WESTERN RESOURCE
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A SUSTAINABLE PATH

Meeting Nevada's Water and Energy Demands

WESTERN RESOURCE
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Western Resource Advocates' mission is to protect the West's land, air, and water.

Our lawyers, scientists, and economists:
1) advance clean energy to reduce pollution and global climate change
2) promote urban water conservation and river restoration
3) defend special public lands from energy development and unauthorized off-road vehicle travel.

We collaborate with other conservation groups, hunters and fishermen, ranchers, American Indians, and others to ensure a sustainable future for the West.

This report is one of a series prepared by Western Resource Advocates on the competing water demands of growing cities, agriculture, electricity generation, and the environment. It was funded by grants from the National Renewable Energy Lab and the Robert Z. Hawkins Foundation.

The report was prepared by Stacy Tellinghuisen with assistance from David Berry, Bart Miller, Taryn Hutchins-Cabibi, Charles Benjamin, and Nicole Theerasatiankul (Western Resource Advocates).

A SUSTAINABLE PATH: *Meeting Nevada's Water and Energy Demands*

EXECUTIVE SUMMARY

Located almost entirely within the Great Basin Desert, Nevada receives, on average, only nine inches of precipitation annually, making it the driest state in the nation.[1] It is also the nation's fastest growing state, with a population expected to grow by 53% between 2000 and 2015.[2] Likewise, the state's demand for electricity continues to rise. Similar trends are occurring throughout the southwestern U.S., straining existing water resources in an extremely arid region.

Nevada's growing municipalities, agricultural sector, and thermoelectric power plants rely heavily on both surface and groundwater resources: the state's surface water resources are already entirely appropriated and, in most parts of the state, additional groundwater rights are limited.[3,4] Identifying future water needs and opportunities for meeting future demand, therefore, is essential.

In this report, Western Resource Advocates assesses future water demands for three sectors — municipal, agricultural, and electricity generation — under a *Business as Usual (BAU)* trajectory and several *Alternate* scenarios that demonstrate the positive impact of water use efficiency, energy efficiency, and renewable sources of energy on Nevada's future water demand. For each sector, we develop several scenarios; in the conclusion, we merge the scenarios in order to provide a broader perspective on Nevada's future water demands.

Under a *Business as Usual* scenario, water demand for municipalities and electricity generation increases markedly by 2030: municipalities and power plants will consume an additional 255,000 acre-feet per year (AFY), a 65% increase over water use in 2006. Increased evaporation driven by higher average temperatures results in additional water losses of 73,000 AFY. This assumes that the two proposed merchant power plants – Toquop and White Pine – are not constructed; if they are, water demands in 2030 will be more substantial.

Fortunately, Nevada's municipalities have substantial room for improving water use efficiency, and Nevada has a wealth of renewable energy resources, many of which consume significantly less water than conventional, fossil fuel-based power plants. Meeting future demands, clearly, will require efficiency measures in all sectors. The following sections provide a summary of these measures and their benefits.

MUNICIPALITIES

The majority of Nevada's population resides in the Las Vegas and Reno/Sparks regions, and receives water from the Southern Nevada Water Authority (SNWA) and Truckee Meadows Water Authority (TMWA), respectively. Although SNWA and TMWA project moderate increases in municipal water use efficiency under *Business as Usual*, their combined demand will grow by 229,000 AFY (61%) by 2030.

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1 Nevada Department of Conservation and Natural Resources, Division of Water Resources. 2008. Nevada Water Facts: Climate and Precipitation. http://water.nv.gov/WaterPlanning/wat-fact/precip.cfm (accessed March 28, 2008).

2 U.S. Census Bureau. 2004. State Interim Population Estimates by Age and Sex: 2004 – 2030. http://www.census.gov/population/www/projections/projectionsagesex.html.

3 Nevada Department of Conservation and Natural Resources. 2008. Nevada Natural Resources Status Report: Water Resources & Supply. http://dcnr.nv.gov/nrp01/env02.htm (accessed March 28, 2008).

4 Nevada Department of Conservation and Natural Resources, Division of Water Resources. 2008. Nevada Water Facts: Introduction to our Ground-water Resources. http://water.nv.gov/WaterPlanning/wat-fact/ground.cfm (accessed March 28, 2008).

Single-family residential (SFR) homes in the Las Vegas and Reno/Sparks regions use significantly more water per person per day than residents in many other large western cities. Our *SFR Efficiency* scenario demonstrates the potential municipal water savings in 2030 if Nevada's SFR sector reduces indoor per capita water use to 45 gallons per capita per day — the current estimate of efficient indoor water use. We assume similar efficiency improvements could be made in outdoor water use. As a result, Nevada's municipalities consume 520,000 AFY in 2030, 86,000 AFY less than that projected under *BAU*.

Although water use in the commercial and industrial sectors is more difficult to compare across cities, we assume these sectors could achieve water use efficiency savings comparable to those made in the SFR sector. In our *System-wide Efficiency* scenario, we illustrate the statewide savings available if municipalities reduce system-wide water use by 35%. These efficiency improvements translate to statewide savings of 157,000 AFY, compared to *BAU* in 2030 *(Figure 1)*.

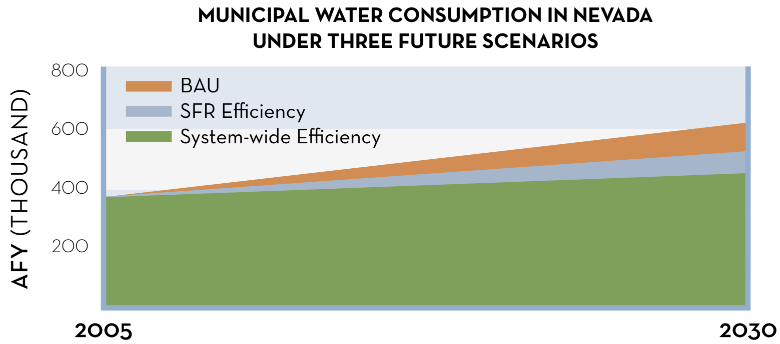


Figure 1 (and 11). *Projected municipal water consumption in Nevada under three future scenarios.*

AGRICULTURAL SECTOR

Historically, municipalities and thermoelectric power plants have obtained water rights from agricultural communities; as a result, land and water use in agriculture has declined. Under *Business as Usual*, we project this trend to continue, with agricultural land shrinking by 10% between 2005 and 2030. Most agricultural land conversions have occurred near Reno and satisfy the urban area's growing demand for land and water. Although interest in ethanol production has risen in recent years, we do not expect to see widespread corn production or increased water demands for irrigation. If cellulosic ethanol production becomes viable, however, this may change.

Climate change will likely have the most substantial impacts on the agricultural sector. Throughout the southwestern U.S., average temperatures are projected to rise, increasing evapotranspiration by 1.24 inches per year by the period 2021-2040. In our *Climate Change* scenario, we project irrigated agriculture statewide will consume an additional 73,000 AFY in 2030 *(Figure 2)*. The increased average temperatures compare to temperatures seen during the Dust Bowl years and the drought of the 1950s; seasonal and decadal drought cycles (such as from La Niña events) would exacerbate these conditions.

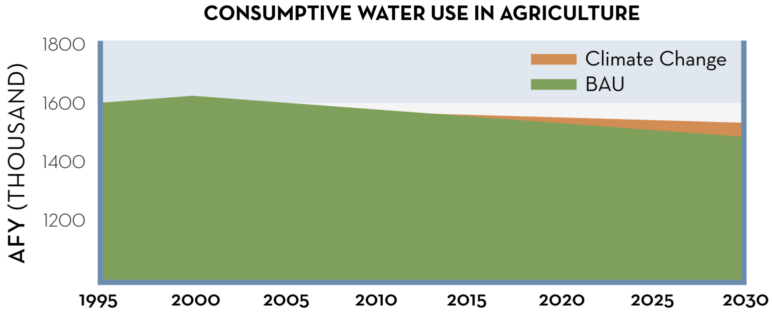


Figure 2 (and 13). *Projected future water consumption in agriculture under* ***Business as Usual*** *and elevated rates of evapotranspiration, driven by climate change.*

ELECTRICITY GENERATION

In 2006, Nevada power plants generated over 32,000,000 megawatt-hours (MWh) of electricity and consumed approximately 16,000 AF of water. To meet growing electricity demand in Nevada and the Southwest, Nevada's utilities and independent power producers propose constructing 3,840 MW of new, coal-fired generating capacity by 2015. The three proposed plants — the Ely Energy Center (EEC), Toquop Energy Project, and the White Pine Energy Station — would generate 29,000,000 MWh annually, almost doubling the state's existing generation. Given a lack of demand for electricity from all three plants and recent national trends, it is not clear that all three plants will be constructed as planned. Therefore, we have developed three *Business as Usual* scenarios:

1. *BAU 1:* The Ely Energy Center plant is constructed
2. *BAU 2:* The EEC and Toquop Energy Project are constructed
3. *BAU 3:* The EEC, Toquop Energy Project, and White Pine Energy Station are constructed

We then present three *Alternate* scenarios, which mirror the *BAU* scenarios but replace new coal-fired capacity with renewable sources of energy, energy efficiency, combined heat and power, and natural gas capacity. In 2015, the three *Alternate* scenarios all demand less water than their *BAU* counterparts.

Projecting the needed capacity and likely energy mix beyond 2015 has inherent challenges and uncertainties. However, by relying on the utilities' integrated resource plans and a series of assumptions, we extend the *BAU 1* and *Alternate 1* scenarios to assess water requirements for electricity generation in 2030. In both scenarios, we assume regulations require carbon capture and storage facilities in baseload coal and natural gas plants constructed after 2015. Our *Alternate 2030* scenario represents a conservative approach: we replace Phase II of the EEC with renewable resources and energy efficiency, but do not replace other planned natural gas facilities *(Figure 3)*. Given these assumptions, the water savings provided by an *Alternate* approach become more pronounced in 2030 *(Figure 4)*.

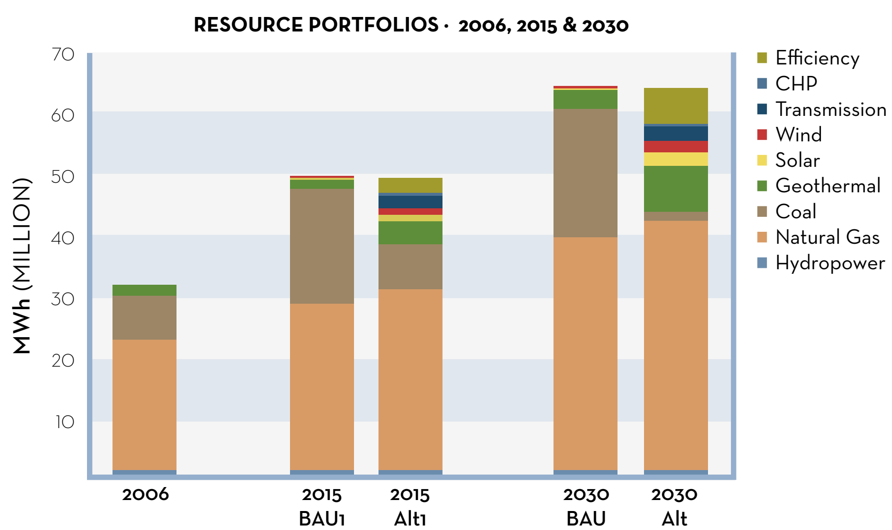


Figure 3 (and 20). *Resource portfolios under Business as Usual and Alternate scenarios. These scenarios do not include the proposed Toquop and White Pine plants.*

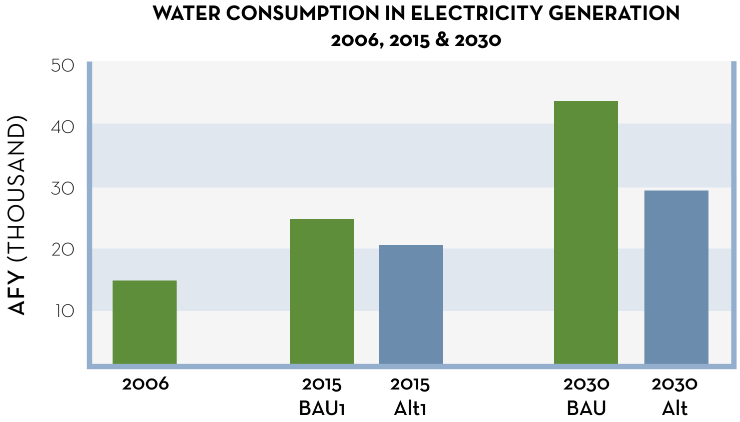
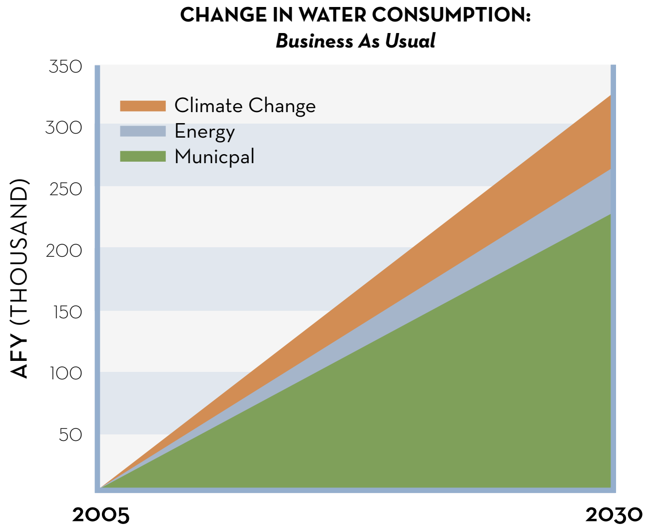


Figure 4 (and 21). *Water consumed for electricity production in Nevada under Business as Usual and Alternate scenarios; these scenarios do not include the proposed Toquop and White Pine plants.*

CONCLUSION

Given Nevada's limited water resources, the substantial growth in water demand for municipalities and thermoelectric generation under *Business as Usual* will have notable consequences in two areas: agricultural and environmental needs. Statewide, growing municipal water needs have the most significant impact on water resources. Locally, however, the water demands of major thermoelectric power plants may be substantial. In our *Alternate* scenarios, we demonstrate that municipal conservation, energy efficiency, and renewable sources of energy enable Nevada to meet almost all of its future water demands with supplies available today *(Figure 5)*. While these measures require up-front investment in efficiency and conservation measures, they delay or eliminate the need for obtaining new — often expensive — water supplies.



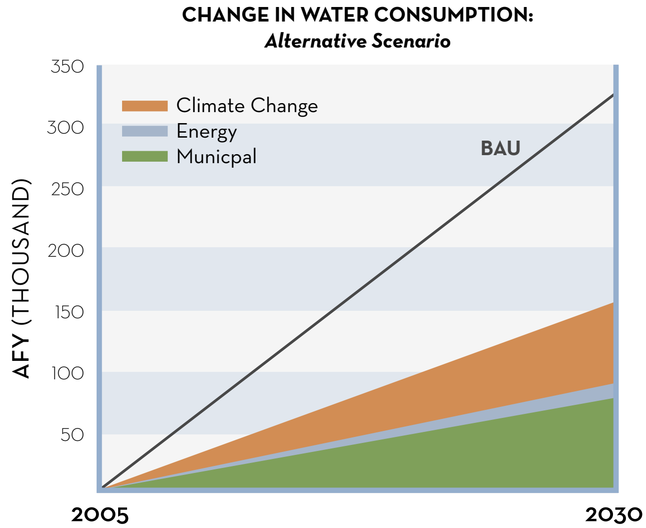


Figure 5 (and 24). *Projected change in water consumption for municipalities and the electricity sector under Business as Usual conditions and an alternative approach. Most of the increased demands will be met through agricultural water transfers (not shown). The climate change estimates include increased evapotranspiration from agricultural irrigation and municipal landscape irrigation.*

INTRODUCTION

The driest state in the nation, Nevada receives, on average, only nine inches of precipitation annually.[5] In recent years, it has also become the nation's fastest growing state, with a population expected to grow by 53% between 2000 and 2015.[6] Nevada's growing municipalities, agricultural sector, and electricity sector rely heavily on both surface and groundwater resources: the state's surface water resources are already entirely appropriated,[7,8] and in most parts of the state, additional groundwater rights are limited.

