

Western Governors' Association

STATE OF ENERGY IN THE WEST

June 2013


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The views expressed herein do not reflect the views of any one Governor but rather the broad views of Western Governors.

The Western Governors' Association is an independent, nonprofit organization representing the Governors of 19 states and three US-Flag Pacific islands. Through their Association, the Governors identify and address key policy and governance issues that include natural resources, the environment, human services, economic development, intergovernmental relations and international relations.

GARY R. HERBERT
Utah Governor

WGA Chairman

Dear Friends of the West,

The Western United States plays a critical role in meeting our nation's energy needs. From conventional fuels to renewable energy, the West's resources provide the majority of the United States' energy supply. These resources are good news for the West and its residents. They also present a challenge: Can the Western states create an approach to development that delivers energy in a way that is secure, affordable and respects the environment?

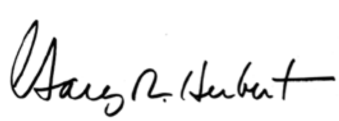
In order to address that concern, my colleagues and I at the Western Governors' Association (WGA) created *The State of Energy in the West*, a comprehensive survey of the vast energy resources in the West, from coal to solar energy, wind power to petroleum. Some of the facts you will learn include the following:

- The West produces more than half of the total amount of coal produced in the United States;
- The West provides nearly 70 percent of the nation's natural gas and its petroleum production output is more than 90 percent of state-level production;
- The High Plains and Rocky Mountains include the country's largest areas of high value wind power resources;
- California is the national leader in installed solar generation capacity;
- Geothermal power is produced almost exclusively in the West.

The State of Energy in the West is one of three projects WGA has created with regard to our year-long focus on energy. We have also published *10-Year Energy Vision*, a blueprint for the country to create an energy policy, and *Energy Perspectives*, a collection of essays by Western governors and Canadian premiers on their specific energy plans.

We hope that Congress and the Obama Administration are able to follow this example of bipartisan cooperation in order to address energy on a national scale. Western Governors consider these efforts a first step toward a blueprint for the country to help create an energy policy that promotes economic growth while protecting our valued natural and environmental resources.

Sincerely,



Chapter 1

The American West: Energy Breadbasket of the Nation

The West is the energy breadbasket of the United States. Awash in conventional and renewable resources, the region plays an indispensable role in meeting our nation's energy needs. Its vast coal reserves – Western production accounts for more than half of the national total – provide power plants with the fuel to offer inexpensive electricity to consumers across the country. The region is also at the forefront of the unprecedented expansion of American oil and gas production. In recent years the West has provided nearly 70 percent[1] of the nation's natural gas, and its petroleum production output has been consistently above 90 percent of state-level production over the last decade.[2]

Projected regional growth will make the United States the world leader in petroleum production within the next five years, which will help unshackle our nation from dependence on OPEC imports.[3]

Renewable energy resources are distributed throughout Western states in far greater abundance than any other region in the country. The High Plains and Rocky Mountains include the largest areas of high value wind power resources in the country.[4] Current estimates suggest that approximately 66 percent of America's installed wind power capacity is located in the West.[5] Individuals and firms are also harnessing the region's vast solar energy, with Southwestern states boasting some of the highest resource potential in the world.[6] California has become the national leader in installed solar generation capacity, with a total output nearly triple that of the next largest state.[7] Geothermal power is the near exclusive province of the West, with 99.5 percent of all installed capacity in 2011.[8] Given the agricultural productivity of the region, it is no surprise the National Renewable Energy Laboratory found that the largest gross area of land with high biomass yield in the country is in the Western states.[9]

Clean energy sources and technologies are utilized throughout the Western states. Hydropower is particularly widespread, with the region accounting for 70 percent of national hydroelectric power generation in 2011.[10] The West's nuclear power generation capacity accounted for approximately 10 percent of national generation in 2012.[11] A large share of this contribution came from the Palo Verde Nuclear Generation Station in Arizona, the country's largest nuclear power facility in terms of output capacity.[12] The contribution of Western states to the production of uranium is indispensable, accounting for 100 percent of domestic mining in 2012.[13]

The diverse resources and priorities of the Western states and their citizens provide an excellent foundation for a comprehensive approach to energy development. To guide that development, the tradeoffs inherent in the use of each energy resource and technology must be taken into account in a balanced fashion. This portion of the *10-Year Energy Vision* provides an overview of the resources and technologies utilized in the West, the role of energy efficiency in energy planning, the transportation of electricity and fossil fuels within the region, environmental impact associated with energy use, the contribution and prospects for economic growth associated with energy industry activities, the role of the Western states in promoting energy security issues ranging from cyber-attacks to military access to resources, and the importance of energy education and technological advancement.

The Fossil Fuels

Fossil fuels have long been preeminent contributors to the American energy mix, both in electricity generation and the transportation sector. In 2011, coal and natural gas accounted for 67 percent of all electricity produced nationally.[14] The use of fossil fuels in the transportation sector was even greater, with petroleum and natural gas accounting for 93 percent and 3 percent respectively.[15]

However, these fuels are finite and sources of airborne emissions when combusted. While the continued utilization of fossil fuel resources is necessary to maintain economic prosperity and the standard of living Americans have come to expect, it must be carried out in a responsible fashion that minimizes environmental and ecosystem impacts.

Coal

Coal is the nation's most abundant fossil fuel resource and has long been the staple fuel for its electric power industry. During the 20th century, coal-fired power plants provided well over half of all electricity generation. This resource continues to play an important role, accounting for 42 percent of national generation in 2011.[16]

In addition to its historic position as the lowest-cost fuel for electricity generation, coal has an essential role in the production of concrete and steel in the industrial sector.[17]

The American coal industry has evolved in response to challenges over the past decade. Public concern about environmental issues has resulted in passage of new regulatory standards for mercury, nitrogen oxides and carbon dioxide emissions. Those regulations have had a substantial impact on the coal industry, given that power plants utilizing coal produce more carbon dioxide emissions than any other source of generation. Compliance with new regulations has meant rapid and often costly emissions control strategies. Current and proposed regulatory actions are likely to spur future investment in the development of advanced coal technologies.

Figure 1.1: U.S. Coal Production in 2012

Weekly Coal Production. Washington, DC: U.S. Energy Information Administration. May 2013. http://www.eia.gov/coal/production/weekly/archive/monthprod2012tot.xls

The Environmental Protection Agency's (EPA) recently proposed Carbon Pollution Standard for New Power Plants presents a significant challenge to the development of new coal-fired electricity generation. If enacted, the regulation would limit the carbon dioxide emissions of newly constructed power plants to 1,000 pounds per megawatt hour.[18] Even the most advanced coal-fired power plants in the United States would not comply with the mandate, meaning that additional coal-fired power plants would require heavy investment in carbon capture and sequestration technology (CCS).

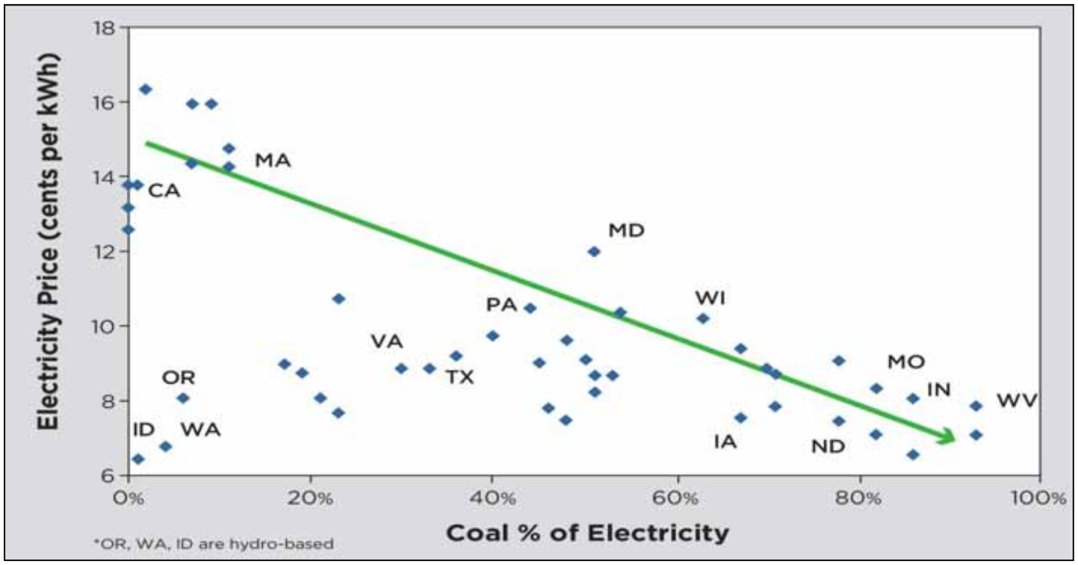
Realizing the benefits of our nation's coal resources within the limits set by the EPA will require heavy investment in CCS technology, as well as the political will to promote public-private research partnerships akin to those seen in the renewables sector.

International Coal Outlook

The World's Leading Fuel by 2025

Robust growth in coal consumption is expected at the international level. In the absence of widespread new carbon limits, the International Energy Agency predicts coal will surpass oil by 2025 as the world's most heavily utilized energy resource. Additional growth during the 2030s is projected to increase the share of coal in the global energy mix to just under 30%. With non-OECD coal demand expected to increase by 76%, there will be robust demand for American coal on the international market in the coming decades.

Figure 1.2: Percent Share of Coal in State Electricity Generation and Average Rate per kWh



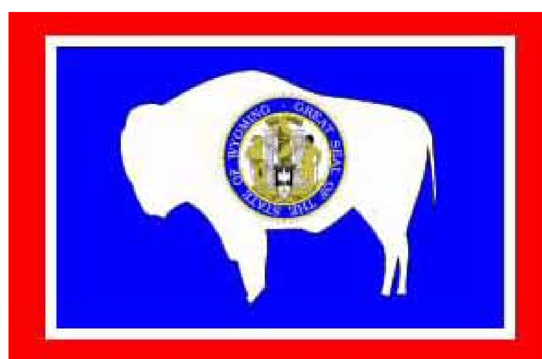
Clemente, Frank. "Coal is the Cornerstone of Electricity." RMEL Electric Energy. Issue 1, P. 20. 14 May 2013. http://issuu.com/hungryeyemedia/docs/2013_issue1_rmel__1_

Despite the challenges, there is reason for optimism about the future of the Western coal industry. Advances in supercritical and ultra supercritical boiler technologies are projected to increase the efficiency of coal-fired generation to as high as 50 percent, resulting in significant reductions in carbon dioxide emissions.[19] At the same time, strong demand on the international market continues to drive American coal industry growth. This is evidenced in recent estimates by the Energy Information Administration (EIA) that exports reached a record high in 2012.[20] Much of this demand was generated by the transition away from nuclear power in Europe and Japan, with American coal exports to Europe up 92 percent from 2010 to 2011.[21]

The continued advance of economic development and industrialization is projected to drive strong coal demand in non-OECD (Organisation for Economic Co-operation and Development) nations. In this country, EIA projections indicate that coal-fired generation will continue to meet well more than 30 percent of electricity demand during the next two decades.[22]

The Wyoming Coal Industry

A key contributor to Western coal production, Wyoming is a coal mining powerhouse at both the national and international levels. The productivity of Wyoming in 2011 exceeded not only the cumulative output of the next five largest coal producing states, but also surpassed the entire national output of Russia. The industry is a pillar of the Wyoming economy, accounting for 14.2% of GDP and 8% employment during 2010.



