southwest Energy Efficiency Project
TTC – Total Transfer Capacity
TOUA - Tohono O'odham Utility Authority
WECC - Western Electricity Coordinating Council

Glossary

GLOSSARY

Baseload Resource
A generating resource that runs continuously except for maintenance and forced outages. A baseload resource is typically run at a capacity factor of 65% or greater on an annual basis.

Biomass
Plant material used as a fuel or energy source; e.g. logging or mill residues, urban wood-waste and construction debris, dedicated wood or agricultural crops, and agricultural waste.

Biogas
Methane and other combustible gases released from the decomposition of organic materials.

Capacity Factor
Actual energy generated over a certain time period divided by maximum generation output over that same time period.

Combined Cycle (CC)
A simple cycle combustion turbine (CT) with a heat recovery unit added. The heat recovery system recovers waste heat from the combustion turbine and uses it to create steam for additional electricity generation.

Compressed Air Energy Storage (CAES)
A generating system by which air is pumped into a storage container during off-peak usage periods of low demand. Later, during on-peak periods the air is released to power a generator when energy is in high demand.

Combustion Turbine (CT)
A natural gas-fired turbine used to drive an electric generator. CTs are designed for meeting short-term peak demands placed on utility power systems. They are frequently ramped up and down to follow load as needed.

Conservation
The reduction of energy consumption resulting from increases in the efficiency of production, distribution and customer end use.

Carbon Dioxide (CO2)
Carbon dioxide is classified as a GHG because it is linked to global warming.

Centralized Solar
A thermal solar facility that concentrates sunlight in order to collect heat and use that heat to create steam which then drives a steam turbine creating electric generation (also referred to as concentrating solar thermal).

Demand
The rate at which electric energy is delivered to or by a system at a given instant, usually expressed in megawatts.

Demand Response (DR)
Programs or policies to control customer demand. Typically, DR programs involve agreements whereby consumers curtail their energy usage at the request of the utility. Includes load control, pricing strategies and interruptible tariffs.

Demand Side Management (DSM)
Programs or policies designed to reduce the amount of energy consumed by end users. Includes Energy Efficiency, Conservation and Direct Load Control.

Dispatchable Resource
A resource whose electrical output can be controlled or regulated to match the energy requirements of the electric system.

Distributed Generation (DG)
Electric generation that is sited at a customer's premises, providing energy to the customer load at that site and/or providing electric energy for use by multiple customers in contiguous distribution substation areas

Distribution System
The utility facilities that distribute electric energy from convenient points on the transmission system to customers.

Duty Cycle
Generating facility design that determines how a facility is operated. Duty Cycle classifications are baseload, intermediate or peaking.

Economic Dispatch
In electrical system operations modeling, the selection of the least-cost resource under a prescribed set of conditions.

Energy
Usage over a period of time, measured in GWh, MWh, or kWh

Energy Efficiency (EE)
Measures, including energy conservation measures, or programs that target consumer behavior, equipment or devices that result in a decrease in consumption of electricity.

Federal Energy Regulatory Commission (FERC)
An agency of the United States government that is responsible for regulating power generation and licensing generation and interstate transmission systems.

Generation Capacity
The maximum amount of power that a generator can physically produce.

Geothermal Energy
Energy derived from heat deep beneath the earth's surface generated from hot rock, hot water or steam.

Gigawatt (GW) and Gigawatt-Hour (GWh)
A gigawatt is a unit of power equal to 1 billion watts, 1 million kilowatts, or 1,000 megawatts. A gigawatt-hour (GWh) is a measure of electric energy equal to one gigawatt of power supplied to or taken from an electric circuit for one hour.

Heat Rate
The ratio of energy inputs used by a generating facility expressed in Btus (British Thermal Units), to the energy output of that facility expressed in kilowatt-hours. (Btu/kWh)

Insolation
The amount of solar radiation that is striking a surface at any given time.

Integrated Gasification Combined Cycle (IGCC)
A plant configuration based on combined cycle technologies that substitutes natural gas for a process that extracts synthetic gas from petroleum coke or other carbon based fuel sources, then uses the synthetic gas (Syngas) as a fuel source.

Integrated Resource Planning
A planning approach that projects the amount of new electricity generation and conservation needed to meet future loads by considering a range of power resource alternatives and future conditions, and using evaluative criteria including but not limited to minimizing cost.

Intermediate Resource
A generating resource that is most economically run at capacity factors between 20% and 65% of the time on an annual basis.