In future years, population growth and electricity demands will likely lead to rising water demands. Historically, municipalities and power producers have looked toward the agricultural sector to meet their water needs. As a result, agricultural land and water use has declined in recent years. Increased interest in ethanol production and higher crop values, however, may limit the likelihood of future agricultural transfers. Compounding these strains, increased water losses from climate change will exacerbate strains on existing supplies.

In the following sections, Western Resource Advocates (WRA) assesses future water demands for municipalities, agriculture, and electricity generation under a *Business as Usual (BAU)* trajectory. We then estimate water needs in a series of *Alternate* scenarios — relying on municipal water use efficiency, energy efficiency, and renewable sources of energy. The *Business as Usua*l and *Alternate* scenarios are developed independently for the municipal, agricultural, and electricity-generating sectors and described in each of those sections. In the conclusion, we combine the scenarios to provide a broader view of future water demands in Nevada. The scenarios developed in this report are defined briefly below, with the abbreviated names in parentheses:

MUNICIPAL WATER USE SCENARIOS

- *Business as Usual (BAU)* – water demands in 2030, assuming municipal water providers' projected population growth and conservation measures.
- *Single- Family Residential Sector Efficiency (SFR Efficiency)* – water demands in 2030, with improved water use efficiency in the single-family residential sector only.
- *System-Wide Efficiency* – water demands in 2030, assuming projected population growth and improved water use efficiency in all sectors.

AGRICULTURAL WATER USE SCENARIOS

- *Business as Usual (BAU)* – water demands in 2030, given recent and projected trends in agricultural to urban land and water conversions.
- *Climate Change*– water demands in 2030 under projected higher temperatures and rates of evapotranspiration.

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5 Nevada Department of Conservation and Natural Resources, Division of Water Resources. 2008. Nevada Water Facts: Climate and Precipitation. http://water.nv.gov/WaterPlanning/wat-fact/precip.cfm (accessed March 28, 2008).

6 U.S. Census Bureau. 2004. State Interim Population Estimates by Age and Sex: 2004 – 2030. http://www.census.gov/population/www/projections/projectionsagesex.html.

7 Nevada Department of Conservation and Natural Resources. 2008. Nevada Natural Resources Status Report: Water Resources & Supply. http://dcnr.nv.gov/nrp01/env02.htm (accessed March 28, 2008).

8 Nevada Department of Conservation and Natural Resources, Division of Water Resources. 2008. Nevada Water Facts: Introduction to our Ground-water Resources. http://water.nv.gov/WaterPlanning/wat-fact/ground.cfm (accessed March 28, 2008).

ELECTRICITY GENERATION WATER USE SCENARIOS

- *Business as Usual 1(BAU 1)* – water demands in 2015, assuming the proposed Ely Energy Center is constructed
- *Business as Usual 2 (BAU 2)* – water demands in 2015, assuming the proposed Ely Energy Center and Toquop Energy Project are constructed
- *Business as Usual 3 (BAU 3)* – water demands in 2015, assuming the proposed Ely Energy Center, Toquop Energy Project, and White Pine Energy Station are constructed
- *Alternate 1* – mirrors the *BAU 1* scenario, but replaces the proposed Ely Energy Center with alternate sources of energy (energy efficiency, renewable sources of energy, combined heat and power, and natural gas)
- *Alternate 2* – mirrors the *BAU 2* scenario, but replaces the proposed Ely Energy Center and Toquop Energy Project with alternate sources of energy
- *Alternate 3* – mirrors the *BAU 3* scenario, but replaces the proposed Ely Energy Center, Toquop Energy Project, and White Pine Energy Station with alternate sources of energy
- *Business as Usual 2030 (BAU 2030)* – water demands in 2030, based on utilities' Integrated Resource Plans (excludes Toquop and White Pine)
- *Alternate 2030* – water demands in 2030, using utilities' Integrated Resource Plans and replacing new coal-fired generation with alternate sources of energy (excludes Toquop and White Pine).

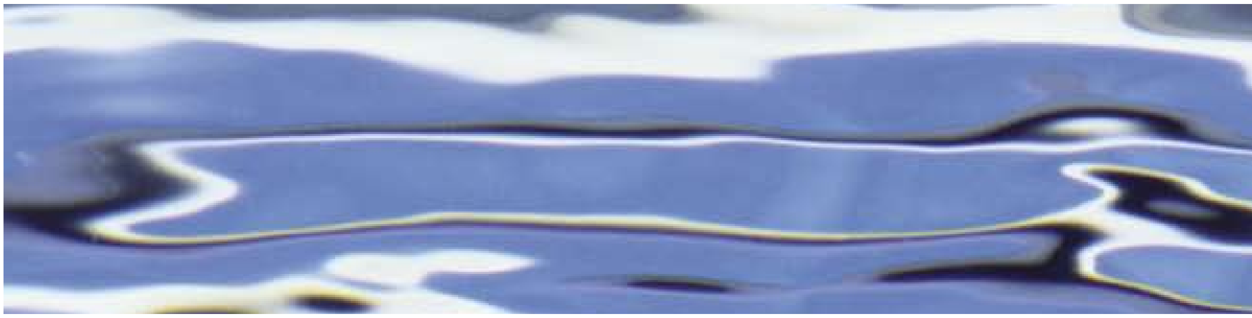
In many parts of Nevada, water is fully or over-allocated; meeting future needs, therefore, will require efforts on the part of all sectors — municipal, agricultural, and electricity generation. Although estimating future water use has inherent challenges and uncertainties, it serves as an important step in identifying the measures necessary to meet future demands. Our *Alternate* scenarios outline feasible actions for water and electric utilities that will decrease their water demand, delaying the need to obtain additional water supplies.

Other reports, including *Hidden Oasis: Water Conservation and Efficiency in Las Vegas, Smart Water,* and *Water in the Urban Southwest: An Updated Analysis of Water Use in Albuquerque, Las Vegas Valley and Tucson*, available through the Western Resource Advocates website, provide a more detailed analysis of municipal conservation measures. *The Balanced Energy Plan for the Interior West, Climate Alert: Cleaner Energy for the Southwest*[9], and reports by the Western Governors' Association[10] provide a more detailed assessment of the potential for renewable energy and energy efficiency.

9 Also available at the Western Resource Advocates website, http://www.westernresourceadvocates.org.

10 Available at http://www.westgov.org/wga_reports.htm.

MUNICIPAL WATER USE



Nevada's population is projected to grow from 2.0 million in 2000 to 3.1 million in 2015 — an increase of 53% — making it the fastest growing state in the nation. In comparison, the U.S. population as a whole is projected to grow only by 14% over the same time period.[11] Most of Nevada's population (90%) will reside in the Las Vegas Valley (Clark County) or the Washoe County region.[12]

Along with population, municipal water demands are projected to grow. Numerous factors influence municipal water use: the relative predominance of single-family residences vs. multi-family dwellings, the type of commercial and industrial operations, regional climate and weather patterns, and conservation measures implemented by the local water agency, to name a few. Because most of Nevada's population growth will occur in Clark and Washoe counties, this analysis focuses on these two regions. The Southern Nevada Water Authority (SNWA) and the Truckee Meadows Water Authority (TMWA) provide water in Clark and Washoe counties, respectively, and have generated projections for future municipal water demands. These projections, which we consider a *Business as Usual* or baseline scenario, do include some measures of conservation. With more aggressive, cost-effective conservation measures, however, these agencies can substantially reduce their future water demands.

Projecting future water use — both withdrawals and consumption — has inherent challenges and requires numerous assumptions, under *Business as Usual* and other scenarios. In the following paragraphs, we outline assumptions for each of these scenarios and describe in greater detail some of the factors affecting future municipal water use in Nevada.

POPULATION GROWTH

In recent years, Nevada's population has outpaced population growth in both the Southwest and the U.S. Most of this growth has occurred in Clark County. Although the county's rapid growth rate slowed slightly in 2004 and 2005, compared to previous years, the total population is projected to continue to increase by 80,000 to 90,000 residents annually through 2013. Beyond 2013, demographers project the annual growth rate will decline gradually as the regional economy matures, leveling out to the national annual growth rate of 1% by 2030.[13] These population projections, developed by researchers at University of Nevada at Las Vegas, compare favorably with those published by the SNWA.[14]

Although Washoe County has not experienced growth on a par with Clark County, its population growth has been significant. Between 2008 and 2013, the regional population is expected to grow by 5,000 to 5,800 residents annually (1.2 to 1.5%). Throughout this time period and beyond, the rate of growth is projected to slow.

11 U.S. Census Bureau. 2004. State Interim Population Estimates by Age and Sex: 2004 – 2030. http://www.census.gov/population/www/projections/projectionsagesex.html.

12 This estimate stems from a different publication, which projects a statewide population of 3.5 million in 2015: Evenson, B., K. Schwer, and W. Cope. 2004. Economic trends and forecasts for Nevada. Las Vegas, NM: Center for Business and Economic Research, University of Nevada. http://www.unlv.edu/centers/cdclv/healthnv/economy.html.

13 Ibid.

14 SNWA projects 3.5 million people will live in the Las Vegas Valley in 2035; this estimate is slightly lower than the population projections for Clark County from the University of Nevada, Las Vegas. Differences may stem from methodology or the slightly different geographical region considered.

Figure 6 and *Figure 7* illustrate historic and projected future population growth in the State of Nevada, Clark County, and Washoe County; *Table 1* lists the population figures used to estimate future water use.

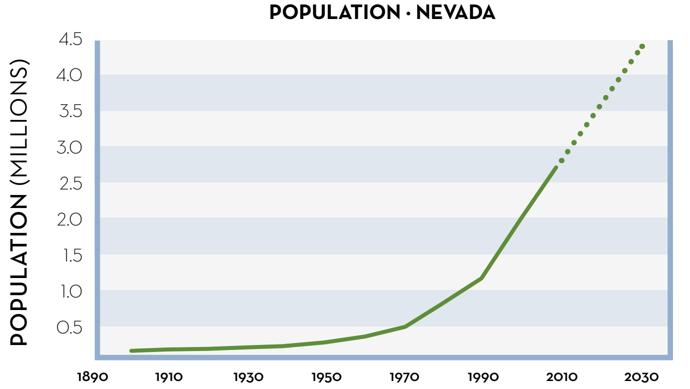


Figure 6. *Historic and projected population estimates for Nevada.*[15]

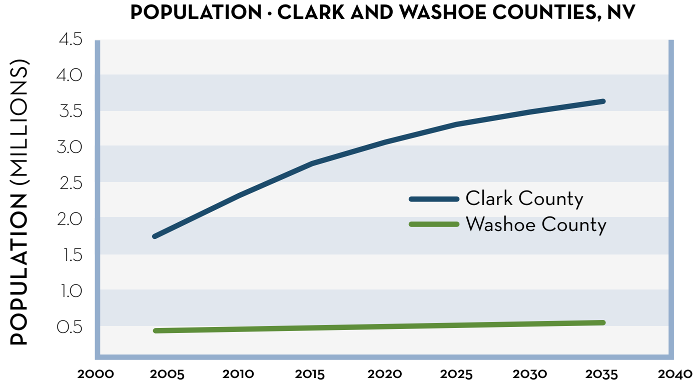


Figure 7. *Historic and projected population estimates for Clark and Washoe counties.*[16]

Table 1. *Population Estimates for Clark and Washoe Counties in 2004, 2015, and 2030.*

	2004	2015	2030
Clark County	1,747,000	2,696,600	3,468,000
Washoe County	367,900	427,400*	487,900

**This estimate is slightly lower than TMWA's population projection for Washoe County, 438,000. Of note, because of the housing boom in the early 2000s, Washoe County's population grew faster than anticipated in TMWA's 2003 Water Resources Plan.*

15 U.S. Census Bureau. 2005. *Interim Projections of the Total Population for the United States and States: April 1, 2000 to July 1, 2030.* http://www.census.gov/population/projections/SummaryTabA1.pdf and http://www.census.gov/

16 Evenson, B., K. Schwer, and W. Cope. 2004. *Economic Trends and Forecasts for Nevada*. Las Vegas, NM: Center for Business and Economic Research, University of Nevada. http://www.unlv.edu/centers/cdclv/healthnv/economy.html.

ECONOMY

Population and economic growth are closely related — in recent years, population growth has driven many sectors of Nevada's economy. Because most growth has occurred in urban areas, it has been accompanied by growth in the construction, real estate, rental, and leasing industries. This growth is likely to continue in future years, although as Nevada's economy matures, the pace will likely slow.[17]

Nevada's economy is subject to numerous outside forces, particularly in certain industries. For example, changes in the value of mined goods directly impact Nevada's mining industry, and legalization of casinos in neighboring states directly impacts Nevada's gaming industry. In addition, downturns in the national economy influence Nevada's overall economy. While these influences may be important, they are challenging to project over long time frames, and therefore are excluded from this analysis.

Although growth is the dominant economic trend, projections for subsectors of the economy may have important implications for water resources. Economic data from recent years[18] do not exhibit any notable trends or shifts in major industries. Therefore, under a *BAU* model, we do not project changing rates of water use for the commercial and industrial sectors. We assume the region's overall commercial and industrial growth mirrors population growth, and that system-wide per capita estimates of water use adequately represent both commercial and residential use.

One sector has exhibited a notable decline in recent years, with important implications for water use: agriculture. The State Water Plan, completed in 1999, projected increasing urbanization in agricultural lands adjacent to municipal areas, particularly in Washoe County and Carson City. (Near Clark County, less agricultural land area is available to convert, though the rate of land conversion is very high.) The changing land use will be accompanied by water rights transfers and decreases in irrigated acreage. Historically, the area of irrigated agriculture has varied substantially on an annual basis. Barring major changes in the economic drivers influencing agriculture (i.e., municipal growth and crop prices), however, irrigated acreage is likely to continue to decline in future years. The agricultural sector is discussed in greater detail in later sections.

SCENARIOS AND WATER USE: 2030

As Nevada's urban centers continue to grow, so will their thirst for water. Water utilities have two clear options for meeting future demand: increasing supplies or reducing demand through conservation and efficiency. We project Nevada's municipal water needs in 2030 under three scenarios:

- *Business as Usual (BAU)*
- *Single-Family Residential (SFR) Efficiency* - increased water use efficiency in the single-family residential sector
- *System-wide Efficiency* - increased water use efficiency across all municipal sectors

All three scenarios rely on the population and economic projections described above and focus on the greater Las Vegas and Reno metropolitan regions. For each scenario, estimates of both withdrawals and consumption are provided.

The *BAU* scenario incorporates moderate increases in water use efficiency, as projected by SNWA and TMWA. SNWA projects system-wide per capita water withdrawals to decline from 264 gallons per day (GPCD) in 2004 to 245 GPCD in 2035. We assume these efficiency gains will be made gradually over that time period *(Figure 8)*. Of the water withdrawn, 60% was consumed in 2004. This proportion may change, depending on whether the agency's efficiency measures focus on indoor appliances or outdoor landscaping (see sidebar). We do not, however, have sufficient data to predict the magnitude or direction of this change. The TMWA estimates its per capita water withdrawals will decline from 270 GPCD in 2005 to 250 GPCD in 2010 as a result of continued installation of water meters on unmetered properties. TMWA does not project additional conservation savings beyond 2010 *(Figure 9)* and does not project changes in the agency's rate of consumptive use (50%).

17 Evenson, B., K. Schwer, and W. Cope. 2004. *Economic Trends and Forecasts for Nevada*. Las Vegas, NM: Center for Business and Economic Research, University of Nevada. http://www.unlv.edu/centers/cdclv/healthnv/economy.html.

18 1997– 2006 for the State of Nevada, and 2001–2004 for the greater Las Vegas and Reno metropolitan areas.

The *SFR Efficiency* scenario focuses on improved water use efficiency in the single-family residential sector. Studies estimated that in 2001, efficient, indoor SFR water use could be as low as 45 GPCD. This estimate reflects a household's use of efficient indoor appliances and fixtures, plus leak detection programs; it does not include behavioral changes.

In comparison, in 2005, residents of Las Vegas used 65 GPCD indoors, while residents of Reno used approximately 83 GPCD indoors. In the *SFR Efficiency* scenario, we assume SFR indoor water use declines from current estimates to 45 GPCD. In Las Vegas, this equates to a 31% reduction in indoor water use; in Reno, a 46% reduction. We assume comparable reductions are made in SFR outdoor water use in each service area.

It is important to note that 45 GPCD is a current estimate of efficient indoor residential water use. Our scenario allows 22 years to reach this goal, and advances in technology will almost certainly reduce this estimate further. We also assume the consumptive use rate does not change between 2005 and 2030; if water agencies focus more attention on outdoor efficiency measures, consumptive use may be lower than our projections.