"Coal should be challenged to advance in terms of becoming cleaner . . . but if you completely shut down coal, you're never going to get to that point." Governor Matt Mead, Wyoming

Petroleum

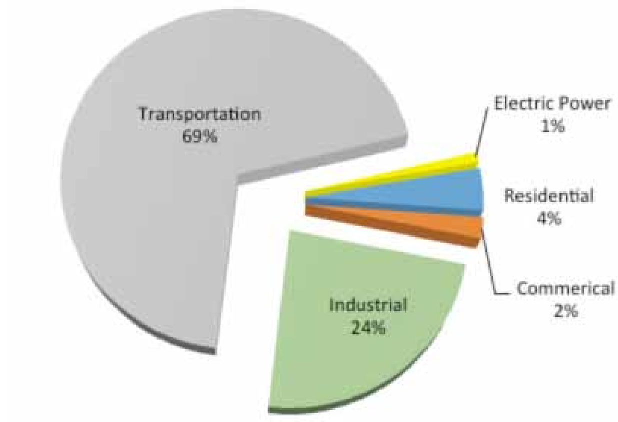
Since the widespread adoption of the automobile during the 20th century, petroleum has risen to become the single most demanded energy commodity in the American economy. The second largest consumer in the world, the United States averaged 18.5 million barrels per day in 2012.[23] Although aggressive production led to the U.S. Being the world's third largest producer in 2011, demand outstripped domestic supply and led to 45 percent of the nation's oil coming from foreign sources during that year. [24]

Canada is the single largest external supplier of petroleum to the American market, with an import volume exceeding 1 billion barrels in 2012. Mexico is also an important supplier, accounting for 10 percent of 2012 imports. When combined, our partners in NAFTA provided 38 percent of all imports in 2012, nearly as much petroleum to the United States as the next largest grouping of suppliers, the Organization of Petroleum Exporting Countries (OPEC). Since the Oil Crisis of 1973, the energy security threat posed by OPEC has been a central feature of political discourse and prominent in the public consciousness. Still, OPEC accounted for approximately 40 percent of total oil imports in 2012.[25]

Petroleum demand is concentrated in the transportation and industrial sectors of the economy, according to the U.S. Energy Information Administration (see Figure 1.3).[26] The transportation sector includes passenger cars, trucks, trains, ships, airplanes and other vehicles. Combustion of petroleum-based products such as diesel fuel and gasoline, in the aggregate, results in substantial emissions of air pollutants and CO_2. The U.S. Environmental Protection Agency (EPA) estimates that 27 percent of all greenhouse gas emissions are from the transportation sector.[27]

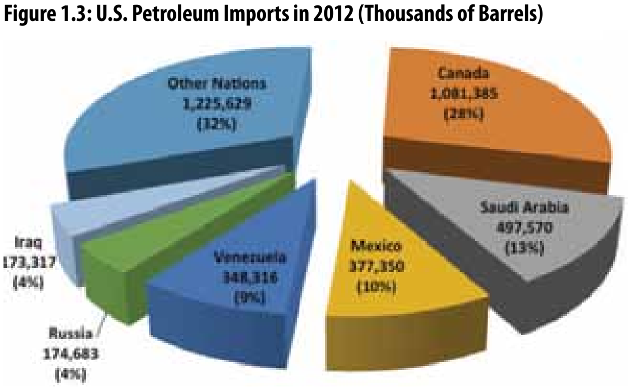
Given the intensity of petroleum use in the American economy, policymakers have long sought to reduce national dependence on imports, especially those from unstable countries. Such efforts have been constrained by the availability of conventional domestic petroleum reserves. However, recent methodological and technological advances in oil extraction have brought transformative change to the industry. Advances in hydraulic fracturing and horizontal drilling have sparked a revolution in American petroleum production.

Figure 1.3: U.S. Petroleum Consumption by Sector (2011)



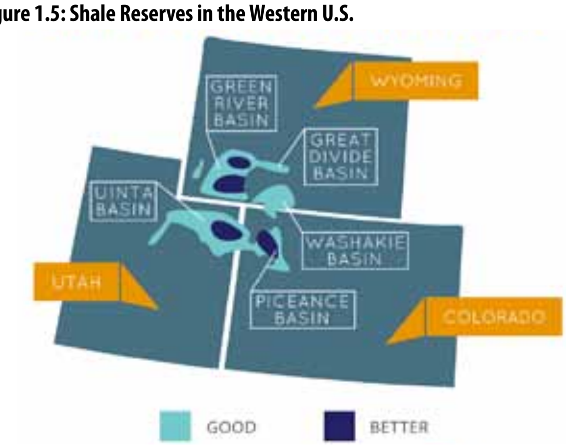
EIA. (2013). Crude Oil Production. Retrieved from http://www.eia.gov/dnav/pet/pet_crd_crpdn_adc_mbbl_m.htm

Figure 1.3: U.S. Petroleum Imports in 2012 (Thousands of Barrels)



U.S. Imports by Country of Origin. Washington, DC: U.S. Energy Information Administration. March 2013. http://www.eia.gov/dnav/pet/pet_move_impcus_a2_nus_ep00_im0_mbbl_a.htm

Figure 1.5: Shale Reserves in the Western U.S.



What is Oil Shale? Institute for Energy Research. 2013. http://www.instituteforenergyresearch.org/energy-overview/oil-shale/

Oil shale is an unconventional petroleum resource consisting of fine-grained sedimentary rock rich in an organic material called kerogen, which converts to liquid oil when heated.[28] There are two approaches to extracting this resource. Mining is the most common. Once mined, the shale is transported to a facility where it is processed to produce oil suitable for refining. A second approach to extraction is in situ retorting, which involves heating underground deposits to 650–700 °F to release oil from the shale on-site.[29] The West is particularly rich in oil shale resources, with the world's largest identified reserves in the spread across Wyoming, Colorado and Utah (see Figure 1.5 on previous page).

Oil sand is another unconventional source of petroleum that is increasing North American production. Sometimes referred to as tar sand, this resource is a mixture of water, clay or other minerals, sand and bitumen.[30] The viscosity of oil sand at room temperature is similar to cold molasses and must be treated before it can be refined into petroleum products. As with oil shale, mining is the dominant mode of extraction for this resource. The oil sand is transported to an extraction plant after mining, where it is mixed with hot water to separate the oil-based bitumen.[31] In cases where resource deposits are too deep for mining to be economic, in-situ production thermally enhanced recovery methods including steam and hot water injection are employed.[32]

Western Crude Oil Production in 2012

(Thousands of Barrels)

Alaska	192,402
Arizona	53
California	194,767
Colorado	47,639
Kansas	43,685
Montana	26,122
North Dakota	242,447
Nebraska	2,714
New Mexico	84,231
Nevada	367
Oklahoma	88,770
South Dakota	1,748
Texas	727,135
Utah	30,039
Wyoming	57,887
WGA	1,740,006
Federal Offshore Licensed	482,963
Rest of U.S.	146,515
U.S. Total	**2,369,484**

Crude Oil Production. Washington, DC: U.S. Energy Information Administration. March 2013. http://www.eia.gov/dnav/pet/pet_crd_crpdn_adc_mbbl_a.htm

According to the International Energy Agency, the United States is projected to become the largest oil production country in the world by 2017.[33] By 2020 this production is expected to make our nation a net exporter of oil for the first time in the nearly 100 years during which the federal government has collected data on petroleum imports and exports.[34]

As was recently pointed out by the International Energy Agency (IEA), the United States is a country with a business climate highly favorable towards exploration and extraction by the oil and gas industry.[35] Since drilling for unconventional shale oil and tight oil began, the increase in production under these favorable conditions has been swift and dramatic.

The West has long accounted for the overwhelming majority of domestic oil production. In 2012, the region accounted for 74 percent of national production.[36] State-level production in other states accounted for only 6 percent of the national total after offshore operations licensed by the federal

Petroleum in Utah: Unconventional Wealth

As innovation drives down the price of unconventional oil resource development, governors in the West have turned their attention to how their states can benefit. Utah Gov. Gary R. Herbert has been particularly active in promoting oil shale and oil sand resource development in his state. According to an assessment by the Utah Geological Survey, oil shale reserves in the north-central region of the state hold approximately 77 billion barrels worth of oil that can be extracted economically with existing technology. Utah also has abundant oil sand reserves. Current estimates indicate that there are approximately 15 billion barrels of recoverable oil in Eastern Utah.

Economic Growth in North Dakota

The Bakken Energy Boom

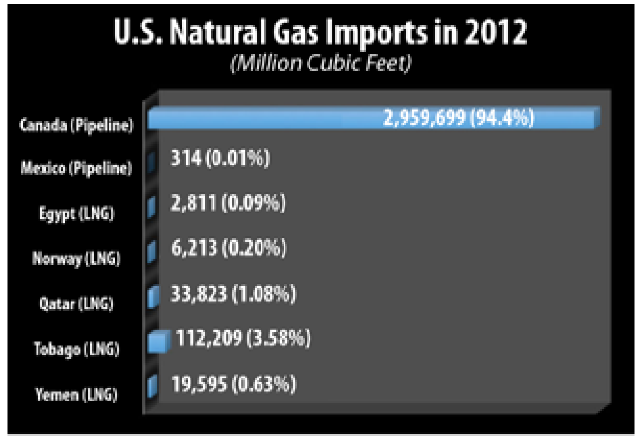
Developments in the extraction of shale oil resources from the Bakken Formation have had a dramatic effect on North Dakota. From 2002 to 2012, annual state crude oil production increased by a staggering 687%. The creation of new oil and gas industry jobs has resulted in the state having the lowest rate of unemployment (now 3.2%) in the nation. Estimates of state oil resources vary, though current estimates place the total at approximately 3.65 billion barrels. More new wells were drilled in North Dakota during 2011 than in the entirety of Canada.

government are taken into account. Continued growth in unconventional oil development and the expansion of conventional drilling operations on federal lands in the West are likely to increase the share of regional production in the coming years.

Natural Gas

Natural gas is the second most heavily utilized energy resource in the United States, accounting for 27 percent of total energy demand in 2012.[37] The resource's diverse applications range from home heating and electric power generation to serving as a feedstock for fertilizer and use for transportation. This diversity has resulted in it being the most evenly distributed of the fossil fuels in terms of its

Figure 1.6



EIA. (2012). U.S. Natural Gas Imports & Exports 2011. Retrieved from http://www.eia.gov/naturalgas/importsexports/annual/

contribution to the sectors of the American economy.[38] The importance of natural gas to the economy has made the development of a secure and stable supply a national priority.