Landfill Gas
Gas generated by the natural degrading and decomposition of municipal solid waste by anaerobic microorganisms in sanitary landfills. The gases produced, primarily methane, can be collected by a series of low-level pressure wells and can be processed into a medium Btu gas that can be burned to generate electricity.

Levelized Cost
The present value of a resource's cost (including capital, interest and operating costs) converted into a stream of equal annual payments and divided by annual kilowatt-hours saved or produced.

Load
The amount of electric power delivered or required at any specified point or points on a system. Load originates primarily at the power-consuming equipment of the customer.

Load Forecasting
The procedures used to estimate future consumption of electricity. Load forecasts are developed either to provide the most likely estimate of future load or to determine what load would be under a set of specific conditions; e.g., extremely cold weather, high rates of inflation or changes in electricity prices.

Load Duration Curve
A load duration curve provides a graphical illustration of the relationship between generating capacity requirements and capacity utilization. The load duration curve helps determine which type of resource best matches system load requirements.

Load Factor
Peak demand divided by average demand.

Load Profile or Shape
A curve on a chart showing power supplied plotted against time of occurrence to illustrate the variance in load in a specified time period.

Megawatt (MW) and Megawatt-Hour (MWh)
One thousand kilowatts, or 1 million watts; the standard measure of electric power plant generating capacity. A megawatt-hour (MWh) is a measure of electric energy equal to one megawatt of power supplied to or taken from an electric circuit for one hour.

Net Maximum Capacity (NMC)
The capacity a unit can sustain over a specified period when not restricted by ambient conditions or equipment deratings, minus the losses associated with station service or auxiliary loads.

Nitrous Oxide (NOx)
Nitrous Oxide is one of several non-CO2 gases that may contribute to global climate change and acid rain.

Peak Capacity
The maximum output of generating plant or plants during a specified peak-load period.

Peak Demand
The maximum demand imposed on a power system or system component during a specified time period.

Peaking Resource
A generating resource that is dispatched to meet a utilities peak load obligations. Typically, these resources are dispatched on limited basis for short durations. Peaking resources typically average an annual capacity factor of less than 20%.

Peak Power
Power generated by a utility system component that operates at a very low capacity factor, generally used to meet short-lived and variable high-demand periods.

Peak Shaving
A strategy used to reduce electricity use during times of peak demand, typically employed through demand-response programs.

Photovoltaic Solar
Solar generation that uses photovoltaic panels to convert sunlight directly to energy.

Planning Period
The future time frame for which a utility bases its integrated resource plan. For purposes of this report, the planning period is 20 years, from 2010-2030.

Plug-in Hybrids Electric Vehicles (PHEV)
Hybrid electric automobiles are vehicles powered by batteries that are recharged with a charging station which draws its supply from an electric utility distribution system.

Portfolio
A set of power supply resources currently or potentially available to a utility. This is used in the IRP to mean alternative sets of resources that could be added to existing resources to meet expected future needs.

Resource Adequacy
A measure defining when a utility has sufficient resources to meet customer needs under a range of conditions that affect supply and demand for electricity.

Resource Mix
The different types of resources that contribute to a utility's ability to generate power to meet its load obligations.

Renewable Resource
A resource whose energy source is not permanently used up in generating electricity. A resource that uses solar, wind, hydro, geothermal, biomass, or similar sources of energy to either generate electric power or reduce the customer electric power requirements.

Reserve Requirement
The requirement that a utility maintains firm capacity at its disposal that exceeds its expected peak demand by a certain percentage.

Shaping
Configuring a resource portfolio so power generation capability and delivery of purchased power closely matches changes in demand over time.

Solar
Electric generation fueled directly by sunlight.

Solar Hybrid
A thermal solar facility with the ability to supplement heat from the sun with heat derived by burning natural gas.

Sulfur Dioxide (SO2)
A common byproduct of the burning of coal that has been linked to acid rain in the atmosphere.

Sun Splash
Sun Splash occurs in a photo voltaic array when clouds gather around the sun to form a reflective frame, thus temporarily increasing the amount of light energy striking the array and therefore causing a momentary increase in the array's output.

Surplus Energy
Energy that is not needed to meet a utility or marketing agency's commitments to supply firm or non-firm power.

Total Transfer Capacity (TTC)
Total Transfer Capacity refers to the capacity of a transmission line.

Transmission System
An interconnected network of electric transmission lines and associated equipment for the movement or transfer of high-voltage electricity between points of supply and points at which it is transferred for delivery to consumers or to other utilities.

Wheeling
The use of a utility's transmission facilities to transmit power to and/or from another utility system.

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