INDOOR VS. OUTDOOR EFFICIENCY

Most outdoor water use, for lawns and gardens, is consumptive. Converting traditional turf grass landscapes to drought-tolerant or water-efficient plants, therefore, reduces the amount of water consumed. Conversely, most indoor water use is not consumptive, and investments in water-efficient indoor appliances reduce overall withdrawals. If efficiency measures focus on indoor use only, the overall rate of consumption is likely to increase.

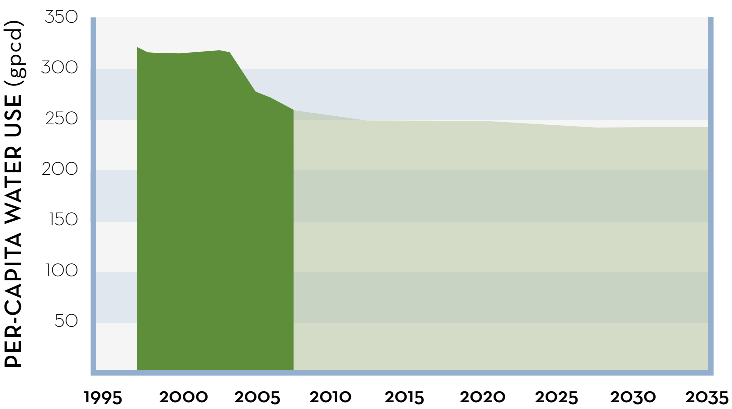
SNWA's allocation from the Colorado River, its primary water supply, is for consumptive use; it receives return flow credits for treated wastewater discharged into Lake Mead. Historically, SNWA has focused on outdoor conservation, e.g., converting turf grass to water-efficient landscapes and offering rebates for swimming pool covers. *

* The Pacific Institute and Western Resource Advocates. 2007. *Hidden Oasis: Water Conservation and Efficiency in Las Vegas*. Boulder, CO

In our *System-wide Efficiency* scenario, we build on the *SFR Efficiency* scenario, demonstrating the impacts of water use efficiency measures in the commercial, industrial, and multi-family residential sectors. Water use efficiency measures in these sectors are more challenging to compare across cities. For example, appropriate measures for one city may differ from those for a neighboring city, depending on the local economy. The *System-wide Efficiency* scenario assumes the commercial, industrial, and multi-family residential sectors can make water use efficiency improvements comparable to those made in the SFR sector. Specifically, the *System-wide Efficiency* scenario reflects a 35% system-wide reduction in withdrawals in both the SNWA and TMWA service areas. For comparison, estimates of potential savings in the commercial and industrial sector range from 15 to 50%, with savings of 15 to 35% typical.[19] We assume the system-wide consumptive use rates remain the same as in the *SFR Efficiency* scenario.

Under *Business as Usual*, demand increases markedly, driven by population growth. Municipal water withdrawals and consumption increase under both *Efficiency* scenarios, but less substantially. If Nevada's municipalities improve the effectiveness of conservation and efficiency measures, we project municipal consumption to grow by only 71,700 AF, compared to a projected growth of 229,000 AF under *BAU*. While the *Efficiency* scenarios require SNWA and TMWA to make up-front investments in efficiency measures, these measures offset the need to obtain future water supplies. Furthermore, by reducing the overall water demand, the agencies conserve the energy and resources needed to provide potable water and treat wastewater. *Table 2*, *Figure 10*, and *Figure 11* present the results of these three scenarios.

SNWA'S HISTORIC AND PROJECTED PER CAPITA WATER DEMAND ESTIMATES



Source: Historic (dark green) and projected estimates from K. Brothers, SNWA, personal communication, October, 9, 2007

Figure 8. *Historic and projected per capita water use in the SNWA service area.*

19 DeOreo, William, Peter Mayer, Benedykt Dziegielewski, Jack C. Kiefer, et al. 2000. *Commercial and Institutional End Uses of Water*. Littleton, CO: American Water Works Association Research Foundation.

20 Southern Nevada Water Authority, cited in *Hidden Oasis*, The Pacific Institute and Western Resource Advocates, 2007, pp. 34.

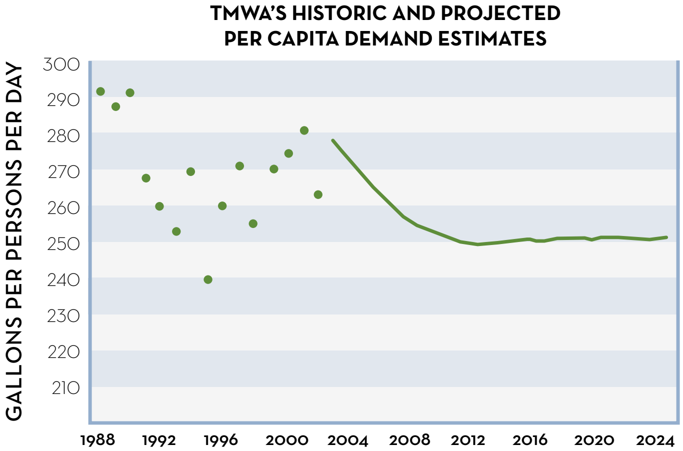


Figure 9. *Historic and projected water use in the TMWA service area.*[21] *Continued installation of water meters is expected to result in the projected per capita decreases.*

Table 2. *Historic and projected water use for SNWA and TMWA under three future scenarios.*

Year/ scenario	Agency	Water use per capita (GPCD)	% Consumed	Withdrawals (AFY)	Consumption (AFY)
2005	SNWA*	264	60%	600,000	333,000
	TMWA	270	50%	87,900	43,950
	Total			**687,900**	**376,950**
2030 BAU	SNWA	245†	60%‡	879,000	527,400
	TMWA	250§	50%	157,200	78,600
	Total			**1,036,200**	**606,000**
2030 SFR Efficiency	SNWA	213	60%	765,000	459,000
	TMWA	194	50%	122,200	61,100
	Total			**887,200**	**520,100**
2030 System-wide Efficiency	SNWA	183	60%	655,700	393,400
	TMWA	176	50%	110,300	55,100
	Total			**766,100**	**448,500**

*Total use provided by SNWA, not derived.

† Estimate is based on efficiency gains in 2035, as projected by SNWA. Analysis assumes that these efficiency gains are achieved gradually over the 30-year time period.

‡ No data was available for projected changes in consumption. The rate of consumptive use may change, depending on whether SNWA's efficiency efforts are in indoor or outdoor (landscaping) use.

§ TMWA estimates its per capita water use will decline to 250 GPCD by 2010, as a result of installing meters on customers' properties. TMWA does not project additional improvements in efficiency.

The expected impacts of climate change serve as an added impetus to improve municipal water use efficiency. Researchers project average rates of evapotranspiration to increase across the Southwest (described in greater detail in the following section, "Agricultural Water Use"). In municipalities, higher temperatures and rates of evapotranspiration may increase the amount of water used to irrigate lawns. According to SNWA, a square foot of turf grass uses 73 gallons of water annually.[22] In other words, turf grass is covered in water to a depth of 117 inches of water each year. Climate change is projected to increase average evapotranspiration by 1.24 inches per year by 2030.[23] This translates to additional evaporative losses of 1.1%, or 6,400 AFY in 2030 under *Business as Usual*. Under the *System-wide Efficiency* scenario, consumptive municipal use increases by 4,800 AFY *(Table 3)*.

21 In 2000, approximately 74% of Washoe County's population resided within TMWA's retail service area. An additional 9.8% resided within TMWA's wholesale service area.

22 The Pacific Institute and Western Resource Advocates. 2007. *Hidden Oasis: Water Conservation and Efficiency in Las Vegas*. Boulder, CO. pp. 39.

23 See the "Agricultural Water Use" section for more background information and detailed calculations.

CROSS-CITY COMPARISONS

Comparing water use across cities is a useful way to estimate the effectiveness of conservation and efficiency measures. Water use between cities varies, depending on local weather and other factors. The following table illustrates SFR water use in the SNWA region, TMWA region, Tucson, and Albuquerque. Despite its hot, arid climate, Tucson residents use substantially less water than residents of Las Vegas or Reno. This stems primarily from Tucson's aggressive water rate structure, which effectively encourages conservation. Tucson's climate is not a perfect match for Las Vegas or Reno. Tucson receives more precipitation annually than Las Vegas and has significantly higher annual and summer temperatures than Reno, but it serves as a useful benchmark.

	Average temperature (°F)	Average high temperature (°F)	Average summer* high temperature (°F)	Average annual precipitation (in.)	SFR per capita water use (GPCD)	SFR per capita indoor water use (GPCD)
Albuquerque, NM	57	70	90	8.5	110	68
Las Vegas, NV	67	80	102	4.1	165†	65
Reno, NV	50	67	87	7.3	170‡	83
Tucson, AZ	69	82	99	11.7	114	57

* Summer temperatures are based on average highs in June, July, and August.
† Water use data is for the Southern Nevada Water Authority service area.
‡ Water use data is for the Truckee Meadows Water Authority service area.
Source: www.weatherbase.com, as cited by The Pacific Institute and Western Resource Advocates in *Hidden Oasis: Water Conservation and Efficiency in Las Vegas*. 2007. Boulder, CO.

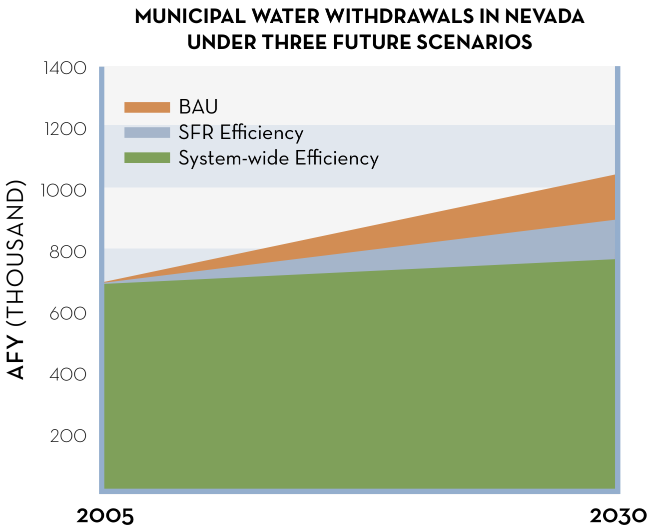


Figure 10. *Future municipal water withdrawals under the Business as Usual, SFR Efficiency, and System-wide Efficiency scenarios.*

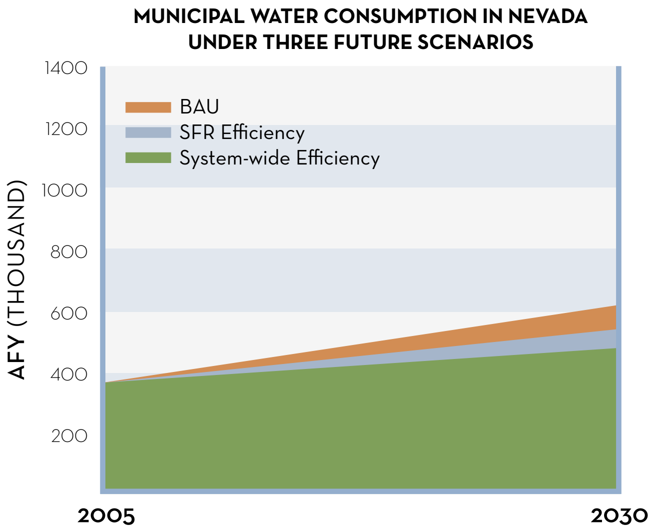


Figure 11 (and 1). *Future municipal water consumption in Nevada under the BAU, SFR Efficiency, and System-wide Efficiency scenarios.*

Table 3. *Withdrawals and consumption in 2030 under three future scenarios and the projected impacts of climate change.*

Scenario	Withdrawals (AFY)	Consumption (AFY)	Additional consumption, climate change (AFY)
BAU	1,036,000	606,000	6,400
SFR Efficiency	887,300	520,100	5,500
System-wide Efficiency	766,100	448,600	4,800

SUMMARY

As Nevada's population grows, municipal water demands are likely to keep pace. In both of Nevada's major urban areas, water supplies are limited. In Southern Nevada, SNWA already uses the majority of its Colorado River allotment, and additional groundwater supplies will be expensive to develop. In the Reno region, new urban developments must acquire water rights from existing landowners. Fortunately, both utilities have significant opportunities to improve their water use efficiency, in both indoor and outdoor applications. The *System-wide Efficiency* scenario provides the two utilities substantial water savings — reducing consumptive use by over 157,400 AF in 2030 relative to *Business as Usual*.

By investing in efficiency measures that are economically viable today, the utilities can significantly delay or eliminate the need to pursue additional supplies. The *System-wide Efficiency* scenario reflects realistic and attainable conservation goals. More aggressive demand management strategies could provide additional savings, further reducing municipal demand for Nevada's limited water resources.

Furthermore, conservation and efficiency measures offer significant cost benefits. In the Las Vegas region, the cost of conservation measures ranges from $163/AF for indoor water-efficient technology rebates[24], to $467/AF for outdoor landscape conversion rebates.[25] In comparison, SNWA's proposed pipeline to groundwater basins in White Pine and Lincoln counties is expected to cost $1,163 to $1,320/AF.[26] Conservation measures offer additional, unquantified benefits by reducing the energy used to convey water, the chemicals used to treat water and wastewater, and reliance on imported water supplies.

24 Based on a water-efficient technology device lifetime of five years. The actual lifetime may be longer, reducing the cost per AF. Given a five-year lifetime, the cost over 25 years would be $815/AF.

25 This cost includes a $2/square foot rebate provided to customers. Landscape rebates are projected to have a lifetime of 25 years.

26 The Pacific Institute and Western Resource Advocates. *2007. Hidden Oasis: Water Conservation and Efficiency in Las Vegas.* Boulder, CO. This estimate includes the capital (construction) costs, but excludes operations and maintenance. The lifetime of major water supply projects would be greater than 25 years.

AGRICULTURAL WATER USE

In recent years, growing municipalities, thermoelectric power plants, and other industries have looked toward agriculture and untapped groundwater basins to meet their water needs. In the future, the municipal and industrial sectors, with their willingness to pay high prices for water supplies, will continue to pressure agricultural communities for water transfers. At the same time, the ethanol boom has renewed interest in growing both corn and other feedstocks.[27]

In the following sections, we consider three factors in assessing future water demands for Nevada's agricultural sector:

- The potential for ethanol production in Nevada.
- Legal limitations of water use, given Nevada's water rights system.
- The impacts of climate change on water use.

Given these factors, we project water demands in Nevada in 2030 under two scenarios: *Business as Usual* and *Climate Change*, which shows increased water needs stemming from changes in temperatures, precipitation, and evapotranspiration. Of note, both scenarios reflect the continued conversion of agricultural water rights to municipal and industrial uses. This has important cultural and socioeconomic implications in the State of Nevada, particularly in rural communities.

POTENTIAL ETHANOL PRODUCTION

In many states, the ethanol boom has increased the value of crops and cropland, leading some farmers to increase production on marginal lands, alter traditional crop rotations, and increase use of pesticides or fertilizers. Traditionally, ethanol production in the U.S. has used corn as a feedstock. The viability and impacts of ethanol production depend on economic and technological factors, both of which may change in future years.

Currently, ethanol production in Nevada is not economically competitive. The cost of ethanol production includes growing the feedstocks (which requires water, energy, and pesticides or fertilizers), transporting the feedstocks to the processing facility, converting the feedstocks to liquid ethanol, and delivering the ethanol to fueling stations. The value of producing corn must compete with other crops. At present, most farmers grow alfalfa, a high-quality, high-value forage for cattle; few farmers produce corn. Most corn is grown as silage, and both silage corn and alfalfa fetch a better price than corn for ethanol.[28]

Furthermore, because of the cost of transporting large volumes of feedstocks to processing plants, proximity to feedstocks is a top priority in siting ethanol plants.[29,30] As no processing facilities exist in Nevada, corn producers would have to ship their wares to processing facilities in California or Idaho, putting them at a competitive disadvantage with local growers in those states.

27 Traditionally, corn and sugarcane (in more tropical regions) have been used to produce ethanol. Currently, however, research is underway to determine the viability of converting cellulosic feedstocks such as grasses, crop residues such as corn stalks, poplar trees, and wood wastes to ethanol.