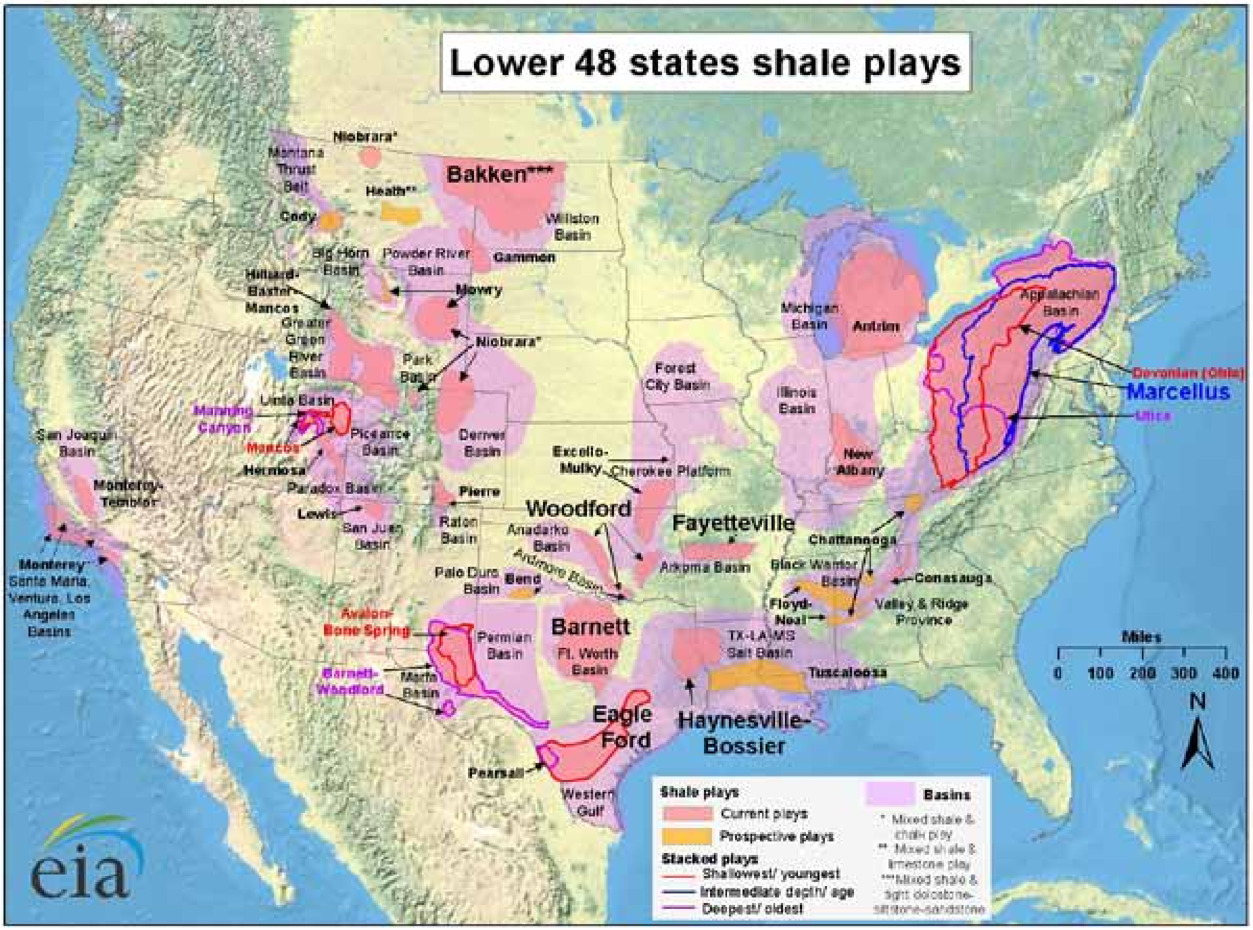
The United States procures natural gas through a combination of domestic production and imports. In 2011, approximately 8 percent of total demand was met by foreign suppliers.[39] Canada has long been the dominant supplier to the American market, accounting for 94 percent of all imports in 2012.[40] The other 6 percent of imports during that year came from a modest amount of pipeline transmission from Mexico and maritime deliveries of liquefied natural gas (LNG) from several other countries (see above Figure 1.6).

The American natural gas industry has boosted domestic production considerably: From 2007 to 2011, imports fell by 49 percent.[43] The unprecedented growth in domestic natural gas production is due primarily to the application of

What is Liquefied Natural Gas?

Liquefied natural gas (LNG) is natural gas that has been converted into a liquid with approximately 1/600th of its gaseous volume state. The phase transition is induced by cryogenically cooling the gas to -260° Fahrenheit. LNG has an energy density equivalent to 64% of gasoline, allowing for economical maritime transport. Natural gas is converted to LNG at an export terminal, where is it shipped to a port with an LNG import terminal with regasification capacity. This allows for natural gas utilization in areas without any local reserves, such as the Pacific Islands. It also affords the opportunity for suppliers to exploit cross-regional price differentials.[41, 42]

Figure 1.7: Shale GasProduction Areas in the Lower 48 States

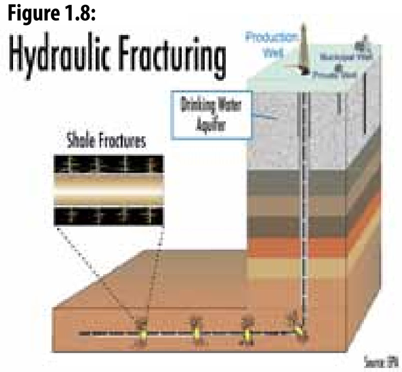


Maps: Exploration, Resources, Reserves, and Production. Washington, DC: U.S. Energy Information Administration. May 2011. http://www.eia.gov/oil_gas/rpd/shale_gas.pdf

modern technology, which has allowed for the extraction of vast unconventional natural gas reserves. This phenomenon has come to be known as the "Shale Gas Revolution."

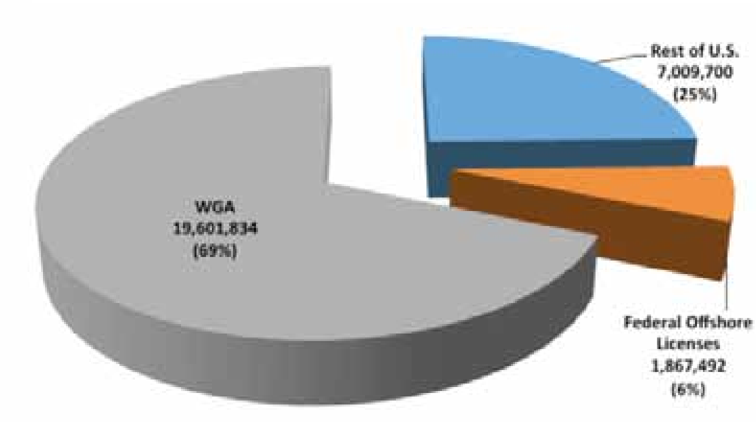
Conventional natural gas production involves the drilling of a vertical well at a natural gas field situated above a reserve deposit where "free gas" is trapped in porous rock. When drilled, the gas travels freely through the porous formation and is collected at the wellhead. Although there are large conventional natural gas reserves found throughout the country, there are substantial unconventional sources that remained outside the reach of economic extraction until recently. Tight gas is a form of unconventional natural gas that is trapped in rock formations where the permeability is too low for it to be extracted via conventional drilling. Shale gas is another form of unconventional resource trapped within porous shale rock formations lacking the permeability required for conventional extraction. In order to extract tight gas and shale gas resource, producers free the resources by fracturing the formations in which unconventional gas is trapped. This is accomplished using a technique known as hydraulic fracturing.

Figure 1.8:



Often referred to as "fracking," hydraulic fracturing involves drilling a well with a depth of up to 10,000 feet, then drilling along a horizontal path once the tight gas or shale gas resource is reached. Once the drilling is completed and the well casing is in place, a mixture known as fracking fluid is injected into the ground to fracture the rock. This liquid consists of approximately 90 percent water, 9.5 percent sand and 0.5 percent chemical additives.[44] Depending on the depth of the well and the characteristics of a given formation, the average hydraulic fracturing well requires between 2 and 4 million gallons of water.[45]

Figure 1.9: U.S. Natural Gas Production in 2011 (Millions of Cubic Feet)



Although hydraulic fracturing was developed during the first half of the 20th century, the modern iteration of this technology entered into widespread service in American production during 2007.[46] With vast shale gas resource reserves available, the ascent of shale gas production has been swift and dramatic. Over the decade from 2000 to 2010, shale gas production increased from less than 1 percent of American production to more than 20 percent.[47]

In 2011 Western regional production accounted for 71 percent of all natural gas production in the United States.[48] The West also played an important role in the import of natural gas. Of imports arriving via pipeline, 66 percent came via an entry point within the Western states during that year.[49] Thirty-one percent of LNG imports were received at terminals located in the West. Export prospects also make the West an important region with respect to LNG. Demand in countries such as South Korea and Thailand has grown steadily and the decline in Japanese nuclear output in the wake of the Fukushima-Daiichi Nuclear Power Plant disaster has contributed to a sharp increase in regional imports.[50]

Western Natural Gas Production in 2011

Million Cubic Feet

Alaska	3,162,922
Arizona	168
California	279,130
Colorado	1,649,306
Kansas	309,952
Montana	79,506
Nebraska	1,980
Nevada	3
New Mexico	1,287,682
North Dakota	157,025
Oklahoma	1,888,870
Oregon	1,344
South Dakota	12,449
Texas	7,934,689
Utah	461,507
Wyoming	2,375,301
WGA	19,601,834
Federal Offshore Licenses	1,867,492
Rest of U.S.	7,009,700
U.S. Total	28,479,026

EIA. (2013). Natural Gas Gross Withdrawals and Production. Retrieved from http://www.eia.gov/dnav/ng/ng_prod_sum_a_EPG0_FGW_mmcf_m.htm

With natural gas prices on the Asian market consistently reaching four times that of the North American average, there is potential for American producers to consider supplying the market.[51]

With domestic natural gas production continuing to rise, there has been a corresponding price drop that has a major impact on the electric power generation sector. Over the past five years, the amount of gas-fired generation has increased by nearly 20 percent. The expansion of capacity reached a milestone in April, 2012, when natural gas and coal reached parity in terms of electricity output, with each providing 32 percent of total generation.[52] Future prospects for the continued growth of natural gas in this area are highly favorable, as long-term projections for natural gas production indicate that prices are likely to remain low. The availability of low-priced natural gas will also benefit other forms of energy, given that natural-gas fired electric power generation is often used to complement variable renewable energy generation.

Natural gas still faces challenges. Although inexpensive natural gas prices have benefited consumers, low prices in the regional market have proven a disincentive for exploration. This has resulted in a possible disconnect between proven reserve and existing reserves, making it more difficult for drillers to secure financing. The Environmental Protection

Hydraulic Fracturing Regulation: States take the Lead

To ensure the responsible development of unconventional natural gas resources, a number of states have taken the lead in regulating hydraulic fracturing. In 2010, Wyoming took the lead by enacting the most comprehensive fracking fluid disclosure regulations in the country. Hailed as a model for state regulation, Wyoming requires that all chemical compounds used in fracking fluid be subject to full public disclosure. As fracking continues to bring inexpensive natural gas to the market, numerous other states including Colorado and California have also introduced regulations that manage the utilization of their resources through effective state-level management. [53]

Agency has also expressed concerns regarding potential methane leakages from pipe fittings and drilling operations, as well as the possible impact of hydraulic fracturing on underground aquifers.[54] Hydraulic fracturing has also raised concerns among community groups due to intensive water withdrawal requirements, as well as the strain placed on municipal infrastructure by large-scale drilling operations.

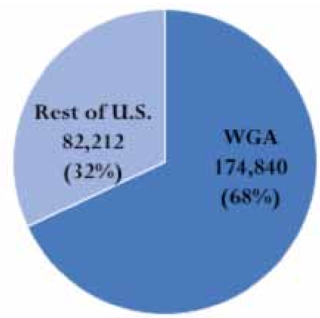
Natural Gas in Texas: The National Leader

At a total output of nearly 8 billion cubic feet of production in 2012, Texas leads the nation in natural gas production. The success of the natural gas industry in the state comes from a wealth of conventional dry natural gas and new operations in the Eagle Ford shale gas formation. In 2011, shale gas accounted for 38% of state natural gas of production.[55]

Hydropower

Hydropower is the leading source of zero-emissions electricity generation in the United States. Hydroelectric facilities produced 8 percent of all electricity generated nationally in 2011, according to the U.S. Energy Information Agency.[56] These facilities utilize flowing water to capture the mechanical energy required to turn a turbine and generate electricity. Large-scale hydroelectric facilities are those with an output capacity of 30 megawatts or greater. To produce this level of output, a dam is constructed to capture the flow of a river.

Figure 1.10: Hydroelectric Power Generation in 2011 (Thousand MWh)



Hydroelectric. Washington, DC: U.S. Energy Information Administration. 2011. http://www.eia.gov/cneaf/solar.renewables/page/hydroelec/hydroelec.html

The vast majority of hydroelectric power production in the United States occurs at large-scale facilities in the West, which produces nearly 70 percent of all hydroelectric power generated across the country.[57] More than half of all hydroelectric power production in the United States occurs in California, Washington and Oregon. In 2011, Washington alone accounted for 29 percent of the national total. The state has two of the largest hydropower stations in the nation – the Grand Coulee and Chief Joseph Dams.

The advantages of hydropower extend to the level of control provided over generation. Once a station is constructed, a reasonably predictable baseload generation capacity can be provided for. When there is an excess of electricity on the grid, hydroelectric power can be shut down and even used to store excess power in some instances. Water resource availability is generally predictable and not subject to market price fluctuations seen in the fossil fuel industry, making the average cost of electricity generated by large-scale hydroelectric stations comparatively stable.

There are challenges associated with large scale hydropower. The construction and operation of hydroelectric stations can interfere with wildlife, in some instances impeding the migration patterns of fish. Intake turbines also can prove hazardous to fish and result in low dissolved oxygen levels that can threaten riparian species. The output of hydroelectric power stations can also be impacted by drought conditions. A reduction in the overall level of water passing through the turbines results in a corresponding drop-off in generation, which can be problematic in cases where hydropower is a primary source of baseload power generation.

Recent developments in hydropower have focused on improving the output capacity of existing dams rather than building new ones. The Department of Energy made available $30.6 million for the upgrading and modernization of seven existing hydropower installations as part of the American Recovery and Reinvestment Act of 2009.[58] Though still under way, the projects are projected to increase national generation by 187,000 megawatt hours per year, enough to power an additional 12,000 American homes.

Hydroelectric Power Generation in 2011

Thousand MWh

Alaska	1,324
Arizona	6,626
California	33,876
Colorado	1,746
Hawaii	86
Idaho	9,161
Montana	9,230
Nebraska	449
Nevada	2,146
New Mexico	253
North Dakota	2,042
Oklahoma	2,894
Oregon	30,288
South Dakota	5,765
Texas	1,032
Utah	792
Washington	66,112
Wyoming	1,018
WGA	174,840
Rest of U.S.	82,212
U.S. Total	257,052

EIA. (2011). Hydroelectric. Retrieved from http://www.eia.gov/cneaf/solar.renewables/page/hydroelec/hydroelec.html

There are currently more than 80,000 dams used for purposes such as irrigation and flood control that have no electricity generation capacity.[59] However, if retrofitted, these dams also have significant potential for electricity generation. A Department of Energy study published in April of 2012 assessed the potential electricity output generation at 54,391MW for these non-power dams.[60] Given concerns regarding the ecological impact of large-scale hydroelectric project, the retrofitting of existing dams offers a promising

Hydroelectric in Washington and Oregon

The Pacific Northwest is the largest hydroelectric power producing region in the United States. The output of Washington is higher than any other state, with three of the five largest conventional hydropower dams located within its borders. The output of Oregon is the second largest in the country, with 80% of state electricity demand met by hydroelectric generation. When combined, the states account for 37 percent of national hydroelectric production.[61]

avenue toward increasing clean energy generation.

Renewable Energy

For a number of environmental and energy security reasons, interest in renewable energy has never been higher. The abundance of wind, solar, biomass and geothermal resources offers a strong incentive for the development and deployment of technology designed to harness them. The U.S. Energy Information Administration estimates that non-hydro renewable energy sources currently contribute 6 percent of total energy consumption nationwide in 2011.[62]

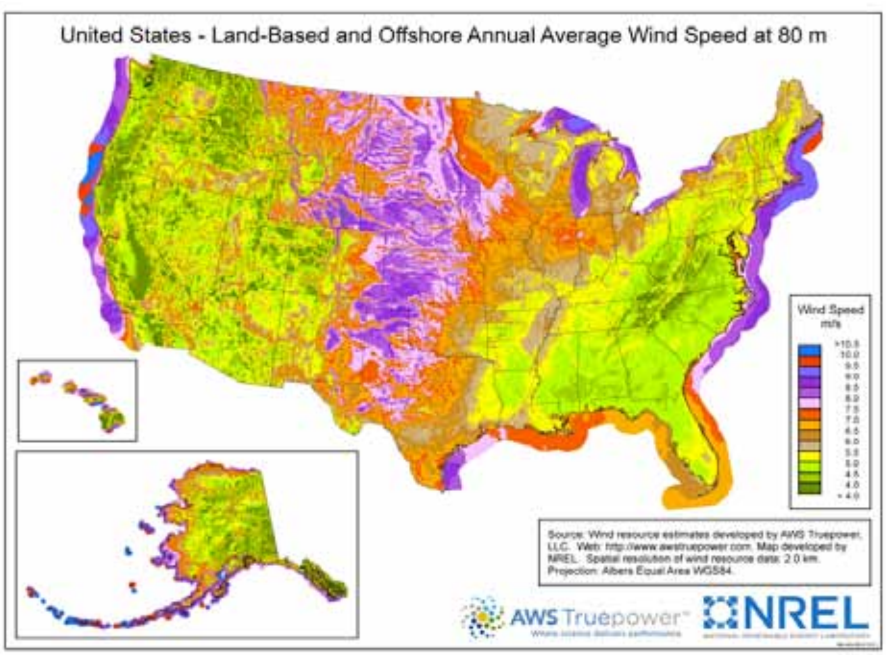
Wind Power

Wind power technology captures the mechanical energy generated by the turning blades to drive a generator. Commercial wind power projects typically involve the deployment of multiple wind turbines towers at a location on land or offshore. In 2012, wind power accounted for 42 percent of additions to electrical output capacity in the United States,[63] making wind the fastest growing form of energy technology in terms of output capacity for that year. There are now more than 45,000 wind turbines operating across the nation, with the cumulative installed output capacity of 60 gigawatts, enough to

power 14.7 million households.[64]

The West leads the nation in wind power resource availability and generation. At the end of 2012, all 19 Western states harnessed wind energy with a total cumulative output of 39,577 MW – 66 percent of all national wind power capacity installed nationally.[65] The share of wind energy generation in the WGA footprint has grown from less than 0.67 percent of the total electricity generation in 2002 to 6.75 percent in 2012.[66] Four of the top five wind power producing states are Western, with additional capacity rollout expected to further boost the regional share of total output. Seven states – South Dakota, North Dakota, Kansas, Colorado, Idaho, Oklahoma and Oregon – have 10 percent or more of their electricity supplied by wind power.[67] Given recent advances in weather forecasting, wind is

Figure 1.11: U.S. Wind Power Resource at 80 meters



Wind Maps. Boulder, CO: National Renewable Energy Laboratory. August 2012. http://www.nrel.gov/gis/wind.html becoming more predictable. As Figure 1.11 shows, the largest cumulative areas with high wind power resource potential are located in the Mountain West.

The growth of wind power across the country has resulted from a combination of public support for renewable energy and technological advancement. Public support for wind power comes both from the federal wind Production Tax Credit (PTC), which provides a 2.2 cent per kilowatt-hour tax benefit to wind power facilities during their first decade of operation, and through the adoption of Renewable Portfolio Standards.[68] This support has helped wind power be cost competitive in the market, while technology advances have led to falling costs. In fact, the cost of wind generated electricity has come down more than 90 percent since 1980 and is projected to continue to fall over the next two decades.[69]

There are a number of benefits associated with the use of wind power generation. Once a wind farm is operational, for example, it is a zero-emissions source. And even relatively small wind farms in the United States can have an output capacity sufficient to power 100,000 households or more. Wind farms also offer the benefit of mixed land use. For instance, a wind farm can be placed on ranchland while maintaining the grazing use value of the land around the turbines. This can provide an additional source of revenue to ranchers, particularly along the vast expanses of the Western High Plains and Rocky Mountains.

Installed Wind Capacity in 2012
MW

Alaska	59
Arizona	238
California	5,549
Colorado	2,301
Kansas	206
Montana	973
Nebraska	2,712
Nevada	645
New Mexico	459
North Dakota	1,679
Oklahoma	778
Oregon	152
South Dakota	3,134
Texas	3,153
Utah	784
Wyoming	12,212
WGA	325
Federal Off-shore Licenses	2,808
Rest of U.S.	1,410
U.S. Total	39,577
Rest of U.S.	20,427
U.S. Total	60,004

EIA. (2013). Installed Wind Capacity. Retrieved from http://www.windpoweringamerica.gov/docs/installed_wind_capacity_by_state.xls

Wind energy offers utilities and ratepayers the advantage of fixed, low prices over 20 years that are not subject to fuel price volatility, helping to keep electricity prices affordable and steady over the long term as part of a balanced energy portfolio. With a well-distributed network of generation across areas with varying resource availability patterns, wind power can also contribute to improved grid stability. Wind power uses almost no water, making it valuable for dealing with drought conditions.

Although wind power offers great potential for emissions-free electricity generation, there are challenges. Given its variability, wind is not a 24/7 baseload generation source. Grid operators use energy storage and other sources of flexibility to accommodate that variability. However, improved and cost-effective storage technologies and other sources of flexibility will have an increasingly important role as variable renewable energy market penetrations increases. In many areas, wind also tends to be most productive during off-peak hours at night when demand for electricity is low. However, wind's short-term predictability has allowed grid operators to integrate wind both cost-effectively and reliably.

As the wind industry looks to the immediate future,

Wind Power in Colorado: Meeting Demand

The American wind power industry is working to meet the challenge of variability through technological innovation. In Colorado, Xcel Energy has partnered with the National Center for Atmospheric Research (NCAR) to develop wind forecasting capable of projecting wind power output a day in advance and in 15-minute intervals. Such advances in predictability have improved the cost-effectiveness and reliability of wind power. As a result, wind power has met over 50% of Xcel Energy power demand on several occasions since 2011.[70]

The bird-safe FloDesign turbine shown above is designed to be identified as an obstacle by birds, causing them to change course and avoid the blades.

there are concerns about cost competitiveness if the current production tax credit is allowed to lapse. Lack of policy certainty around the continuation of the federal production tax credit has inhibited wind development and supply-chain investments over a long-term planning horizon. In some states, utilities are also not financially incentivized to purchase renewable power, and there is often a lack of incentives to exceed or accelerate compliance with state renewable requirements.