28 Jay Davidson. University of Nevada at Reno. Personal communication. January 9, 2008.

29 Bryan and Bryan, Inc. 1999. Kansas Ethanol Plant Feasibility Study. http://kdoch.state.ks.us/KDOCHdocs/AG/Kansas_Ethanol_Plant_Template.doc.

30 Recently, ethanol plants have also been sited near markets for their waste products: dairy and feedlot operations. See Roberts, Martha G., Timothy D. Male, and Theodore P. Toombs. 2007. *Potential Impacts of Biofuels Expansion on Natural Resources: A Case Study of the Ogallala Aquifer Region.* New York: Environmental Defense.

WATER USE IN ETHANOL PRODUCTION FACILITIES

This analysis focuses primarily on water use in agricultural production, but processing facilities also have a significant local impact on water resources. A typical corn ethanol facility uses 3.0 to 6.0 gallons of water per gallon of ethanol produced (average, 4.2 gallons in 2005).* Depending on the facility, this estimate may be in addition to any water used off-site to meet the processing facility's substantial electricity demands.†

As conversion processes have improved, facilities' water use has declined.‡ Cellulosic processing plants, though still in the demonstration phase, are projected to use less water; a pilot plant in Georgia that will convert wood waste to ethanol estimates it will use 1.2 gallons of water for every gallon of ethanol produced.§ This facility relies on electricity from the grid. The electricity generation would require an additional 0.7 to 1.9 gallons of water per gallon of ethanol produced.** Thus, although this analysis does not incorporate water demands for ethanol processing plants – and to generate the power used by ethanol plants – their water use is not inconsequential.

* Keeney, Dennis, and Mark Muller. 2006. Water Use by Ethanol Plants: Potential Challenges. Minneapolis, MN: Institute for Agriculture and Trade Policy. http://www.iatp.org/iatp/publications.cfm?accountID=258&refID=89449.

† Many ethanol facilities generate their electricity on-site, using crop residues. Others rely on the grid for their electricity.

‡ Keeney and Muller. 2006.

§ Range Fuels, Inc. 2007. Construction and Operation of a Proposed Cellulosic Ethanol Plant, Range Fuels, Inc. Treutlin County, Georgia. Final Environmental Assessment, prepared for U.S. Department of Energy, DOE/EA 1597. http://www.eere.energy.gov/golden/PDFs/ReadingRoom/NEPA/Final_Range_Fuels_EA_10122007.pdf.

** The production facility's environmental impact report estimates an annual electricity requirement of 291,000 MWh (the equivalent of a 40-MW coal plant operating at 85% capacity). Georgia's energy sources are primarily coal and nuclear thermoelectric plants. This calculation assumes typical cooling water requirements of 240 to 640 gallons/MWh for a steam plant with a wet recirculating cooling system. Data sources: Range Fuels' 2007 report plus Clean Air Task Force and the Land and Water Fund of the Rockies. 2003. The Last Straw: Water Use by Power Plants in the Arid West. http://www.catf.us/publications/reports/The_Last_Straw.pdf.

As conversion technologies improve, cellulosic ethanol production may have greater economic viability in Nevada than corn-based ethanol. Researchers at the University of Reno Cooperative Extension are investigating poplar trees for ethanol, and trial plots in other parts of the country have shown positive potential for switchgrass. These crops, however, still must compete with alfalfa for profit margins.

Converting agricultural lands in production to corn or switchgrass may have limited effects on existing water supplies. Corn requires slightly less water than alfalfa, and switchgrass (if irrigated) requires a similar amount of water. A newly-developed crop, tef, produces forage similar to alfalfa and requires approximately half the water of alfalfa. If it becomes a viable feedstock for cellulosic ethanol, its production may have positive overall impacts on water use in agriculture.

Although the conversion of existing lands to ethanol production seems unlikely, marginal or unfarmed lands may be converted to agricultural production. In parts of the state, water is not yet fully allocated; new agricultural production in these regions would directly impact existing water resources. Furthermore, corn requires more fertilizer and pesticide than many crops, and corn production induces higher rates of soil erosion than native or cultivated grasses. Thus corn production, even if on a limited scale, may have notable localized impacts on water quality and availability. Based on the economic factors outlined above, however, we expect new agricultural production to be very limited. Therefore, our scenarios do not reflect additional water use (withdrawals or consumption) for corn or cellulosic ethanol production.

LEGAL LIMITATIONS OF NEVADA'S WATER RIGHTS SYSTEM

The system for allocating water rights in the western U.S. directly impacts patterns of agricultural production. In brief, most property in Nevada is annually allocated 3.5 to 4.5 AF of water per acre of land, if available water supplies exist. To prove "beneficial use," most farmers apply their full allotment every year; furthermore, water rights cannot be separated from the land. In most parts of Nevada, water limits crop production, and a farmer could not legally fallow one field and double water use on an adjacent field. Nevada farmers would have a disadvantage compared to midwestern farmers with more substantial water supplies. The water rights system further limits farmers' likelihood of growing corn for ethanol.

CLIMATE CHANGE'S IMPACTS ON WATER RESOURCES

In recent years, scientists have reached a resounding consensus on the causes and likely effects of global climate change. Projecting the direct and indirect impacts of climate change on a regional scale still has many uncertainties and challenges. Determining which greenhouse gas emissions scenario the world will follow — a political question — presents the biggest uncertainties. Other challenges lie in downscaling climate projections from global to regional models. For example, globally higher temperatures will intensify the water cycle, resulting in higher rates of evaporation and precipitation. Regionally, however, the impacts of climate change on precipitation are more variable, particularly in coastal and mountainous regions — which describes most of the western U.S.[31]

Despite these uncertainties, some of the most substantial impacts of climate change in the western U.S. are likely to be on water resources, through changes in temperature, precipitation, and evapotranspiration. Higher temperatures lead to higher rates of evaporation from both reservoir surfaces and plants. Higher winter and spring temperatures will result in more winter precipitation falling as rain and earlier snowmelt. This is particularly important in the West, where snowpack represents an important storage reservoir, melting at the time when it is most valuable to farmers.

In a recent comprehensive assessment, researchers found that 46 out of 49 global circulation model simulations[32] project a more arid southwestern U.S. in future years *(Figure 12)* — with the droughts of the past becoming the norm. Relative to the period 1950–2000, the annual difference between precipitation and evaporation is projected be 1.24 inches higher in the period 2021–2040.[33] This difference compares to changes in precipitation seen during the Dust Bowl years in the Southwest, 1932–1939.[34] Past droughts have been caused by natural variability in ocean and atmospheric circulation (e.g., La Niña events). Future drying is caused by an overall warming, and normal climatic variability would induce additional and increasingly severe droughts.[35]

IRRIGATION EFFICIENCY VS. CONSUMPTIVE USE

Irrigation efficiency is the volumetric ratio of water beneficially used by crops (consumptively) to applied water. The irrigation efficiency of sprinkler systems ranges from 60 to 80%; flood irrigation systems have efficiencies of 45 to 60%.* Consumptive use represents the amount of water incorporated in the plant structure or evapotranspired by the plant, in addition to evaporative losses from conveyance or application systems. Consumptive losses are influenced by local climate, soils, and patterns of irrigation.

Two types of irrigation dominate in Nevada: flood and sprinkler systems. Farms relying on groundwater typically irrigate with sprinkler systems, while regions with surface water supplies use flood irrigation. For farms pumping groundwater, energy (electricity) costs are often the highest on-site costs.* The overall consumptive use of sprinkler and flood systems depends on a host of factors. Converting from a flood to sprinkler system may increase irrigation efficiency, reducing overall withdrawals and consumptive losses in irrigation canals. Because of the energy costs associated with sprinkler systems, most flood irrigators in Nevada work toward improving irrigation efficiency without converting their irrigation systems.†

* Johnson, Drew, Larry Pochop, Greg Wilkerson. 2001. *Hydrologic Impacts of Improved Irrigation Efficiencies and Land Use Changes*. http://wwweng.uwyo.edu/civil/research/wwrp/annualreports/2001/project1.pdf.
† Davidson, Jay. University of Nevada. Personal communication to Stacy Tellinghuisen, January 9, 2008.

Although the impacts of climate change will affect all sectors of society, they may be most keenly felt by agriculture. Given the potential changes and uncertainties, we generate a baseline scenario incorporating climate change effects into Nevada's future agricultural water needs. This scenario estimates the statewide impact of increased consumptive water use of 1.24 inches per year over all irrigated areas. Increased temperatures may have additional impacts, such as lengthening the growing season in some cooler parts of the state, while making agricultural production untenable in hotter regions. We do not attempt to quantify these impacts on water resources.

31 National Assessment Synthesis Team, U.S. Global Change Research Program. 2000. Climate Change Impacts on the United States: The Potential Consequences of Climate Variability and Change. http://www.usgcrp.gov/usgcrp/Library/nationalassessment/overview.htm.

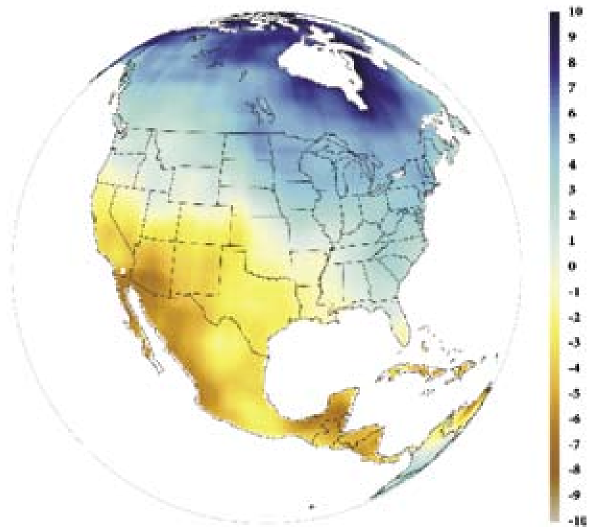
32 These ensemble runs were produced by 19 global circulation models.

33 Seager, Richard, Mingfang Ting, Isaac Held, Yochanan Kushnir, et al. 2007. "Model Projections of an Imminent Transition to a More Arid Climate in Southwestern North America." *Science* 316 (5828): 1181– 1184. DOI: 10.1126/science.1139601. http://www.ldeo.columbia.edu/res/div/ocp/drought/science.shtml.

34 From 1932 to 1939, the annual difference between precipitation and evaporation was 1.29 inches higher than average; during the 1950s Southwest drought (1948–1957), it was 1.87 inches higher than average.

35 National Assessment Synthesis Team, U.S. Global Change Research Program. 2000. *Climate Change Impacts on the United States: The Potential Consequences of Climate Variability and Change*. http://www.usgcrp.gov/usgcrp/Library/nationalassessment/overview.htm.

PROJECTED CHANGE IN PRECIPITATION
1950 - 2000 TO 2021 - 2040 (PRECENT OF 1950 - 2000)



Seager, Richard, Mingfang Ting, Isaac Held, Yochanan Kushnir, et al. 2007.

Figure 12. *Projected change in precipitation, based on 49 simulations from 19 different global circulation models.*

Given the current statewide withdrawal rates of 3.5 to 4.5 AF/acre and the average consumptive rate of 52%, average consumption of agricultural withdrawals is approximately 1.8 to 2.3 AF/acre.[36] If water demand increases by 0.1 AF/acre by 2030, (1.24 inches/acre), the statewide consumptive use of agricultural water will increase by approximately 66,500 AF, relative to *Business as Usual* projections *(Figure 13)*.[37] In regions where farmers rely on shallow aquifers for irrigation, elevated rates of consumption will have only local effects on water resources by reducing rates of groundwater recharge. In places where downstream users rely on agricultural return flows, however, reduced flows may intensify regional competition for limited water resources. Note that in both future scenarios, total agricultural lands decrease by 10%, from 716,000 acres in 2005 to 643,000 acres in 2030.[38]

CONSUMPTIVE WATER USE IN AGRICULTURE

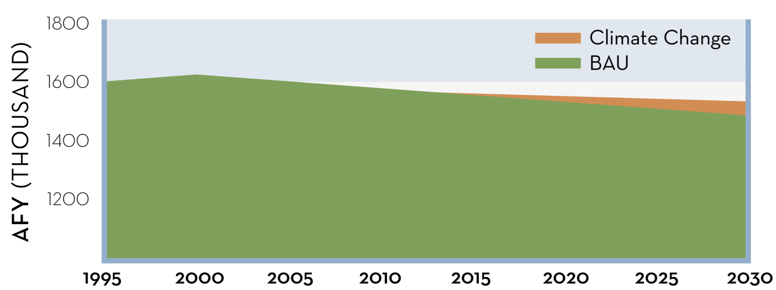


Figure 13 (and 2). *Consumptive use of irrigation water in Nevada, 1995–2030, estimated under Business as Usual conditions and increased rates of evapotranspiration that result from climate change.*

WRA's analysis of the impacts of climate change assumes an average increased rate of evapotranspiration for the entire state. Total consumptive water use and the rate of consumption vary throughout the state *(Figure 14)*, and the actual impacts of climate change will depend on local agricultural conditions. Likewise, our *Business as Usual* scenario makes generalizations for the entire state, but

36 Statewide, average rates of withdrawal and consumption are at the high end of this range (as of 1995): withdrawals averaged 4.36 AFY, and consumptive use, 2.26 AF/ac. See Nevada Department of Conservation and Natural Resources, Division of Water Resources. 1999. Nevada State Water Plan: Part 2, Water Use and Forecasts. http://water.nv.gov/WaterPlanning/wat-plan/pt2-cont.cfm.

37 52% is used as the consumptive rate, which reflects the rate of consumption for an average water withdrawal of 4.36 AF/ac.

38 This was the last estimate generated by the Nevada State Water Plan, which projects the amount of land in agriculture in 2020. The Census of Agriculture estimated 747,000 acres of cropland was irrigated in 2002.

local trends are somewhat variable. For example, the 1999 State Water Plan projects that rates of agricultural irrigation will increase in future years in the northeast (Elko County), while in counties near the Las Vegas and Reno metropolitan areas agricultural use is projected to decline markedly *(Table 4)*. The impact of increased rates of evapotranspiration will likely be more profound in counties or basins with fully allocated water resources, where additional water is not available.

CONSUMPTIVE WATER USE IN AGRICULTURE · 2000 **RATE OF CONSUMPTIVE WATER USE IN AGRICULTURE · 2000**

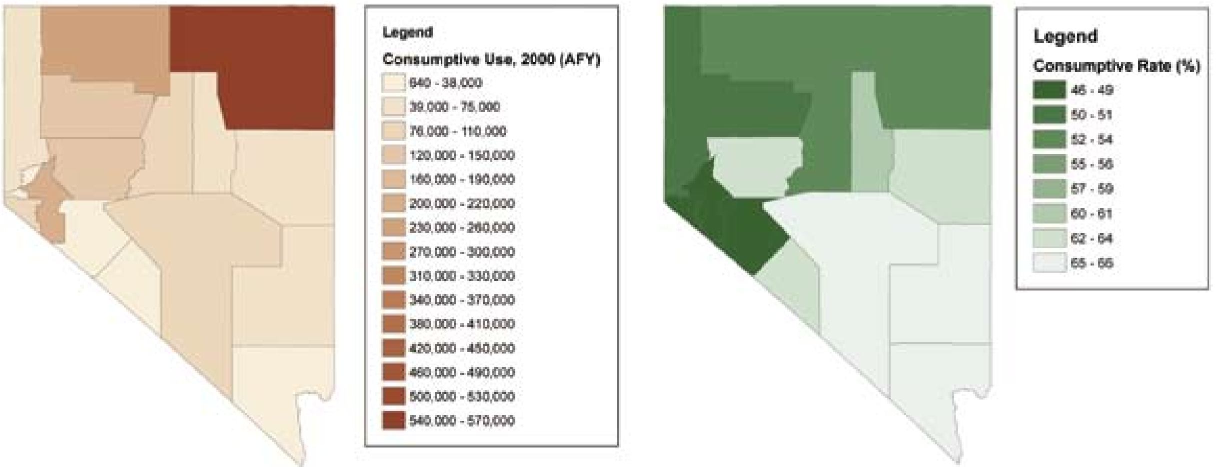


Figure 14. *Total consumptive water use and rate of consumptive water use in agriculture in 2000.*

Table 4. *Projected difference in withdrawals for agriculture between 1990 and 2020, as a volume and a percent of 1990 withdrawals.*

County	Difference in withdrawals, 1990–2000 (AFY)	Difference from 1990 withdrawals (%)
Carson City	-2,100	-33
Churchill	-51,700	-18
Clark	-20,160	-49
Douglas	-8,000	-4
Elko	120,540	13
Esmeralda	0	0
Eureka	0	0
Humboldt	0	0
Lander	18,000	12
Lincoln	9,840	17
Lyon	0	0
Mineral	4,240	15
Nye	-8,400	-7
Pershing	0	0
Storey	0	0
Washoe	-23,400	-17
White Pine	0	0

SUMMARY

If recent trends persist, the municipal and industrial sectors will continue to look toward agriculture to meet their growing water demands. As a result, under *Business as Usual*, we project that the area of land in agricultural production is likely to decline by 10% between 2005 and 2030. Accordingly, water consumed by agricultural irrigation will decrease by 162,000 AFY. Most of the agricultural water will be converted to municipal and industrial uses, and will predominantly occur around the Las Vegas and Reno/Sparks metropolitan areas.