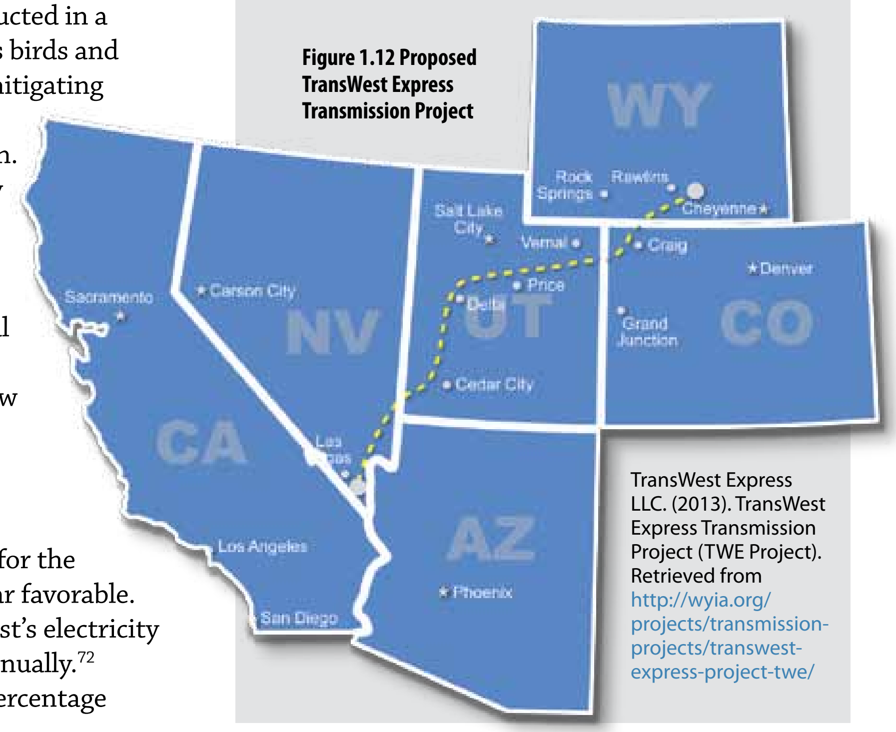
An additional challenge for wind power is the impact on birds and bats. According to estimates from the U.S. Fish and Wildlife Service, annual bird deaths attributed to turbines average at 2.19 per turbine per year.[71] Siting and permitting wind projects must therefore be conducted in a responsible manner that best protects birds and bats by preventing, minimizing and mitigating collisions, as well as related impacts such as habitat loss and fragmentation. Additionally, the wind power industry is working to reduce impacts on wildlife through pre-construction surveys, macro and micro siting techniques, and research on additional measures that can be employed. Such efforts include the development of new turbine designs and operational methods, as well as acoustic deterrents.

Given its record of growth, prospects for the American wind energy industry appear favorable. Today, wind supplies 6.75% of the West's electricity demand, with the amount growing annually.[72] If wind installations increase by 0.7 percentage

Wind Power Across the West: Interstate Cooperation

South-central Wyoming features some of the highest-capacity, lowest-cost wind energy resources in the country. Various project developers are working both to harness those resources and to provide California and Desert Southwest utilities with access to them. For example, TransWest Express LLC is developing the TransWest Express Transmission project. As the Figure of the proposed route indicates, this project is aimed at developing the shortest route possible for delivering low-cost wind power generated in Wyoming to meet energy demand in the Desert Southwest. The approximately 725-mile TWE Project proposes to cross four states following designated corridors as much as possible, and is the subject of comprehensive federal environmental analysis that began in 2008. Through interstate cooperation, the strong winds of Wyoming will eventually help complement and enhance the renewables produced in California, Arizona and Nevada, improving overall grid stability in the West and minimizing keeping ratepayer costs affordable.[74]

Figure 1.12 Proposed TransWest Express Transmission Project



TransWest Express LLC. (2013). TransWest Express Transmission Project (TWE Project). Retrieved from http://wyia.org/projects/transmission-projects/transwest-express-project-twe/

points per year (4,400 MW) wind will comprise 13 percent or more of the region's electricity needs by 2023.[73] Wind has succeeded in becoming competitively priced in the marketplace. However, in order for wind to stay competitive with other sources additional cost improvement advances are required, especially in the near-term. Limited access to markets is another issue to address. Many of the nation's best wind energy resources are found in isolated expanses of Western prairieland, where connecting to transmission networks is costly and difficult.

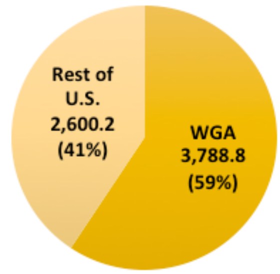
A complicating factor in getting renewable energy, and especially wind power located in states without significant electricity demand, from where it is generated to where it is needed is the process of obtaining construction permits for new transmission lines that cross federal lands and areas designated sensitive habitats under the Endangered Species Act (ESA). In order for the region to expand its clean energy capacity, the federal permitting process for transmission must become more efficient. Policymakers are currently engaged in ongoing discussions aimed at rectifying the need for land use and species protection with the desire to produce clean, domestic energy. Such efforts make a valuable contribution to addressing these conflicting objectives in a constructive fashion and should be encouraged to continue.

Solar

The largest potential renewable energy source in the West is solar energy. There are currently two dominant forms of solar power technology: Photovoltaic (PV) and Concentrating Solar Power (CSP). PV solar is the most widely used, generating electricity by arranging semiconductor materials into flat panel cells that directly convert sunlight using a phenomenon known as the photovoltaic effect. A variety of solar PV products are available in the market, each with distinct applications and attributes. Most common are flat-plated silicon solar panels, which are found on rooftops around the world.

Newer solar PV products, including roof shingles and flexible building integrated materials, offer innovative ways to integrate solar PV into a building when typical roof-mounted or ground-mounted systems may not be applicable. These panels can be deployed to generate power on a small scale for residential and commercial structures, as well as at utility scale through the deployment of multiple panels into a large array known as a solar park. CSP technology redirects and concentrates sunlight using mirrors and lenses to produce intense thermal energy that powers an electrical engine.

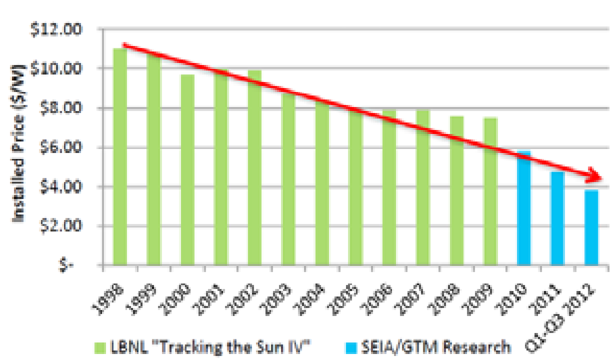
Figure 1.13: U.S. Total Solar Power Capacity in 2012 (MW)



Data provided by SEIA.

The American solar power industry has experienced strong growth, reaching a total installed capacity of 6,400 MW in 2012.[75] The majority of this growth came from PV solar. Five of the top ten solar PV states in the country, in terms of installed capacity, are Western U.S. states (California, Arizona, Nevada, Colorado, New Mexico). The Western states increased their solar PV capacity by more than 1,350 percent between 2006 and 2012. In 2012, California, already the nation's largest solar market, experienced a 60 percent growth in solar PV, making the state home to half of all installed solar PV in the U.S. by the start of 2013. According to the United States Energy Information Administration, PV installations accounted for approximately 5 percent of the total capacity additions during 2012.[76] This strong growth in PV solar has been attributed to the falling price of residential installations, which declined by 33 percent year-on-year from the third quarter of 2011 to the

Figure 1.13b: Blended Average System Price



Provided courtesy of First Solar

Solar in the Air Force: The Nellis AFB PV Park

The vital importance of military installations to the security of our nation demands the uninterrupted supply of electricity. At Nellis Air Force Base northeast of Las Vegas, this challenge is being met using the abundant renewable resources of the West. The Nellis Solar Power Plant is a PV park with 14.2 MW of installed capacity, enough to meet over a quarter of electricity demand on base.[79]

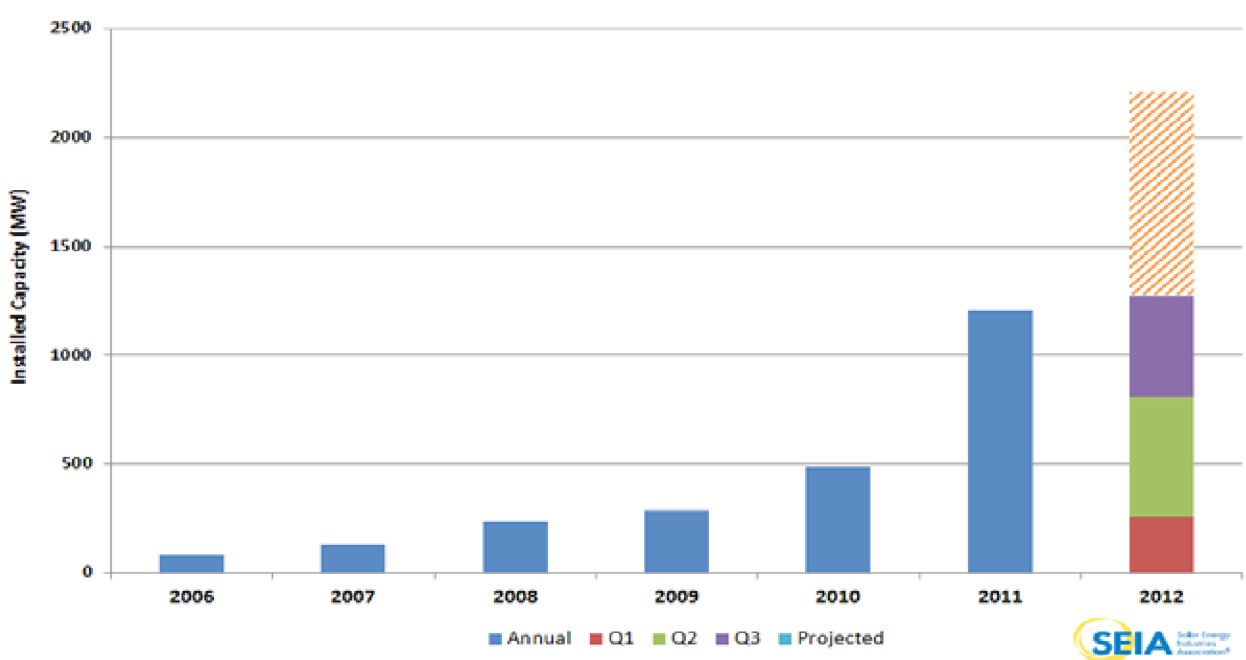
third quarter of 2012. The capital costs in 2012 for large-scale PV are around $2.50 per watt.[77]

Although CSP capacity growth remains limited, a number of projects are under construction that will bring more than 800 MW [78] of capacity online once completed in 2013.[80] Among these will be a new CSP plant in Irvine, California with a designed output capacity of 370 MW. The solar industry believes that if CSP plants with thermal storage expanded by 5,000 megawatts, it would lead to significant reductions in the cost of generated electricity, making solar a far more competitive energy source.[81]

The vast solar resources available in the West make it well suited to lead the country in utilization of this clean energy technology. According to recent NREL estimates, the region accounts for approximately 62 percent of usable PV solar potential.[82] California and Arizona have undertaken aggressive efforts to utilize this potential, which has made them the largest PV solar states in terms of installed capacity at 194 MW and 192MW respectively.[83] For CSP, NREL estimates that virtually all solar resources suitable for production are located in the West. Of all CSP power development projects currently under way, only one exists outside of the Western states.

A number of advantages come with the use of solar energy technology. In the case of PV solar, electricity generation can occur at any location where a solar panel can be properly installed. From the roofs of residential and commercial buildings to open tracks of land, PV offers the potential for emissions-free distributed generation. PV solar panels also require little maintenance other than cleaning the collection surface. Solar PV provides a multitude of grid benefits to utilities and, by extension, non-solar customers, including but not limited to: reduction in utility energy and capacity generation requirements, particularly during peak periods; reduction in system losses; avoidance or deferral of distribution and transmission

Figure 1.14: Annual PV Installed Capacity



Provided courtesy of First Solar

investments; localized grid support, including enhanced reliability benefits; and, fuel-price certainty.