Although interest in ethanol production has been piqued recently, Nevada is an unlikely candidate for expanded corn production. If cellulosic ethanol production becomes viable and profitable, the conversion of land and water rights from agriculture to urban uses may slow.

The sharpest effects of climate change may be felt by the agricultural sector. In the southwestern U.S., researchers project increased average rates of evapotranspiration, in addition to intensified droughts and heat waves. Although actual projections of changing evapotranspiration vary, we use an average estimate. Applying this estimate to the State of Nevada, we project an additional 66,500 AFY of water consumed by irrigation. The increased rates of evapotranspiration will directly impact the availability of water for agricultural and environmental needs.

WATER USE IN ELECTRICITY GENERATION

Population and economic growth in Nevada and neighboring states have driven electricity demand in recent years. To meet power demands in 2015, the Nevada utilities and independent power producers anticipate constructing several new thermoelectric power plants. These new power plants would have significant water demands, competing directly with municipal, agricultural, and other industrial water uses. We assess the water demands under four *Business as Usual* scenarios and compare them to water demands under several *Alternate* scenarios, in which new electricity demand is met through energy efficiency and a portfolio of renewable resources.

BACKGROUND

Water used in electricity generation can vary significantly, depending on how the primary energy source is converted to electricity and the method of cooling. Several steps of the electricity generation process require water (see sidebar). In this analysis, however, we focus on the on-site water needs at generation facilities. The following paragraphs provide a brief overview of water use for electricity generation from fossil fuels and renewable resources; other reports[39] describe these water needs in greater detail.

WATER USE FOR CONVENTIONAL ELECTRICITY GENERATION

In the U.S., most electricity is generated by producing steam from water heated by coal, natural gas, or nuclear fuel, which drives a turbine and generator. The steam must be cooled and condensed using water (in once-through or wet recirculating systems) or air (in dry-cooled systems).

Hybrid cooling systems use water for cooling during summer months and air for cooling during cooler months. The average water use for a plant relying on hybrid cooling depends on what portion of the year it uses wet cooling. Power plants that do not use steam (e.g., combustion turbines) do not require water for condensing steam. Combined cycle plants have both a combustion turbine and a steam generator.

WATER USE FOR RENEWABLE SOURCES OF ENERGY

Renewable sources of energy, including geothermal, bioenergy, solar, and wind power, use water in a variety of ways. Geothermal plants use geothermal heat to generate electricity in dry, steam, or binary cycle plants. Much like conventional thermoelectric plants, vapor is used to turn a turbine and must be cooled, condensed, and captured using water or air. Unlike conventional plants, however, geothermal plants often rely on geothermal fluids[40] for cooling and other water needs. *Figure 15* shows high rates of water use for wet-cooled, binary cycle, geothermal plants. At present, only one geothermal plant in the U.S. uses freshwater for its cooling needs. All others use steam condensed from geothermal fluids, which typically have very high levels of dis-

WATER USE FOR POWER PRODUCTION: ON-SITE AND OFF-SITE

Although this report focuses on the water required at the electricity generation facility, there may be numerous off-site impacts on water resources. For example, mining, refining, and transporting fossil fuels often require water, and biomass crops may need irrigation. Furthermore, manufacturing solar panels, wind turbine blades, or cement (for a thermoelectric power plant or hydroelectric dam) may demand additional water. Often, these impacts are felt in other watersheds, however, and may not compete directly with local municipal or agricultural demands. Therefore, we exclude them from this analysis.

39 Clean Air Task Force and the Land and Western Resource Advocates. 2003. *The Last Straw: Water Use by Power Plants in the Arid West.* http://www.catf.us/publications/reports/The_Last_Straw.pdf. *The Last Straw* cites many of these reports. More recently, the Department of Energy, Electric Power Research Institute (EPRI), and National Renewable Energy Lab (NREL) have published reports.

40 Geothermal fluid is often high in salts and other minerals, and generally cannot be used for agricultural irrigation or municipal needs. Typically, if it is produced from a geothermal well, geothermal fluid is re-injected into that well following use.

solved minerals, making them unsuitable for other uses.[41]

Sources of bioenergy vary. Biomass, such as agricultural or forestry wastes, can be co-fired with fossil fuels or burned in a thermoelectric biomass facility and has water use comparable to fossil-fuel-based thermoelectric facilities. Biogas (methane) captured from landfills or wastewater treatment plants can be combusted to generate electricity, with minimal water requirements.

Solar photovoltaic and wind facilities may use small amounts of water to wash their solar panels, mirrors, or wind turbine blades. Concentrating solar power (CSP) facilities use solar heat to generate steam (or other vapor); this steam is typically condensed using a wet recirculating or dry cooling system.[42]

WATER USE FOR EMERGING TECHNOLOGIES

If fossil fuel plants are required to capture and store greenhouse gas emissions in the future, water demands may increase. Carbon capture and storage (CCS) is most likely to be employed in coal plants that use integrated gasification combined cycle (IGCC) conversion technologies. IGCC plants, in the demonstration phase in the U.S., require slightly less water than conventional pulverized coal combustion plants. In both IGCC and conventional power plants, carbon capture and storage creates additional auxiliary power loads: CCS is projected to require up to 30% of a power plant's output.

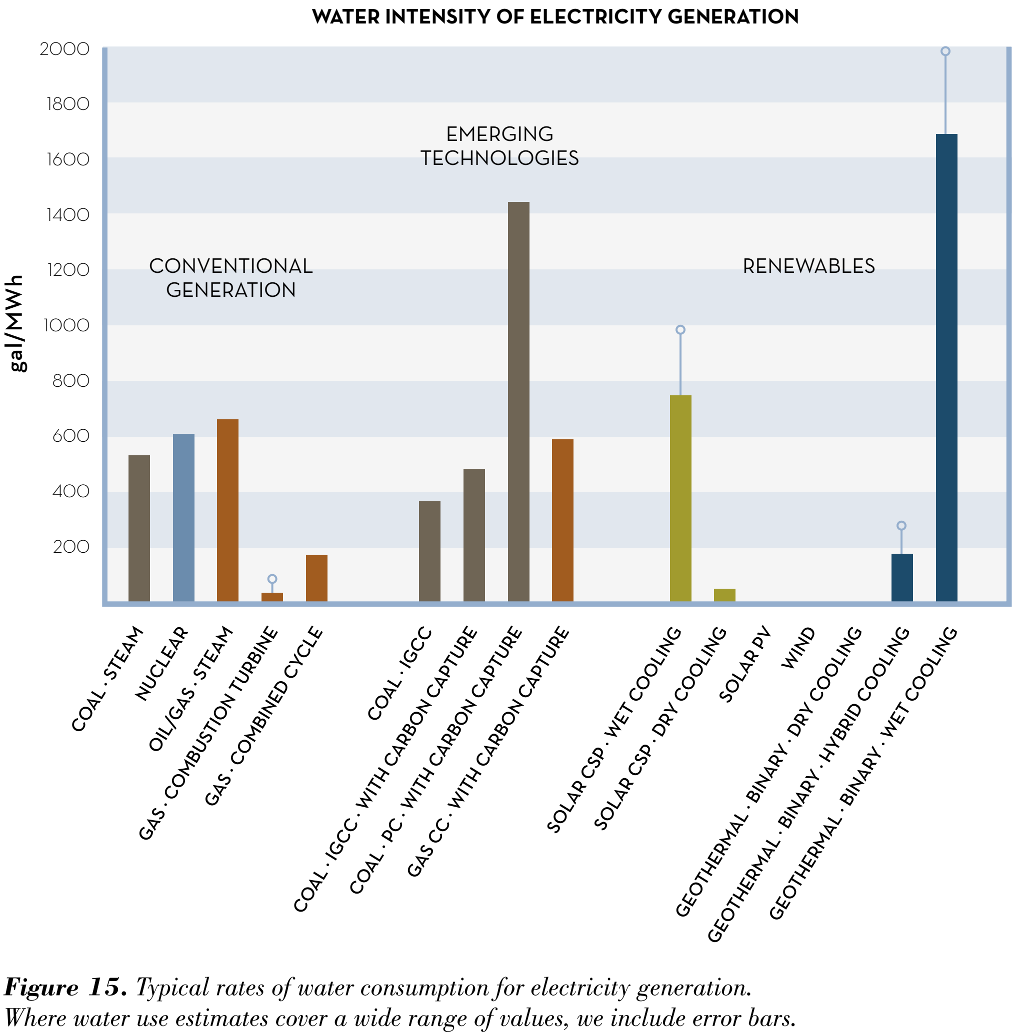


Figure 15. *Typical rates of water consumption for electricity generation. Where water use estimates cover a wide range of values, we include error bars.*

41 Karl Gawell, Geothermal Energy Association. Personal communication to Stacy Tellinghuisen, March 27, 2008. The Heber facility in Southern California uses freshwater for cooling.

42 The most common solar CSP facilities are parabolic troughs; other types of solar CSP plants do not generate electricity from thermal heat or steam.

Table 5. *Typical water use for electricity generation.*

Fuel/Plant	Water consumption (gal/MWh)	Cooling system	Source
Coal, steam	541	Wet recirculating	Energy Information Administration. 2002. Form 767, Steam-Electric Plant Operation and Design Report, Cooling System Information.
Nuclear	609	Wet recirculating	Ibid.
Oil/gas, steam	662	Wet recirculating	Ibid.
Combustion turbine*	0–100	-	
Combined cycle	180	Wet recirculating	Electric Power Research Institute. 2002. Water and Sustainability (Volume 3): U.S. Water Consumption for Power Production – The Next Half Century. Report prepared by Bevilacqua-Knight, Inc. Report 1006786. Clean Air Task Force and the Land and Water Fund of the Rockies. 2003. The Last Straw: Water Use by Power Plants in the Arid West. http://www.catf.us/publications/reports/ The_Last_Straw.pdf.
Coal, IGCC	365	Wet recirculating	National Energy Technology Laboratory. 2007. Cost and Performance Baseline for Fossil Energy Plants: Volume 1: Bituminous Coal and Natural Gas to Electricity Final Report (Revision 1, August 2007). http://www.netl.doe.gov/energy-analyses/pubs/Bituminous Baseline_Final Report.pdf.
Coal, IGCC, with CCS	500	Wet recirculating	Ibid.
Coal, PC, with CCS	1,438	Wet recirculating	Ibid.
Natural gas, combined cycle, with CCS	583	Wet recirculating	Ibid.
Solar CSP	760	Wet recirculating	Stoddard, L., J. Abiecunas, and R. O'Connell. 2006. Economic, Energy, and Environmental Benefits of Concentrating Solar Power in California. Overland Park, KS: Black & Veatch.
Solar CSP, dry cooling	78	Dry cooling (or dish with Stirling engine)	Kelly, B. 2005. Nexant Parabolic Trough Solar Power Plant Systems Analysis, Task 2: Comparison of Wet and Dry Rankine Cycle Heat Rejection. A report for NREL, SR-550-40163. http://www.nrel.gov/csp/troughnet/pdfs/40163.pdf.
Solar photovoltaics	0		Clean Air Task Force and the Land and Water Fund of the Rockies. 2003. The Last Straw: Water Use by Power Plants in the Arid West. http://www.catf.us/publications/reports/The_Last_Straw.pdf.
Wind	0		Ibid.
Geothermal, binary	0	Dry cooling	Kagel, Alyssa, Diana Bates, and Karl Gawell. 2007. A Guide to Geothermal Energy and the Environment., Washington, D.C.: Geothermal Energy Association. Washington, D.C. http://www.geo-energy.org/publications/reports/Environmental Guide.pdf.
Geothermal, binary	74–368†	Hybrid cooling	Data provided by Charles Kutscher. 2008. Empire Energy Geothermal Power Plant, Empire, NV: Evaporative Cooling Analysis for Condenser Intake Air. Golden, CO: National Energy Renewable Laboratory. Published as Kutscher, Charles and David Costenaro. 2002. Assessment of Evaporative Cooling Enhancement Methods for Air-Cooled Geothermal Power Plants. Golden, CO: National Renewable Energy Laboratory. NREL/CP-550-32394.
Geothermal, binary	~1,700, variable	Wet recirculating‡	Kozubal, Eric and Charles Kutscher. 2003. Analysis of a Water-Cooled Condenser in Series with an Air-Cooled Condenser for a Proposed 1-MW Geothermal Power Plant. Geothermal Resources Council Transactions, Vol. 27.

* Combustion turbines do not require water for cooling. They may require water for other on-site processes.

† Range of values reflects four different hybrid cooling systems, tested at the Empire Energy Geothermal Plant in Empire, NV. We use an average value (117 gal/MWh).

‡ Geothermal plants can use geothermal fluids for their cooling water needs. Water use in wet-cooled geothermal plants varies substantially, depending on the temperature of the geothermal resource; high temperature resources have lower water use per unit of energy generated.

NEVADA'S RENEWABLE PORTFOLIO STANDARD

Key points:

- By 2015, 20% of Nevada's electricity must come from renewable sources.
- 5% of this must be met with solar resources.
- Energy efficiency measures can meet up to 25% of the RPS requirements.

This energy penalty translates directly into increased water needs for each unit of net generation. In addition, several steps in the CCS process use cooling water to condense and compress gases.[43]

Table 5 and *Figure 15* show the projected water requirements for conventional forms of generation, renewable sources of energy, and emerging forms of generation (IGCC and pulverized combustion (PC) plants, with and without CCS).

In 2006, Nevada power plants generated 32,024,000 MWh of electricity, and consumed approximately 16,000 AF of water.[44] Natural gas fueled most of this generation, followed by coal, geothermal, and hydroelectric power *(Figure 16)*. In June of 2007, Nevada's first major solar power plant, Nevada Solar One, a 64-MW solar thermal plant near Las Vegas, began generating electricity. It is not included in the 2006 totals.

BUSINESS AS USUAL SCENARIOS: 2015

Nevada's two major power utilities, Nevada Power and Sierra Pacific Power, and independent power producers have plans to construct three major thermoelectric facilities by 2015: the Ely Energy Center (EEC), Toquop Energy Project, and White Pine Energy Station. These facilities, in various stages of planning and permitting, represent 3,840 MW of additional generation capacity. If constructed as planned, they will generate almost 29,000,000 MWh of electricity annually.[45]

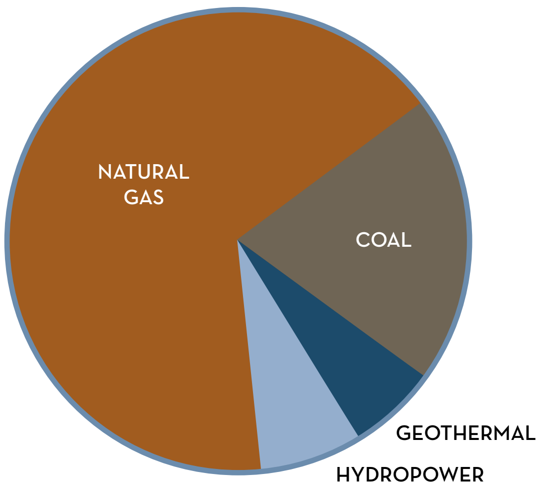


Figure 16. *Electricity generation by power plants in Nevada in 2006.*

Sierra Pacific Resources plans to construct the Ely Energy Center, which will consist of 1,500 MW of capacity in Phase I (2011 and 2013) and an additional 1,000 MW of capacity in Phase II (in an undetermined year). Power generated at the EEC will serve both Nevada Power and Sierra Pacific Power, via the planned Eastern Nevada Transmission Intertie (EN-ti). Independent power producers have proposed two additional coal plants, the Toquop Energy Project and White Pine Energy Station.