An advantage of CSP solar is its capacity to generate electricity at utility scale with the potential to accommodate for variability. Many CSP projects now integrate Thermal Energy Storage Systems (TES) capable of storing the thermal energy in a medium such as molten salt, which is then drawn upon to power the electrical generator during periods of low sunlight or darkness. Advanced TES is capable of continuing CSP plant generation for six hours after sunset, on average. CSP with thermal storage is valuable in two ways. First, the times of the day when solar is most intense overlaps with the times of greatest electricity demand. CSP also deals with the issue of grid integration by minimizing variability and technology advances are enabling CSP to operate even closer to 24/7. Although TES does help to make the intermittency issue less acute in the case of CSP plants, these systems do add to the costs of a facility.

CSP plants are also compatible with the arid and semi-arid lands of the desert southwest since they can be built with dry cooling technologies that consume about 12 percent of the water needed for wet cooling. However, any thermal plant that is air cooled will lose 3 to 7 percent of the available power.[84] For CSP with 6-hours of thermal storage, capital costs are around $7.10 per watt and $4.60 per watt without storage.[85]

As with all technologies, solar faces challenges. As PV deployment increases, variability will be a growing concern, and one that the solar industry is working to overcome. Absent a cost effective and scalable energy storage system, PV cannot generate electricity during periods of darkness. Variability also represents a challenge with respect to grid reliability. Solar technologies also have relied on government support to compete with conventional generation. State mandated renewable energy generation requirements and tax incentive programs for the purchase of residential PV solar units continue to play an important role in encouraging solar deployment.

Net metering (a bill credit that allows electric customers to generate their own electricity) is one of the most effective policies for supporting

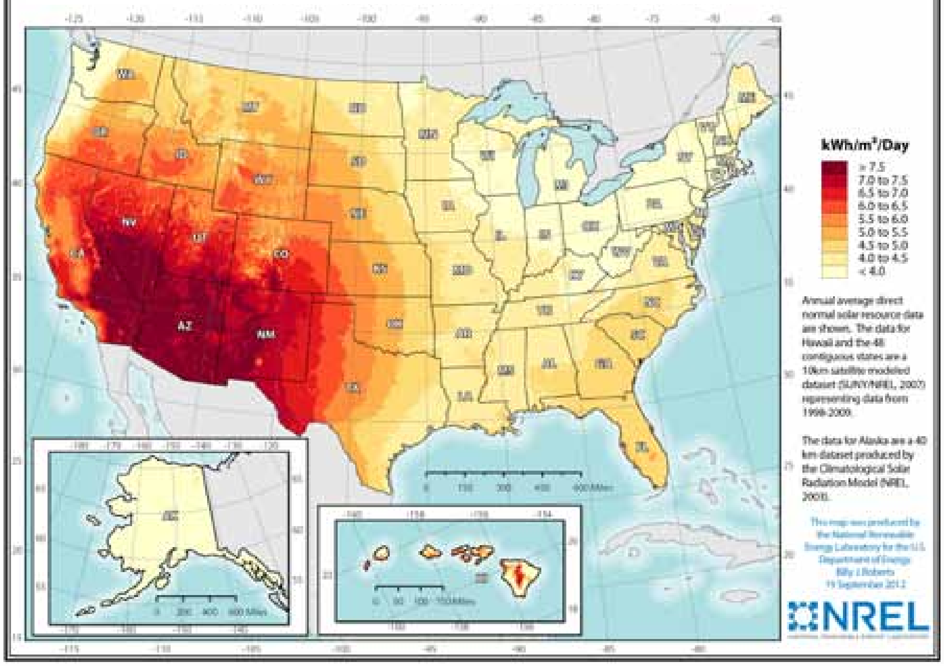
customer generation of renewable electricity. Texas, Idaho and South Dakota, however, have not enabled the use of net metering. Promoting and adopting best practices for net metering across the WGA footprint can be a key driver for the solar PV market.

Local jurisdictions in the West have distinct solar permitting requirements that create a highly inefficient patchwork of processes and fees that can dramatically increase the costs of a solar installation. Moreover, the solar industry and solar customers are unable to benefit from standardization across borders, adding further complexity and costs to the process. Promoting a streamlined, consistent permitting process across the West will help reduce the cost of distributed solar.

While the physical and electrical properties of PV do not vary by state or utility, the requirements for solar interconnection vary dramatically across the West, often making it cumbersome, expensive and time consuming to interconnect to the grid. Consistent application of reasonable interconnection procedures is an appropriate strategy to address safety and reliability concerns.

As the American solar power industry continues to develop, a number of obstacles to large-scale deployment must be overcome. Unfavorable market conditions resulting from a combination of slow economic growth relative to earlier periods has limited investments in CSP solar, given the large up-front capital costs ranging from $7-$9 million per MWh for a plant with integrated TES.[87] A large-scale PV facility costs $3 million per MW. Solar power is fueled by free solar radiation. Whether PV or CSP, installations cannot offset initial capital expense through expensing fuel. Given that CSP is also viewed as a relatively new technology, there is a

Figure 1.15: Concentrating Solar Resource of the United States



NREL. (2012). Solar Maps. Retrieved from http://www.nrel.gov/gis/solar.html

higher level of perceived risk among investors. This perception is further exacerbated by uncertainties with respect to incentives and regulation. Indeed, the market currently offers little incentive to deploy renewable energy solutions like CSP to meet peak energy demand. Additionally, utilities in many states with renewable portfolio standards have met their targets ahead of schedule and do not require additional renewable generation capacity.

Even when financing is available, the development of a CSP power plant is a complex process. Sensitivity and cost can make the identification and purchase of large areas of suitable land difficult to obtain. Procurement processes are also varied across jurisdictions and are frequently onerous. Given that CSP power plants are situated in isolated areas, inadequate access to transmission and difficulties in the siting and permitting process present substantial challenges.

The prospects for solar power development in the West are favorable, but realizing this potential will require that technological hurdles continue to be overcome and prices continue to fall. And there are institutional obstacles that must be dealt with. For example, the administrative costs associated with the installation of residential PV units significantly add to the total cost and there have been scattered issues with homeowners' associations attempting to prevent households from installing PV units because of covenant restrictions.

Arizona Public Service (APS) Chooses PV

The dramatic cost declines in solar energy are changing the paradigm for resource procurement. In 2012, Arizona's largest investor-owned utility, APS, introduced an Integrated Resource Plan that included a resource procurement option called the "Enhanced Renewable" option, which would take the utility's procurement of renewable energy to 22.8% of retail sales by 2025.

According to APS, the levelized price of solar PV is on par or cheaper than new fossil fuel alternatives. In addition, there is no fuel risk and minimal to zero water use. The utility noted in its plan that the Enhanced Renewable option "provides a resource mix that significantly reduces the Company's reliance on natural gas and its associated price volatility. In addition, it envisions that more than 90% of future energy growth is met by clean energy resources." [86]

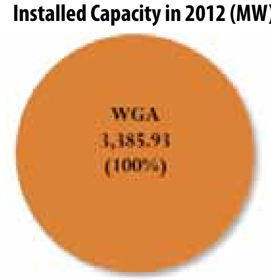
Geothermal

Conventional Geothermal Power

Geothermal power plants utilize thermal energy created by the earth, available at or near the surface, to generate electricity using a thermal engine. In 2011 the eight states that produced commercial geothermal energy (California, Nevada, Utah, Oregon, Hawaii, Alaska, Idaho and Wyoming) had a cumulative output of 3,386 MW.[88] Production is particularly significant in California, where geothermal is half of in-state renewable power production and 5 percent of total power production; and in Nevada, where geothermal now provides more than 10 percent of the state's in-state electricity.[89]

Geothermal production has grown steadily for the past six years, increasing by roughly 20 percent. Additionally, 2,000MW of geothermal power are in the development pipeline across the West. The Western states accounted for 100 percent of commercial geothermal energy produced in the United States in 2012, with 82 percent of that capacity in California.[90] Production in Hawaii met 20 percent of electricity demand on the Big Island during that year.[91] The role of the West only stands to grow in view of recent estimates from the United States Geological Survey. It found that not only are virtually all geothermal resources located in the Western states, but the total on-line power is barely 10 percent of the potential from estimated and undiscovered resources.

Figure 1.16: U.S. Geothermal Installed Capacity in 2012 (MW)



Western Geothermal Production in 2012 MW	
Alaska	0.73
California	2,732.20
Hawaii	38.00
Idaho	15.80
Nevada	517.50
Oregon	33.30
Utah	48.10
Wyoming	0.30
WGA	3,385.93
Rest of U. S.	0.00

NREL. (2013). Geothermal Maps. Retrieved from http://www.nrel.gov/gis/geothermal.html

The production of geothermal power is attractive in a number of respects. Although geothermal installations are not completely free of greenhouse gas emissions, the levels produced are negligible relative to conventional forms of generation. In fact, binary geothermal plants can be built today with zero air emissions during operation. Geothermal plants have the smallest footprint of any power plant technology, provide reliable 24/7 power, do not require water for cooling, and recycle all the geothermal fluid. The internal heat of the earth remains relatively constant at all times, allowing for a constant output level and baseload generation potential. The average lifespan of a geothermal plant is between 30 and 50 years, but the geothermal resource remains constant over time, allowing for the indefinite utilization of the given resource.[92]

Enhanced Geothermal Systems

A recent breakthrough that could transform the geothermal energy industry has been the development of Enhanced Geothermal Systems (EGS) technologies. EGS involves drilling wells to where hot, dry and impermeable rock is found, which is located at an average depth of 3 kilometers beneath the surface.[93] High pressure water is then pumped into the injection well, which widens natural fractures in the rock. A second well, known as the production well, then carries water heated by the rock back up to the surface, where it is fed into a system where steam is generated to power a turbine.[94]

Given that EGS is a recent innovation still in the experimental phase, reliable cost estimates for commercial scale production are still being refined. However, current estimates indicate that large-scale commercial EGS installations placed in areas with high resource availability could produce electricity at 3.6 to 9.32 cents per kilowatt hour.[96] As the Figure 1.17 shows, the West has vast EGS resource potential.