Several factors influence the likelihood that power companies will construct all three proposed coal plants. If the Ely Energy Center is constructed as planned, it will meet the near-term power needs of Nevada Power and Sierra Pacific's customers. We assume the Toquop and White Pine plants will provide power to markets outside of Nevada; however, it is not clear that a market for power from both plants exists. Furthermore, presumably the Toquop and White Pine plants would enter into long-term contracts with electric utilities in Arizona and Utah, which would expose those utilities to substantial financial risk. If Sierra Pacific Resources encounters problems with permitting, siting, or funding the EEC, however, it may choose to purchase power from the White Pine plant, rather than construct the EEC.[46]

43 National Energy Technology Laboratory. 2007. *Cost and Performance Baseline for Fossil Energy Plants: Volume 1: Bituminous Coal and Natural Gas to Electricity Final Report (Revision, August 2007).* http://www.netl.doe.gov/energy-analyses/pubs/Bituminous%20Baseline_Final%20Report.pdf.

44 This estimate does not include water that evaporated from Lake Mead or other reservoirs, because it is not directly attributable to the hydroelectric power generation. It also does not include geothermal fluid, evaporated in wet-cooled geothermal plants.

45 Assuming they operate at an 85% capacity factor, the industry median for coal plants. Linvill, Carl, Christopher Cooke, Suzanne Phinney, and Richard McCann. 2008. *Laying a Foundation for Nevada's Electricity Future: Generation Facility Uncertainties and the Need for a Flexible Infrastructure*. Prepared for The Energy Foundation by the Aspen Environmental Group and M. Cubed.

46 We do not provide a scenario in which only the White Pine Energy Station is constructed, but if the White Pine plant replaces the EEC, water demands will be similar to the BAU 1 scenario.

Given these uncertainties, we provide three versions of a *BAU* scenario:

- *BAU 1* – Only the EEC is constructed.
- *BAU 2* – The EEC and Toquop Energy Project are constructed.[47]
- *BAU 3* – The EEC, Toquop Energy Project, and White Pine Energy Station are constructed as planned.

The utilities and independent power producers have outlined their facilities' cooling technologies and water demands in permitting applications and other documents. Using these estimates, we project future water needs for the B*usiness as Usual* scenarios *(Figure 17* and *Table 6)*. These scenarios do not reflect any additional water use at existing facilities. In November 2007, Sierra Pacific Resources announced plans to expand its Harry Allen natural gas plant, adding 500 MW of combined cycle generation capacity. This capacity was added in response to permitting delays and uncertainties surrounding the EEC. In all of the 2015 *BAU* scenarios, we include the Harry Allen expansion.

ALTERNATE SCENARIOS: 2015

Recent permitting challenges and political developments have led utilities to delay or cancel plans for several major generating facilities in Nevada. These delays have resulted primarily from concerns surrounding the cost and risk associated with coal. As a result, Phase I of the Ely Energy Center is not likely to be online in 2011 as originally projected. Fortunately, Nevada has a wealth of renewable resources, including high-quality geothermal, solar, and wind power, which can replace the proposed EEC.

We generate three *Alternate* scenarios that demonstrate the water savings incurred by replacing the power from coal plants in *BAU 1, BAU 2,* and *BAU 3* with alternative sources of energy:

- *Alternate 1* – replaces proposed generation from the EEC.
- *Alternate 2* – replaces proposed generation from the EEC and Toquop Energy Project.
- *Alternate 3* – replaces proposed generation from the EEC, Toquop Energy Project, and White Pine Energy Station.

In our *Alternate 1* scenario, we replace the proposed generation in Phase I of the EEC with a mix of energy efficiency, transmission[48], and generation from renewable sources of energy, combined heat and power (CHP) at casinos, and natural gas plants *(Figure 17)*. The proposed mix relies heavily on a recent report, *Laying a Foundation for Nevada's Electricity Future*, by Linvill and others.[49] From this report, we adjust the proposed mix of resources slightly *(Table 7)*.

In the *Alternate 2* scenario, we build on *Alternate 1* scenario, replacing the electricity generated at the proposed Toquop Energy Project with a mix of renewable sources of energy and energy efficiency. Although the electricity will likely be delivered to utilities in other states, we assume they could invest in energy efficiency to offset some of their power needs. The Western Governors' Association (WGA) task force on energy efficiency estimated demand management savings of 20% by 2020. We assume 13% of new demand in 2015 could be met through efficiency (*Figure 17* and *Table 8*).

We use a similar approach to develop the *Alternate 3* scenario, replacing the proposed White Pine Energy Station with renewable sources of energy (*Figure 17* and *Table 9*). The *Alternate 3* scenario does not incorporate any additional energy efficiency savings (estimated available savings for Nevada are tapped out in the A*lternate 2* scenario). If, however, power from the White Pine plant is delivered to residents in Utah or other neighboring states, additional efficiency savings may be available.

The additional capacity from renewable resources includes geothermal, wind, and solar thermal power; it does not include significant amounts of electricity generated from solar photovoltaics (PV). The

47 The White Pine plant is projected to use 5,000 AFY, while the EEC plant is projected to use 8,000 AFY. Our BAU 2 scenario reflects projected water use at the EEC and Toquop; if the White Pine plant replaces the EEC, total water demands for the BAU 2 scenario will be slightly lower.

48 "Transmission" refers to electricity that could be generated from existing capacity and shared between the northern and southern operating grids. It could also potentially include imported power from the Rocky Mountain or Pacific Northwest regions.

49 Linvill, Carl, Christopher Cooke, Suzanne Phinney, and Richard McCann. 2008. *Laying a Foundation for Nevada's Electricity Future: Generation Facility Uncertainties and the Need for a Flexible Infrastructure.* Prepared for The Energy Foundation by the Aspen Environmental Group and M. Cubed.

additional capacity is based on potential capacity identified by WGA reports, Western Resource Advocate's *Renewable Energy Atlas of the West*,[50] and published capacity factors. For reference, the total renewable capacity added in the three *Alternate* scenarios is less than the potential deemed economically and technologically feasible by WGA reports (*Table 10* and *Figure 18*).

In the three *Alternate* scenarios, we consider several factors: base and peak load demands, the intermittency of some renewables, and the rate of capacity additions by each sector in recent years (e.g., the solar thermal and wind sectors have added capacity more aggressively than the geothermal industry of late). We do not perform an extensive analysis on any of these factors, but focus on replacing both capacity and net energy. Some additional capacity from natural gas combustion turbines may be necessary to balance patterns of demand and renewables' intermittency. The water required by combustion turbines, however, is minimal.

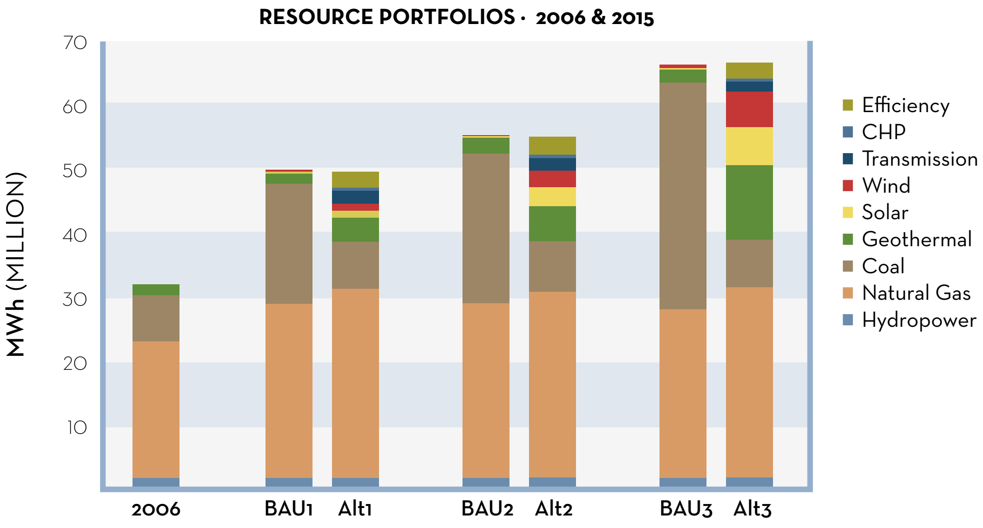


Figure 17. *Electricity generation in Nevada in 2006 and under six future scenarios. Total generation in 2006 is 32,024,000 MWh.*

50 Nielsen, John, Susan Innis, Leslie Kaas Pollack, Heather Rhoads-Weaver, et al. 2003. *Renewable Energy Atlas of the West.* Western Resource Advocates.

Table 6. *Electricity generation and water use for the Business as Usual scenarios in 2015. The BAU 1, 2, and 3 scenarios include different combinations of coal plants.*

Facility	Generation (MWh)	Rate of water use* (gal/MWh)	Water use (AFY)
Existing conventional power plants (2006)	28,479,282	Varied	16,472
Existing geothermal plants	1,683,595	Varied†	0*
Power plants under construction	4,266,950‡	Varied	2,843
Proposed facilities			
EEC, Phase I	11,169,000	233	8,000
Toquop Energy Project	5,584,500	146	2,500
White Pine Energy Station	11,839,140	138	5,000
Harry Allen Natural Gas Plant	2,285,000	180	1,815
Planned renewable generation	1,071,539	Varied	257
Decommissioned power plants	(3,143,722) §	Varied	(4,428)
Total (BAU 3)	**63,235,000**		**32,459**

* The water use (gal/MWh) for future facilities is derived from utility documents that estimate total annual water use and projected generation, given median capacity factors for coal plants. For the Harry Allen plant, SPR has not provided estimates of annual water use; we project water use based on typical rates in combined cycle facilities.

† We do not include geothermal fluids in our totals.

‡ Generation at the Clark plant's combustion turbines is not included.

§Decommissioned plant data does not include two turbines at the Clark plant.

Table 7. *Energy sources proposed to replace the EEC Phase I plants in the Alternate 1 scenario (before 2015).*

Source	Linvill et al.: proposed generation (MWh)	Alternate 1 scenario: proposed generation (MWh)	Alternate 1 scenario: proposed capacity (capacity credits) (MW)	Rate of water use (gal/ MWh)	Water use (AFY)	Notes/ assumptions
Renewables						
Geothermal	2,234,000	2,234,000	300	191*	1,309	Assumes binary, hybrid-cooled system.
Wind	600,000	600,000	400 (80)	0	0	
Solar thermal with storage	200,000	900,000	250 (170)	78	215	Assumes parabolic trough, dry cooling.
Solar PV	87,000	87,000	30–60 (7–14)	0	0	
Efficiency						
Residential	724,000	724,000	25	0	0	
Commercial	159,000	159,000	207	0	0	
Lamp Standards	1,080,000	1,080,000	186	0	0	
CHP (gaming facilities)	456,000	456,000	60–120	0	0	Some CHP facilities use absorption chillers, which increase overall water consumed. Recent CHP additions in Las Vegas, however, have not included absorption chillers. Excess heat is used to heat water for hotel use.
Transmission	2,000,000	2,000,000	-	188	1,157	Assumes transmission allows for additional generation at existing power plants; water use rate reflects system-wide average rate in 2006.
Natural gas, combined cycle	3,395,000	2,300,000	350	180	1,270	Linvill adds 300–500 MW of natural gas capacity, generated at an unspecified mix of combined cycle and combustion turbine plants. The projected generation was developed to completely replace the generation at the EEC.
Natural gas, combustion turbine		395,000	150	0	0	
Total	**10,935,000**	**10,935,000**	**2,003 (1,568)**	**-**	**3,951**	

*We assume binary, hybrid-cooled plants use freshwater for cooling; in reality, these plants may use geothermal fluids, depending on the availability (and cost) of freshwater.

Table 8. *Renewable resources and energy efficiency that replace the Toquop coal plant in 2015. The Alternate 2 scenario is a combination of these resources and those listed in Table 7.*

Facility	Capacity (capacity credit) (MW)	Generation (MWh)	Rate of water use (gal/MWh)	Water use (AFY)	Notes/ assumptions
Geothermal	195	1,572,000	191*	920	Assumes binary, hybrid-cooled system.
Wind	475 (95)	1,412,000	0	0	
Solar thermal	525 (357)	1,886,000	78	450	Assumes parabolic trough, dry cooling.
Solar PV	0	0	0	0	
Efficiency	190	726,000	0	0	
Total	**1,385 (837)**	**5,596,000**	**-**	**1,370**	

* We assume binary, hybrid-cooled plants use freshwater for cooling; in reality, these plants may use geothermal fluids, depending on the availability (and cost) of freshwater.

Table 9. *Renewable resources and energy efficiency that replace the White Pine coal plant in 2015. The Alternate 3 scenario is a combination of these resources and those listed in Table 7 and Table 8.*

Facility	Capacity (capacity credit) (MW)	Generation (MWh)	Rate of water use (gal/MWh)	Water use (AFY)	Notes/ assumptions
Geothermal	695	5,610,000	191*	3,290	Assumes binary, hybrid-cooled system.
Wind	1,195 (240)	3,558,000	0	0	
Solar thermal	770 (525)	2,772,000	78	660	Assumes parabolic trough, dry cooling.
Solar PV	0	0	0	0	
Efficiency	0	0	0	0	
Total	**2,660 (1,460)**	**11,940,000**	**-**	**3,950**	

* We assume binary, hybrid-cooled plants use freshwater for cooling; in reality, these plants may use geothermal fluids, depending on the availability (and cost) of freshwater.

Table 10. *Renewable capacity and efficiency savings added under the Alternate 3 scenario (the most aggressive scenario) and, for reference, the WGA projections for economically and technologically feasible additions by 2015.*

Source	Total new capacity, Alternate 3 scenario (MW)	Total generation, Alternate 3 scenario (MWh)	Feasible capacity* (MW), WGA	Feasible generation (MWh), WGA
Geothermal	1,190	9,416,000	1,500	12,089,000
Wind	2,070	5,570,000	2,770	8,250,000
Solar thermal	1,545	5,558,000	2,000[51]	9,811,000
Solar PV	45	87,000	Many 1,000s	-
Efficiency	-	2,689,000	-	4,441,000[52]

* Feasible capacity reflects gross MW, while capacity added in Alternate scenarios reflects net MW.

51 Potential capacity for Nevada is from the following book: Nielsen, John, Susan Innis, Leslie Kaas Pollack, Heather Rhoads-Weaver, et al. 2003. *Renewable Energy Atlas of the West.* Western Resource Advocates.

52 Nevada's utilities anticipate employing 1,670,000 MWh of efficiency measures by 2015. The difference between WGA projections and utility projections is 2,771,000 MWh.

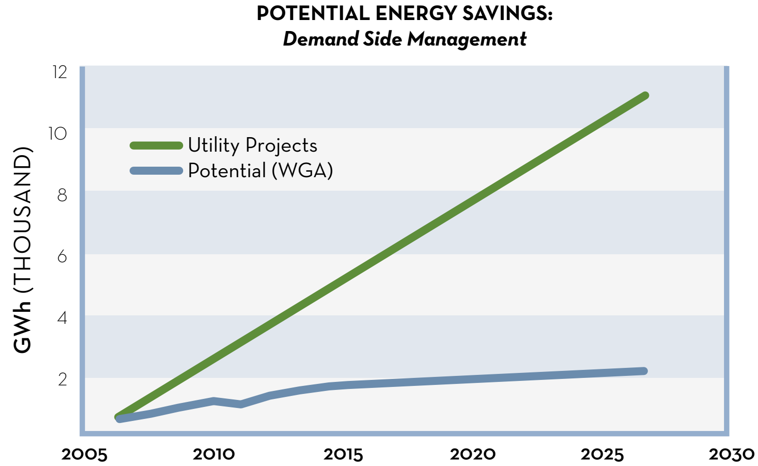


Figure 18. *Electricity savings under the utilities' projections and the WGA's energy efficiency task force.*

WATER USE: 2015

In all of the future scenarios, electricity generation is projected to consume more water in 2015 than it did in 2006 (*Figure 19*). Under the *BAU 1* scenario, water requirements grow from 16,000 AF in 2006 to 25,000 AF in 2015, despite the EEC's use of hybrid cooling technology. The *Alternate 1* scenario, which replaces the EEC Phase I coal plants with energy efficiency, renewables, transmission, CHP, and natural gas, reduces overall water needs relative to the *BAU 1* scenario. Compared to 2006, however, the *Alternate 1* scenario uses an additional 4,000 AF of water annually.