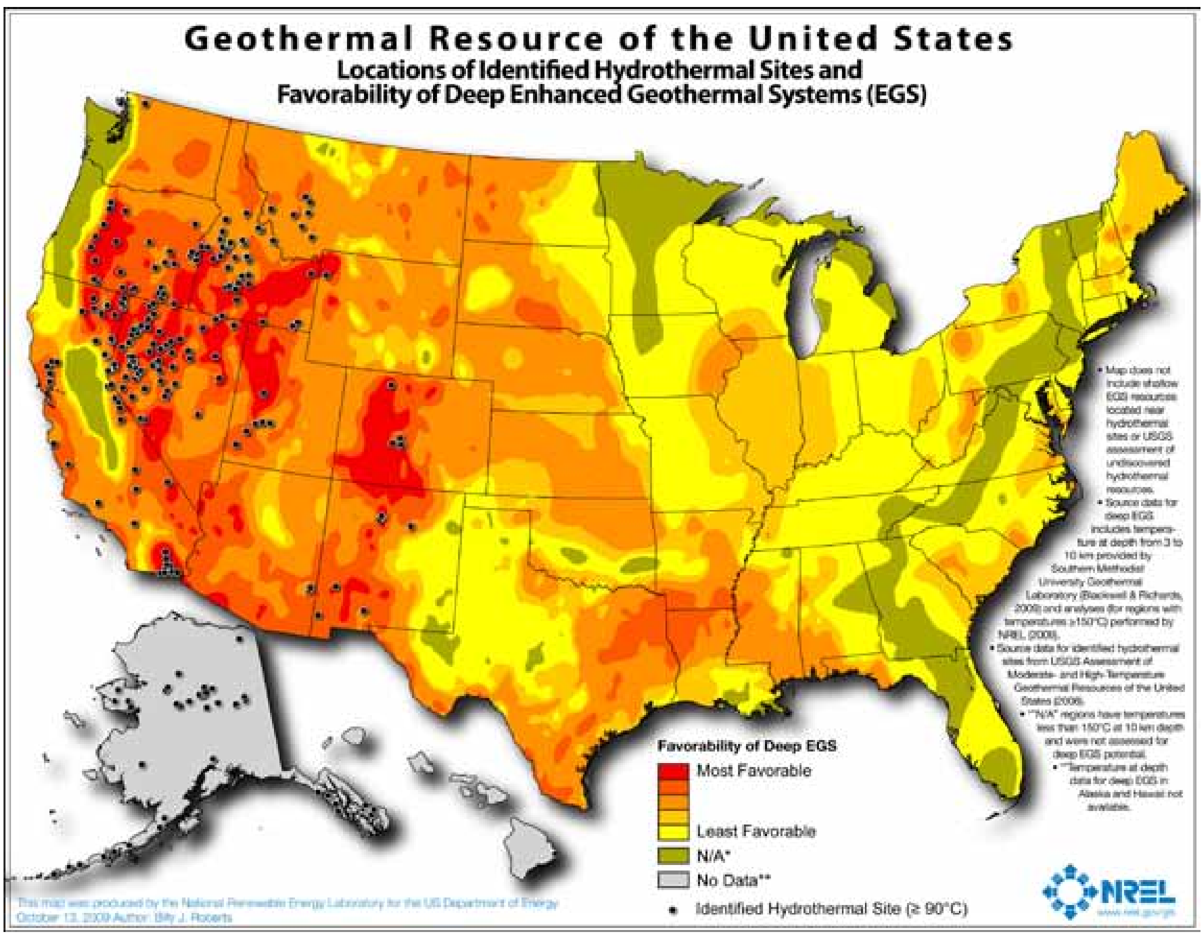
Although still a developing technology, the advent of EGS could allow geothermal power generation to expand as never before. Conventional geothermal power deployment is limited to a relatively small number of locations with specialized geological conditions, which limits deployment potential. The deployment potential of EGS is considerably greater. These installations can be placed virtually anywhere that geological conditions are stable and the underlying strata is well suited to accessing crystalline bedrock. As to the economic viability of a given EGS installation, the principal factor is access to land.

Since geothermal is independent of external fuel supplies, it is insulated from the market volatility in fuel prices. Geothermal is competitively leased, paying royalties where 50 percent of the revenues are returned to the state and 25 percent paid back to the county, in turn supporting local schools and other public programs.[97] Finally, there have been

California: World Leader in Geothermal Power

The single largest producer of geothermal power in the world is California. Current estimates place the 2,732 MW of installed capacity in the state above the next largest producer, the Philippines, by more than 800 MW. Aggressive expansion relative to installed capacity is expected in the state over the next several years, with more than 1,000 MW of capacity currently under development. With virtually all of the most productive areas for geothermal generation located in the West, the case of California may set a trend for future development of this clean energy resource.[95]

Figure 1.17: Geothermal Resources of the Western States



DOE. (2013). Geothermal Maps. Retrieved from http://www1.eere.energy.gov/geothermal/maps.html successful demonstration projects showing there is a real near-term potential for co-production of geothermal power from oil and gas wells across the Western states.

The American geothermal industry faces a number of challenges. With respect to conventional methods of generation, much of the known resource base has already been utilized, so it will be important for geothermal to gain access to untapped resources. Given that it is not limited by the same constraints as conventional geothermal, EGS holds significant promise to move the industry forward. The placement of an EGS plant near a small population center can help maintain energy security across the grid through decentralization. Indeed, stations of this kind could be used to meet much of the electrical power needs of isolated towns in places such as rural Wyoming and Nebraska, or even at military installations.

The complexity of developing EGS projects presents additional challenges for future development. Given that it is a recent innovation, the perceived risk associated with EGS disincentives investment. The risks inherent in finding and developing resources further exacerbate perceived risks during the exploration phase. Once a suitable location is identified, there a difficult and time-consuming permitting and environmental review process is required. According to estimates from the National Renewable Energy Laboratory, the typical project can take over seven years to bring to completion. Additionally, geothermal co-production needs further demonstration to convince oil and gas operators that there is no risk of disruption to their operations.

EGS offer the potential for transformative growth in the geothermal industry. Given the potential for such installations to be cited a substantially larger number of locations than traditional geothermal, EGS can contribute to distributed generation and provide well-paying local jobs to the communities near which it is deployed. However, additional support into research and development into this technology is required before it is ready for commercialization.

Geothermal Heat Pumps

A geothermal heat pump (GHP) is a central heating and/or cooling system that pumps heat to or from the ground. It uses the earth as a heat source (in the winter) or a heat sink (in the summer). This design takes advantage of the moderate temperatures in the ground to boost efficiency and reduce the operational costs of heating and cooling systems. GHPs provide a renewable, distributed energy supply that reduces peak electricity demands and mitigates the need for new generation and transmission.

Geothermal heat pumps have been in use since the late 1940s. They use the constant temperature of the earth as an exchange medium instead of the outside air. This allows the system to reach fairly high efficiencies (300% to 600%) on the coldest winter nights, compared to 175% to 250% for air-source heat pumps on cool days.[98]

Although many parts of the country experience seasonal temperature extremes–from scorching heat in the summer to sub-zero cold in the winter–at 20 feet below the earth's surface the ground remains at a relatively constant temperature all year. Like a cave, this ground temperature is warmer than the air above it during the winter and cooler than the air in the summer. The GHP takes advantage of this by exchanging heat with the earth through a ground heat exchanger.

As with any heat pump, geothermal water-source heat pumps are able to heat, cool, and (if so equipped) supply a house with hot water. Relative to air-source heat pumps, they are quieter, last longer, need little maintenance, and do not depend on the temperature of the outside air.

GHPs provide cost-effective heating and cooling in all 50 states for residential, commercial and government/institutional facilities, including many businesses, public schools and U.S. military facilities. Although they are a proven and valuable technology for reducing the thermal loads of buildings, GHPs are an underutilized technology across the West. GHPs provide a renewable, distributed energy supply that reduces peak electricity demands. They are very clean, reducing CO_2 emissions from the average residence by 63 metric tons over a 20-year operating cycle.[99]

The use of GHP technologies has grown rapidly across the nation and the west during the past 20 years, although it has been slowed by the recent recession and the availability of inexpensive natural gas. Still, innovations leading to high efficiency GHP installations hold great promise to attract new consumers. GHPs slash the thermal loads and energy use of buildings by up to 70 percent.[100]

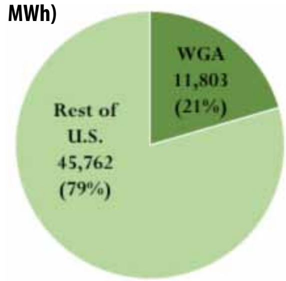
There are a number of challenges associated with GHPs. For the Western states to realize the full potential of GHP technology innovations, the cost of hard rock drilling and pipe grouting in soils with poor moisture retention must be reduced. Many electric utilities have not explored the potential of how GHPs can help cut summer peak demand and build load during the winter months.

There can also be a lack of understanding of the technology on the part of state agencies, leading to misguided regulations. Different rules and regulations in each state and jurisdiction raise costs and risks for the GHP industry, especially for system designers and installers. Currently, installation costs are high compared to conventional heating and air conditioning, but this can be reduced if there is a greater adoption of the technology and as economies of scale in equipment production and installation are achieved.

Biomass

Biomass is a blanket term describing the utilization of organic material as an energy source, either through direct combustion or conversion into a fuel. From the combustion of forest biomass “waste wood” for heat and electricity generation to refinement of solid waste into a combustible gas to the distillation of ethanol from energy crops, biomass energy sources offer a diversity of uses and are abundant in the West.

Figure 1.18: U.S. Total Biomass Electricity Generation (Thousand MWh)



Western Biomass Electricity Generation in 2011

Thousands of MW

Alaska	--
Arizona	203
California	6,327
Colorado	65
Hawaii	288
Idaho	504
Kansas	61
Montana	--
Nebraska	67
Nevada	--
New Mexico	10
North Dakota	7
Oklahoma	297
Oregon	698
South Dakota	--
Texas	1,694
Utah	59
Washington	1,523
Wyoming	--
WGA	11,803
Rest of U.S.	45,762
U.S. Total	57,565

EIA. (2013). Electric Power Monthly with Data for March 2013. Retrieved from http://www.eia.gov/electricity/monthly/pdf/epm.pdf

Wood is one of the most heavily used sources of biomass energy in the United States. Formed into shavings or pellets, wood biomass is used as a direct source of heat and in electricity generation. There are several sources of wood biomass, including harvesting forestlands for timber, small trees and brush from land clearing and landscaping operations on private and public lands, the reprocessing of wood residues from manufacturing, and recycling post-consumer materials. The use of wood biomass for energy production is prevalent in the wood and paper products industry, where manufacturing byproducts are used to generate steam for process heat and sometimes electricity co-generation.

Biomass is also derived from a process known as waste-to-energy. This process entails using municipal solid waste (MSW) to generate electricity by way of combustion. Approximately 80 of every 100 pounds of MSW produced in the United States is suitable for combustion.[101] In 2011, the 76 American waste-to-energy plants were used to produce steam for heating and generate 14 million kilowatt hours of electricity. Waste-to-energy plants serve an important function of reducing the amount of material that must be disposed of in landfills.

MSW is not the only source of biomass energy derived from waste. Biogas is another form of biomass energy that can be captured from landfills and animal waste. With respect to the former, the breakdown of organic waste in landfills produces

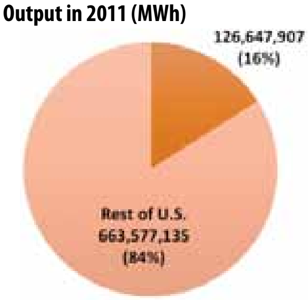
Biomass Energy in Idaho

Efforts to provide clean, local energy have made Idaho one of the leading biomass energy producers in the West. Biomass sources provide approximately 9% of total energy consumption in the state. The University of Idaho, for example, has been heating its main campus with wood for 25 years, saving Idaho taxpayers as much as $2 million per year by burning residues from local sawmills instead of natural gas. Several wood products manufacturing plants have electricity co-generation facilities that produce renewable energy. Idaho has demonstrated how others can realize the promise of wood bioenergy in the West. [103]

methane that can be captured and used in the same fashion as natural gas. There are currently 594 landfill energy projects operating across the country, the majority of which are located in California. [102] Animal waste derived biomass is produced using solid animal waste processed in large tanks where anaerobic bacteria cause decomposition and the production of methane gas. Both forms of biogas can be used on-site to generate electricity or sold to local utilities. According to the most recently available estimates, the West leads the nation in operational landfill energy sites.

Biomass in some ways is the simplest form of renewable energy currently being used in America. For example, humans have always used wood to heat homes and cook food. In other ways it can be complex because while energy is often perceived as the lowest value use for wood, it is also the most versatile source of renewable energy. It can be used in thermal electric power production and transportation applications. With that complexity of opportunities come challenges. In states where renewable portfolio standards include biomass energy, the use of wood to produce electricity to meet those renewable portfolio standards should be monitored to assess the impacts of not only greenhouse gas emissions, but also forest growing stocks that uptake carbon dioxide from the atmosphere and store it. The impact of forest management on air and water quality, as well as sensitive species, is carefully regulated by federal law.