Similarly, relative to projected water demands under *BAU 2* and *BAU 3*, the *Alternate 2* and *Alternate 3* scenarios offer substantial savings. These scenarios replace the proposed generation at the Toquop and White Pine power plants with a mix of energy efficiency and renewable resources — geothermal, solar thermal, and wind power. Although Nevada offers significant potential for solar photovoltaics, it currently costs significantly more than other renewables. Therefore, it was not incorporated into the *Alternate* scenarios.

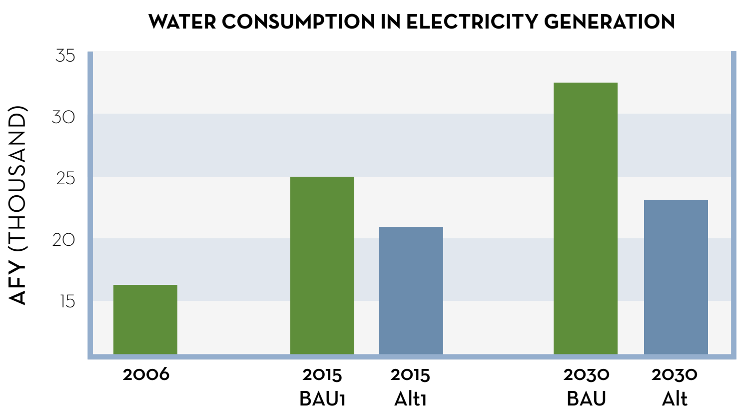


Figure 19. *Water consumed for power production in Nevada in 2006 and under six future (2015) scenarios. See Figure 17 for the mix of resources employed in each scenario.*

SCENARIOS AND WATER USE: 2030

Decisions about energy generation have long-lasting impacts on water resources. Large, baseload power plants may operate for 50 years or longer, and as new generation capacity is added, the effects on Nevada's water resources will be cumulative. Projecting the needed capacity and likely energy mix beyond 2015 has inherent challenges and uncertainties. However, by relying on the utilities' integrated resource plans (IRPs) and a series of assumptions, we extend the *BAU 1* and *Alternate 1* scenarios in order to assess water requirements for electricity generation in 2030 *(Figure 20)*.

Our estimates of water use for electricity generation in 2030 assume that only the EEC Phase I plants are built before 2015. If Toquop and/or White Pine are also constructed, water use in 2030 will be incrementally higher. We extend the *BAU 1* scenario for 2015 to 2030 using the utilities' IRPs, which identify needed generating capacity through 2026 (Nevada Power) and 2027 (Sierra Pacific). For simplicity, we assume this added capacity meets demand through 2030.

The *BAU 2030* scenario assumes all coal- and gas-fired baseload plants constructed after 2015 incorporate CCS technology and new coal plants use IGCC conversion technology. Nevada Power and Sierra Pacific plan to add numerous natural gas combustion turbines and "peaker" plants to their generating fleet. We assume these facilities will not require water for cooling and therefore do not attempt to quantify their total generation. Between 2015 and 2030, Nevada Power and Sierra Pacific plan to retire a significant portion of their existing fleet of coal and natural gas plants. The water use associated with these plants is subtracted from the total water demands in 2030.

In the *Alternate 2030* scenario, we replace the EEC Phase II coal plant[53] with energy efficiency and renewable sources of energy *(Table 11)*. Of note, the renewable capacity and energy efficiency measures employed by 2030 under the *Alternate 2030* scenario fall within those identified by the WGA as feasible by 2015 *(Table 10)*. In addition to the EEC, Sierra Pacific and Nevada Power anticipate constructing 1,633 MW of baseload natural gas plants. The *Alternate 2030* scenario does not replace this capacity or any of the planned peak production capacity; it does assume combined cycle gas plants use CCS.

Under both future scenarios, electricity generation will require substantially more water in 2030 than was used in 2006. Given the assumptions outlined above, under a *Business as Usual* trajectory, power plants in 2030 will demand 43,000 AF of water — over 26,000 AF more than power plants required in 2006. In comparison, the *Alternate 2030* scenario requires 29,000 AFY *(Figure 21)*. If additional planned generating capacity (e.g., combined cycle natural gas plants) is replaced with energy efficiency measures, demand management, and water-efficient renewable sources of energy, total water use in 2030 may be reduced.

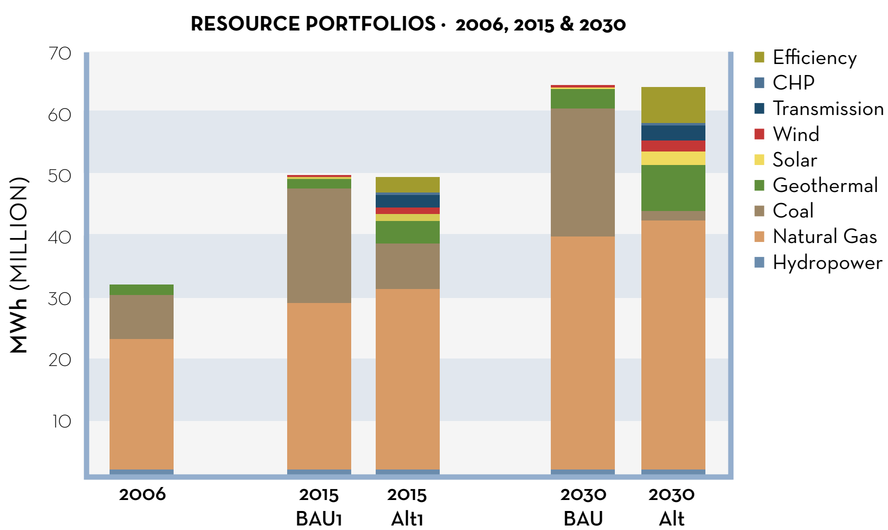


Figure 20 (and 3). *Resource portfolios in 2006, 2015, and 2030. The BAU scenarios include only the EEC coal plants, not the proposed Toquop or White Pine plants.*

53 Sierra Pacific and Nevada Power describe Phase II as a 1,000-MW IGCC coal plant, to be constructed at an undetermined point in time.

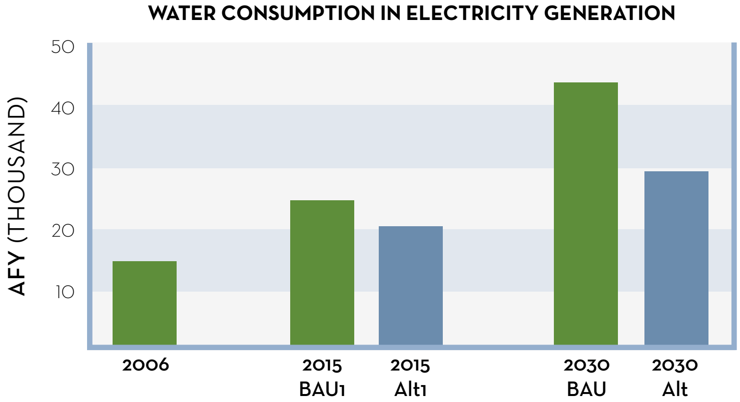


Figure 21 (and 4). *Water consumed for electricity production in Nevada under two future scenarios.*

Table 11. *Renewable sources of energy and energy efficiency measures that replace the EEC Phase II coal plant in the Alternate 2030 scenario.*

Resource	Total potential additional generation (MWh)	Water use (AFY)
Geothermal	1,300,000	762
Wind	500,000	0
Solar CSP	1,300,000	311
Solar PV	0	0
Efficiency	3,913,000	0
Total	**7,013,000**	**1,073**

SUMMARY

Nevada utilities and independent power producers plan to construct over 6,000 MW of new capacity in the next seven years, almost all of which will rely on fossil fuels. Although the major proposed plants — the Ely Energy Center, Toquop, and White Pine — plan to rely on more efficient hybrid cooling technologies, they will have substantial impacts on local water resources. If all three of these coal plants are constructed, water consumed in power production in Nevada is projected to increase by 16,000 AFY — doubling the current water use for electricity generation. If only the EEC is constructed, water demands for electricity generation will grow by 8,500 AFY by 2015 — a 52% increase over 2006 demands. Extending this scenario to 2030, and assuming that stricter regulations require new power plants to capture and store carbon emissions, annual water use for power production may increase by 26,400 AFY (160%), relative to 2006.

By relying more heavily on energy efficiency and renewable sources of energy, Nevada utilities and power producers can substantially reduce their impacts on water resources. Our *Alternate 1* scenario, which replaces Phase I of the proposed Ely Energy Center with a mix of resources, consumes only 4,000 AFY (27%) more water in 2015 than was used in 2006. Likewise, under the *Alternate 2* and *Alternate 3* scenarios, which replace conventional coal-fired generation with a mix of renewables and energy efficiency, water demands grow relative to use in 2006. The *Alternate* scenarios provide substantial water savings, however, relative to the *BAU* trajectories.

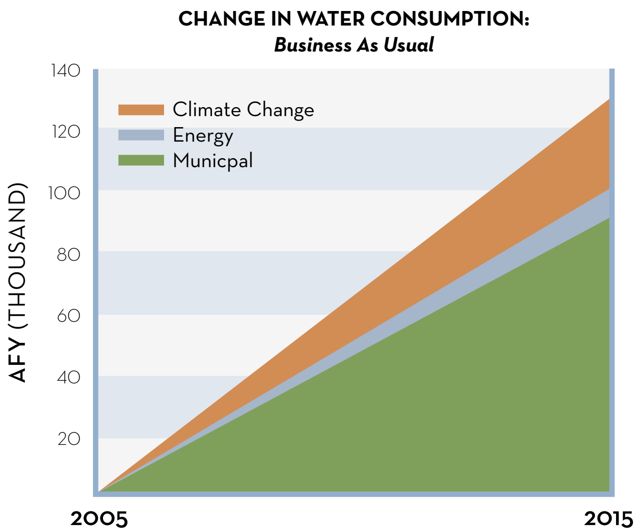
These scenarios include numerous assumptions and, clearly, many factors will influence future energy mixes. We assess only the water implications of different energy portfolios. Other issues, such as risk, regulation of greenhouse gases and other emissions, and the cost of renewable technologies, will influence future energy decisions.[54] However, the impact on Nevada's water resources should be considered in determining future energy portfolios.

54 Western Resource Advocates. 2008. *Investment Risk of New Coal-Fired Power Plants*. Boulder, CO.

CONCLUSION

Over the next 25 years, water demands for municipal uses and thermoelectric generation will continue to grow in Nevada. To meet these needs, municipalities and power plants will likely look toward untapped groundwater basins and the agricultural sector as sources of water.

Under several scenarios, we project the water demands for the municipal, agricultural, and electricity generating sectors in 2015 and 2030. Under a *Business as Usual* trajectory, water consumed by municipalities and thermoelectric generation increases by 100,000 AFY by 2015 *(Figure 22)*. Compounding this, climate change is projected to intensify drought cycles and increase average temperatures and rates of evapotranspiration throughout the southwestern U.S. Average projected increases in evapotranspiration will result in additional water losses of 29,000 AFY from irrigation of agriculture and municipal landscapes. Most of the growing municipal and industrial demands will be met through agricultural water transfers and groundwater development. Net statewide water consumption is projected to increase by almost 57,000 AFY by 2015 *(Figure 23)*.



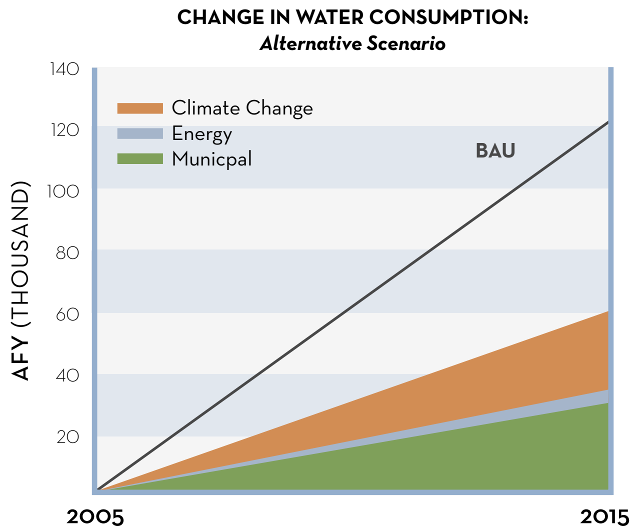


Figure 22. *By 2015, under Business as Usual, the volume of water consumed annually by municipalities, power plants, and due to climate change will increase by almost 130,000 AF. Compared to BAU, alternative scenarios save 67,000 AFY (municipal figures reflect the System-wide Efficiency scenario; energy figures reflect the BAU 1 and Alternate 1 scenarios).*

As competition for scarce water resources increases, water use efficiency measures in all sectors will be essential. Using several alternative scenarios, we present a different picture of Nevada's future water demands. Efficiency measures in the municipal sector and an alternate approach to meeting electricity needs reduces projected demand substantially — delaying the need for obtaining new, more expensive water supplies.

Fortunately, Nevada's major municipal water utilities have substantial room for improving water use efficiency, by investing more heavily in demand management strategies and available, affordable efficiency measures. By investing in urban water use efficiency measures in the residential and commercial sectors, municipalities' annual water demand grows by only 29,000 AF between 2005 and 2015 — saving 63,000 AFY over projected *BAU* demands in 2015 *(Figure 22)*.

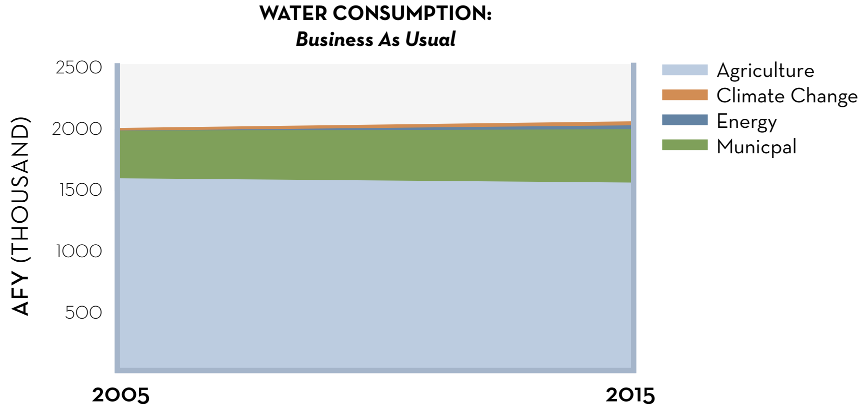
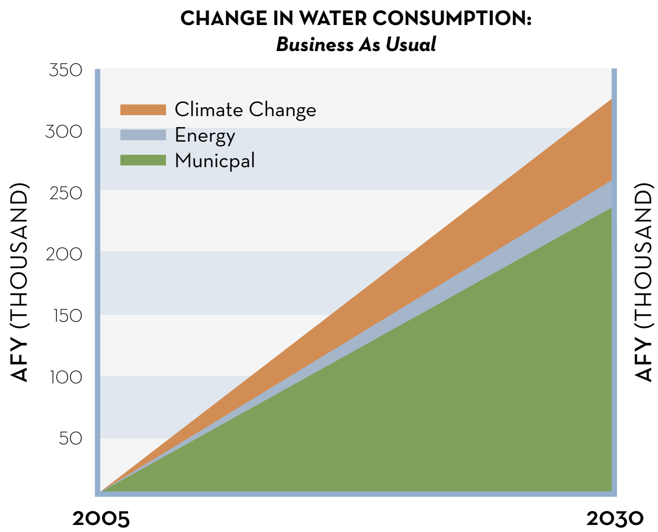


Figure 23. *Under Business as Usual, net annual water consumption will increase by 57,000 AF by 2015. Most of the increased water demand in the municipal and electricity-generating sectors will be met through agricultural water transfers.*

Nevada is also endowed with a wealth of renewable sources of energy, many of which require significantly less water than traditional fossil-fuel-based generation. By replacing the proposed Ely Energy Center with alternative sources of energy, water demand for electricity production increases by 4,000 AFY between 2005 and 2015 — a savings of 7,000 AFY, relative to the *BAU* scenario *(Figure 22)*. Although agricultural land conversions continue, reducing water demand in municipal uses and electricity generation relieves pressure on agricultural and environmental needs.



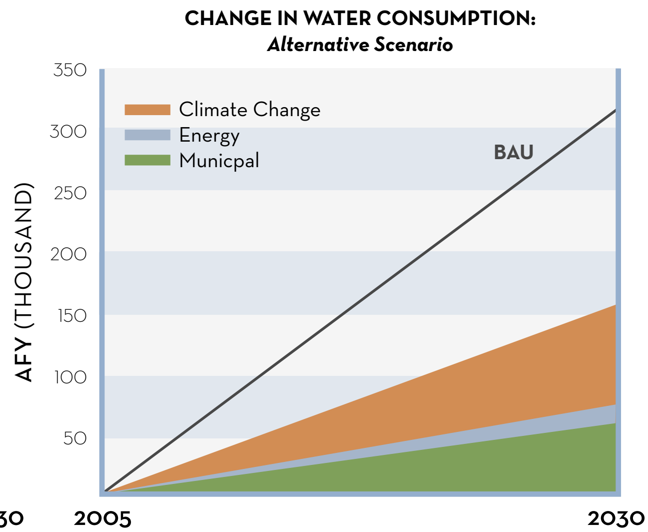


Figure 24 (and 5). *Increased municipal water use efficiency, energy efficiency, and reliance on renewable sources of energy dramatically reduces total water demands in 2030, compared to Business as Usual; relative to BAU, the alternative scenarios save 172,000 AFY in 2030.*

Expanding our analysis to 2030, similar patterns emerge. Under *Business as Usual*, water consumed by municipalities, in electricity generation, and due to increased rates of evapotranspiration continues to grow, while agricultural water use declines (*Figure 24* and *Figure 25*). Under the alternative scenarios, water consumed by the municipal and power sectors grows by 84,000 AF – significantly less than demands under *BAU (Figure 24)*. Increased water losses due to climate change play a more substantial role in 2030, accounting for an additional 71,000 AF of water.

The measures employed between 2015 and 2030 represent a conservative approach: municipalities reduce per capita water use to volumes attainable today, and only one major conventional thermoelectric facility added after 2015 (the EEC Phase II coal plant) is replaced with efficiency and renewables. Undoubtedly, additional water use efficiency measures and sources of energy will become economically and technologically viable.

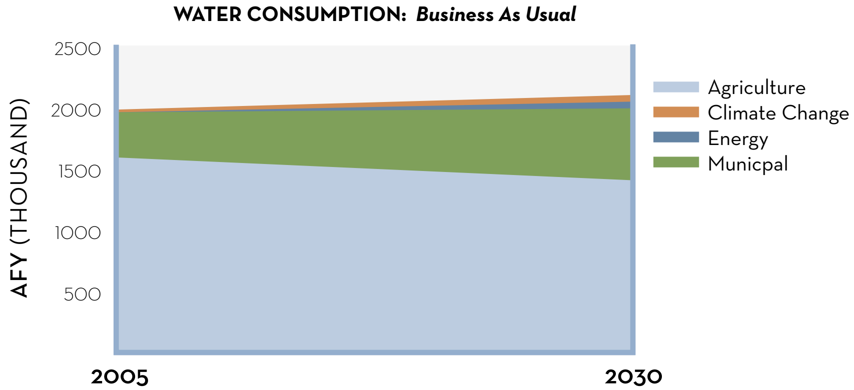


Figure 25. *Total annual water demands grow by 167,000 AF between 2005 and 2030. Most of the increased demand from municipalities and power plants will be met through agricultural water transfers.*

Although the impacts of climate change were integrated into the agricultural analysis, their importance bears additional mention. Recent reports suggest that the impacts of climate change in the Colorado River Basin, Southern Nevada's primary water supply, will be much more dire. Barnett and others[55] project that if demand in the basin continues to grow and the current drought deepens, Lake Mead has a 50% chance of being dry by 2021 and has a 10% chance of running out of usable water supplies by 2014. While basin-wide management strategies may help mitigate these impacts, these projections highlight the potential for future conflict over Nevada's scarce water resources. Furthermore, it underscores the need for a comprehensive, multifaceted approach to managing Nevada's water resources — one that incorporates actions in the municipal, agricultural, and electricity-generating sectors.

55 Barnett, Tim P., David W. Pierce, Hugo G. Hidalgo, Celine Bonfils, et al. 2008. Human-Induced Changes in the Hydrology of the Western United States. *Science* 319: 1080–1083.

Meeting Nevada's future water and energy needs requires an integrated and innovative approach — one that involves both the water and energy sectors.

We propose several measures to address the policy gaps, connect energy and water decisions, and promote integrated planning. While this report focuses on Nevada, many of these measures are applicable in other states and regions.

1. Accelerate water conservation to provide energy savings and accelerate energy conservation and use of renewable energy sources to provide water savings.

By reducing demand and the need to pump, convey, and treat water supplies, water conservation can offer significant energy savings. Water conservation devices that reduce use of hot or cold water can provide additional, significant energy savings. In most states, energy utilities have been encouraged or required to reduce electricity demand through energy efficiency measures; typically, energy utilities have not been allowed to meet energy efficiency goals through water conservation measures. In Southern California, for example, power companies have made limited investments in water conservation measures — despite the known energy savings — because of regulatory barriers to accounting for the energy savings. This is changing: California's Public Utilities Commission (PUC) has initiated a pilot program to quantify the in-home energy savings associated with water conservation devices. We recommend other states' PUCs use data from this pilot program and other sources to encourage electric utilities to invest in water conservation measures to meet energy efficiency goals.

Energy conservation often also provides water savings. Where energy efficiency measures reduce generation at water-intensive power plants, they also reduce water consumption. Within a customer's residence, ENERGY STAR washing machines and other appliances often use less water. Saving potable water — and reducing wastewater — provides an additional reason to invest in energy efficiency measures, and we encourage states to expand or enhance their energy efficiency goals and standards. Just as importantly, some renewable energy resources (e.g., wind and solar photovoltaics) use negligible amounts of water. Meeting new demands with these renewables instead of fossil fuel plants will yield valuable water savings.

2. Accurately reflect the value of energy and water in utility planning processes.

In many places, both electricity and water are artificially cheap. Where energy utilities have water rights, the cost they pay to use that water is much lower than the opportunity cost[56] of the water. Power plants, for example, pay to pump and treat their cooling water supplies. The value of this water — if it were made available to municipalities — is often much higher. Accurately reflecting the value of water may make some forms of renewable energy more cost-competitive. For example, many forms of renewable generation do not consume water — if these water savings are made available to meet municipal or environmental needs, they may avoid the need for municipalities to develop new water supplies. We recommend that utilities, plus state and local regulatory agencies, perform cost/benefit analyses on proposed energy portfolios that accurately include the opportunity cost of water used in electricity generation.

56 The ***opportunity cost*** represents the foregone value of an alternate use of the water. In this example, the opportunity cost would be the value of the power plant's water to local municipalities if it allowed municipalities to avoid developing new water supplies.

3. Be creative.

As water utilities develop new supplies, they should explicitly assess greenhouse gas emissions associated with the energy needed to produce and deliver those supplies and seek to reduce the carbon footprint of water supply activities. For example, water utilities may be able to design their systems to store water and make use of intermittent renewable resources, such as wind energy for water pumping, thereby reducing greenhouse gas emissions attributable to water supply.

Integrating the power and wastewater sectors can be mutually beneficial. Thermoelectric power plants can and should utilize secondary water supplies, such as treated wastewater. By using treated wastewater, power plants reduce their impacts on pristine freshwater supplies and receive a reliable, drought-proof water supply. Many plants in the western U.S., including the Palo Verde nuclear plant in Arizona, already rely on recycled water. State and regional water authorities should require new thermoelectric power plants to utilize recycled water supplies, where available. To this end, we encourage co-location of power plants and wastewater treatment plants.

Wastewater treatment plants produce methane gas. Often, the treatment plants flare the methane gas, but it can also be used to generate electricity. Albuquerque's main wastewater treatment plant, for example, meets half of its electricity and heating needs with methane produced on-site. Flaring methane gas, rather than generating electricity, represents a lost opportunity for both water and power utilities.

4. States' renewable portfolio standards and fuel standards should be "water smart."

As states adopt or expand their renewable portfolio standards and renewable fuel standards, they should explicitly consider water resources. Although ethanol development is unlikely in Nevada, renewable fuel standards in other states may encourage non-sustainable use of water resources.

5. Recognize the benefits of decentralized solutions.

Decentralized approaches to meeting new water and energy demand have multiple benefits. In the water sector, rainwater harvesting — by decreasing demand — can avoid pumping, conveying, and treating water to potable standards before it is applied to a landscape. Rainwater-harvesting systems typically use gravity to distribute water over a landscape — requiring no additional energy. Similarly, other forms of low-impact development (e.g., bioswales and permeable pavement) enhance infiltration and reduce stormwater runoff — reducing irrigation needs and energy used to treat stormwater runoff (where applicable). We encourage local planning commissions, plus state and local governments, to require low-impact development in new residential or commercial developments.

Many forms of decentralized electricity generation — including solar panels and combined heat and power facilities — use less water than conventional, centralized thermoelectric power plants. As with energy conservation, utilities, as well as state and local decision-makers, should recognize these water savings and encourage the development of decentralized electricity generation.

TECHNICAL APPENDIX

MUNICIPAL WATER USE

The following tables summarize current water use patterns in the SNWA and TMWA service areas, and projected water use under *Business as Usual* conditions:

CURRENT USE

	Withdrawals (AF/yr)	Consumption (AF/yr)	Consumptive Use Factor (%)	Source
SNWA: Total Water Use, 2004 (surface and GW)	600,000	360,000	60%	WRA, Hidden Oasis
TMWA, 2005	87,900	43,950	50%	TMWA

	Water Use Per Capita, 2004 (GPCD)	Water Use Per Capita, 2035* (GPCD)	SFR Water Use Per Capita, 2004 (GPCD)
SNWA	264	245	165
TMWA	270	250	165+

* Per capita water use is projected by SNWA as 245 GPCD in 2035; for simplicity, we assume this reflects water use rates in 2030. Per capita water use in the TMWA service area is projected to decline as a result of metering, but is not projected to decline after 2010.
+ Derived from TMWA's estimated water use for a single-family residence in 2004 (150,000 gallons) and the average household size, according to the U.S. Census Bureau (2.49 residents): 150,000 gallons/2.49 residents/365 days = 165 GPCD

BUSINESS AS USUAL SCENARIOS

1. Future water withdrawals for SNWA and TMWA are calculated using projected population and per capita water use estimates:
   population * water use rate = total water use
2. Consumptive use rates do not change from current rates (60% in SNWA and 50% in TMWA)

2030, BAU	System-Wide Per Capita Use (GPCD)	Total (AF/yr)
SNWA, Withdrawals	245	879,000
Consumption	147	527,000
Consumptive Use Rate	60%	
TMWA, Withdrawals	250	157,000
Consumption	125	79,000
Consumptive Use Rate	50%	
Total Withdrawals		**1,036,000**
Total Consumption		**606,000**

SINGLE-FAMILY RESIDENTIAL EFFICIENCY SCENARIO

For the *Single-Family Residential Efficiency* scenario *(SFR Efficiency)*, we assume indoor water use declines from current use rates to 45 GPCD, the current estimate of efficient indoor water use. We assume comparable reductions could be made in outdoor water use rates:

1. In the SNWA service area, per capita indoor water use in the SFR sector decreases from 65 gpcd in 2005 to 45 gpcd in 2030, or by 31%. Comparable reductions are made in outdoor water use rates. Water use in other sectors – commercial, industrial, and institutional (C, I, & I) – does not change. The overall, system-wide consumptive use rate does not change from 60%.
   Total Withdrawals = ((SFR use rate * 69%) + (C,I&I use rate)) * Population
   Total Consumption = Total withdrawals * 60%

2. In the TMWA service area, per capita water use in the SFR sector decreases from 83 gpcd in 2005 to 45 gpcd in 2030, or by 46%. Comparable reductions are made in outdoor water use rates. Water use in other sectors – commercial, industrial, and institutional (C, I, & I) – does not change. The overall, system-wide consumptive use rate does not change from 50%.
   Total Withdrawals = ((SFR use rate * 54%) + (C,I&I use rate)) * Population
   Total Consumption = Total withdrawals * 50%

2030, Single-Family Residential Efficiency	System-Wide Per Capita Use (gpcd)	Total (AF/yr)
SNWA, Withdrawals	213	765,000
Consumption	128	459,000
Consumptive Use Rate	60%	
TMWA, Withdrawals	194	122,000
Consumption	97	61,000
Consumptive Use Rate	50%	
Total Withdrawals		**887,000**
Total Consumption		**520,000**

SYSTEM-WIDE EFFICIENCY SCENARIO

For the *System-wide Efficiency* scenario, we assume system-wide water use could be reduced by the same percentage as single-family residential use was reduced in the *SFR Efficiency* scenario:

1. In the SNWA service area, system-wide per capita water use decreases by 31%:
   Total Withdrawals = (System-wide water use rate * 69%) * Population
   Total Consumption = Total withdrawals * 60%

2. In the TMWA service area, system-wide per capita use decreases by 46%:
   Total Withdrawals = (System-wide water use rate * 54%) * Population
   Total Consumption = Total withdrawals * 50%

2030, System-wide Efficiency	System-Wide Per Capita Use (gpcd)	Total (AF/yr)
SNWA, Withdrawals	183	656,000
Consumption	110	393,000
Consumptive Use Rate	60%	
TMWA, Withdrawals	176	110,000
Consumption	88	55,000
Consumptive Use Rate	50%	
Total Withdrawals		**766,000**
Total Consumption		**449,000**

CLIMATE CHANGE IMPACTS: MUNICIPAL WATER USE

Data/Assumptions:

1. One square foot of turfgrass uses 73 gallons of water/year.
2. This equals an application rate of 9.76 ft, or 117 inches of water (depth).
3. Increasing this depth by 1.24 inches/yr (projected increase in evapotranspiration by 2030), the total depth of water = 118.24 inches. This is a 1.1% increase.
4. We apply a 1.1% increase to total projected consumption in 2030 under both scenarios:
   BAU: 606,000 * 101.1% = 612,400 AFY
   SFR Efficiency: 520,100 * 101.1% = 525,700 AFY
   System-wide Efficiency: 448,600 * 101.1% = 453,400 AFY
5. This calculation assumes all of the water consumed in SNWA and TMWA's service areas is used to water landscapes. A portion of the water consumed may evaporate from industrial or other operations, but presumably, higher temperatures would increase the rate of evapotranspiration in these situations, too.

AGRICULTURAL WATER USE

To project future water demand for agriculture under *BAU*, we rely on the Nevada Water Plan (1999), which projects irrigated land, withdrawals, and consumption from 1995 (historic observation) to 2020. We use this data and a linear regression to estimate irrigated land in 2030 *(Figure 1 and Table 1)*.

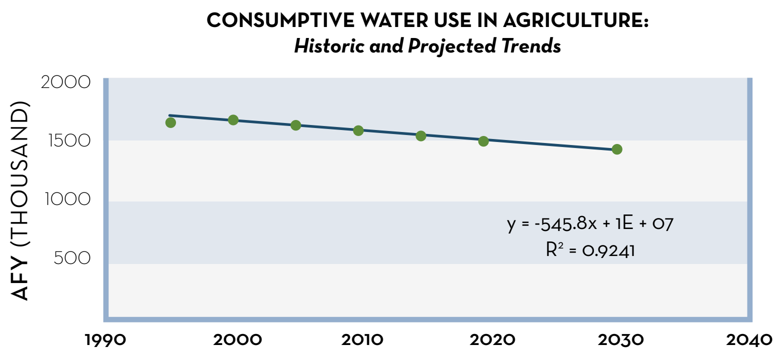


Figure 1. *Historic and projected water withdrawals, 1995 – 2030.*

Table 1. *Agricultural trends under Business as Usual. Beyond 2020, projections are derived from the linear regression equation (shown on the graph above).*

	1995	2000	2005	2010	2015	2020	2030
Total Irrigated Acreage	715,439	727,500	715,563	700,742	683,247	665,753	643,124
Irrigation Water Withdrawals	3,113,585	3,160,754	3,109,348	3,045,636	2,970,521	2,895,406	2,796,817
Irrigation Consumptive Use	1,612,079	1,636,501	1,609,885	1,576,898	1,538,007	1,499,115	1,448,070
Consumptive Use Rate	52%	52%	52%	52%	52%	52%	52%

CLIMATE CHANGE IMPACTS: AGRICULTURAL WATER USE

We project increased consumptive use in irrigation for the period 2021 – 2040 based on Seager et al., who estimate an increased evapotranspiration rate of 1.24 inches/yr.

1. We assume this estimate reflects the midpoint year, 2030
2. Total increased consumption = irrigated land area * 1.24 inches/yr
   In 2030, increased consumption = 66,500 AF/yr
3. With climate change impacts incorporated, the overall consumptive rate in 2030 = 54.2%

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