Figure 1.19: U.S. Nuclear Power Output in 2011 (MWh)



Western State Nuclear Power Generation in 2011

MWh

Arizona	31,277,863
California	36,663,247
Kansas	7,318,888
Nebraska	6,933,174
Texas	39,648,457
Washington	4,806,278
WGA	126,647,907
Rest of U.S.	663,577,135
U.S. Total	790,225,042

EIA. (2013). Electric Power Monthly with Data for March 2013. Retrieved from http://www.eia.gov/electricity/monthly/pdf/epm.pdf

Nuclear Power

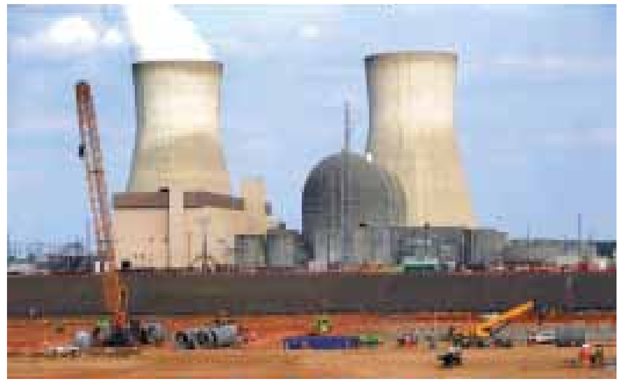
Nuclear power is the fourth largest contributor to the American energy mix. According to the Energy Information Administration, that production accounted for 19.2 percent of all electricity consumed nationally in 2011.[104] Western nuclear generation contributed 16.6 percent of the total, with 14 of the nation's 104 reactors located throughout the region.[105] Included among these is the Palo Verde Nuclear Generation Station in Arizona, which is the single largest nuclear power plant in the United States. The three reactors in service at the site have a cumulative installed output capacity of 3,942 MW, enough to power 3.1 million average American homes.[106]

There has been little growth in nuclear reactors since 1978, when the U.S. Nuclear Regulatory Commission (NRC) issued the final license for construction of a new nuclear reactor approved during the 20th century. Though several reactors licensed by that year were constructed during the intervening decades, it was not until 2012 that the NRC issued another license to construct a new nuclear plant. A consequence of this freeze: Many American commercial nuclear reactors have approached or exceeded their originally permitted life of 30 to 40 years. Energy Information

Administration estimates indicate that the average age of a reactor in the American fleet is now 32 years old.[107] However, the NRC does allow operating licenses to be renewed for an additional 20 years past the original term if the reactor and installation pass exhaustive operational safety evaluation.

The cumulative output capacity of American nuclear power generation is not solely the product of the number of reactors, thanks to operational efficiency gains and upgrades to existing facilities. From 1978 to 1988 nuclear power, as a share of national electricity generation, grew from 12.5 percent to 19.5 percent. That share has remained at about 19 percent ever since, even as demand has increased. Additionally, increases in fuel cycle length has brought the average annual capacity factor – the percentage of the time the reactor is operational and not offline – from 65.5 percent in 1978 to 89.1 percent in 2011.[108] Since 1977, the NRC has approved 6,823 megawatts of electricity (MWe) output in power upgrades to existing reactors, the equivalent of six additional reactors.[109]

Nuclear power harnesses fuel with enormous energy relative to its size. A single fuel pellet, about the size of the tip of the little finger, produces as much energy as 149 gallons of oil, one ton of coal or 17,000 cubic feet of natural gas.[110] Five of these pellets are capable of supplying the electricity needs of an average American household for an entire year. The fuel required to provide the energy used by the average American for their entire lifetime would fit into soft drink can. If all expended fuel from the more than half century that our nation has had commercial reactors in service were collected, it would weigh approximately 63,000 metric tons and could be stacked 30 feet high on an area the size of a football field. Regarding the source of this fuel, American uranium mining operations are all currently located in the Western states.[111]



Spent nuclear fuel is thermally hot and highly radioactive, requiring special handling and equipment. This fuel is first stored in deep pools of water designed to withstand heat and contain radioactivity. After a minimum five-year period during which thermal and radioactive cooling occurs, spent fuel is moved to dry metal containers that are sealed within a concrete or metal shell. These containers are specifically designed to withstand extreme climatic conditions and even direct attack from projectile weapons; each has an intended lifespan of 60 years. However, a long-term storage solution for spent nuclear fuel has yet to be devised.

Southwest Regional Focus

The Palo Verde Nuclear Power Plant in Arizona

The nuclear power industry is growing in the West, as shown by the Palo Verde Nuclear Generation Station located near Phoenix, Ariz. With three individual reactors and a combined output capacity of 3,810 MW, it is the largest nuclear power plant in the country. This installation plays an important role in meeting energy demand throughout the Southwest, providing an excellent example of how nuclear power can contribute to future energy development in the West.

All nuclear reactors currently operating in the United States have an output capacity ranging from 800 to 1200 MW.[112] The reactor designs that have recently been approved by the NRC are all large reactors with output capacity comparable to those in the existing fleet, though all are of a new generation with regard to safety, operational simplicity and efficiency. These new reactor designs feature a variety of advanced features, digital control systems, including passive safety shutdown systems, core-melt catchers, additional redundancies in back-up safety systems, and dual reinforced containment domes. Such design features stand to prevent accidents and errors of the sort that resulted in the Fukushima Daiichi incident. However, the upfront costs associated with licensing and construction of such reactors make large-scale nuclear extremely capital intensive. For instance, the two new reactors approved for construction by the NRC in 2012 will cost an estimated $14 billion when completed.[113]

Nuclear power offers a number of advantages that make it well-suited to energy development in the West. In regional markets where there is growing interest in transition toward cleaner energy technologies, nuclear power offers baseload power with near-zero emissions. Land use requirements for nuclear energy are also small, with a 1,000 MW power plant necessitating only one square mile of land. Although the upfront capital cost of building a nuclear power plant are higher than other types of generation, the cost of fuel per kilowatt-hour is the lowest when compared to other fossil fuel facilities.

Although the immediate future of nuclear power appears to be the continued upgrading and deployment of large-scale reactors, a new generation of small reactor designs may provide an avenue forward for the industry. Small Modular Reactors (SMR's) provide an output capacity ranging from 25 to 300 megawatts. The small output of SMRs relative to large-scale reactors makes them well-suited to areas where the existing transmission grid infrastructure is insufficient to support a conventional reactor. Once additional advances in the technology have been reached, SMRs may prove a cost-effective means of providing baseload generation to small electrical markets, isolated areas, smaller grids, sites with limited water and acreage, military installations or areas where heavy industrial production require intensive power use. A key advantage of SMRs is that they are prefabricated. Rather than constructing the unit onsite, SMRs are constructed as a central location and shipped to the point of deployment. These units also feature a modular design, allowing for several to be grouped to best suit the power needs of a

Figure 1.20: Monthly Fuel Cost to U.S. Electric Utilities 1995-2011 (2011 cents per kWh)

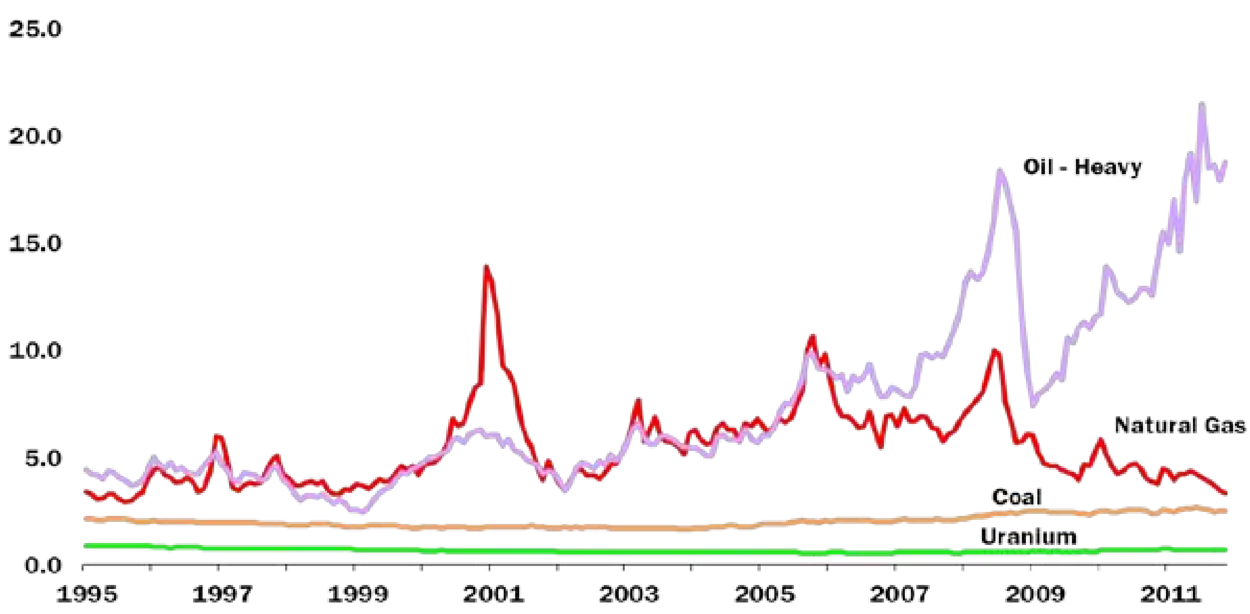


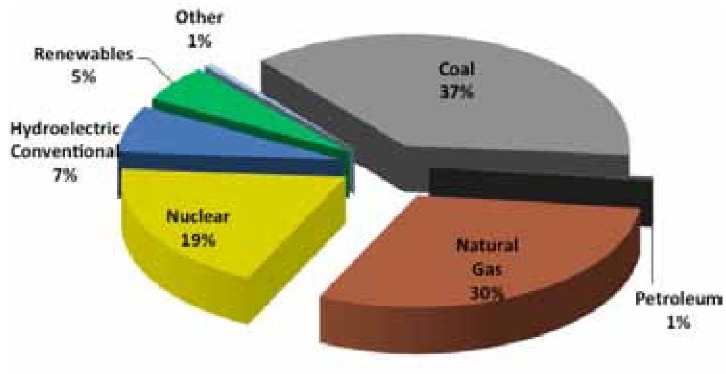
Image courtesy of NuScale Power

given community. An additional advantage of this design is that modular nuclear reactor stations can increase their input in response to demand with additional units.

Nuclear energy faces a number of challenges. The primary drawback to building new facilities is that large-scale nuclear power plants are highly capital intensive, costing in excess of $10 billion and taking years to amortize the initial cost.[114] One tool that has been successful in creating an initial cost reduction is a Construction Work in Progress (CWIP) allowance. A CWIP allows a utility to recover new plant construction costs as they are incurred, as opposed to requiring recovery of those costs only once the plant begins to operate and generate revenue. Although current ratepayers essentially assist future customers through a CWIP allowance, all customers avoid the shock of a substantial rate increase once the plant becomes operational.

In the West, availability of water for cooling is an issue. While a nuclear plant doesn't consume any more water than a combined cycle natural gas plant, it can have large withdrawal requirements if it is using "once through" cooling technology. This is problematic in many areas of the arid Southwest. It is also the case that certain areas in the West do not have the transportation infrastructure available to ship some of the larger items necessary for the assembly of a large-scale nuclear facility.

Figure 1.21: U.S. Electricity Generation by Source (2012)

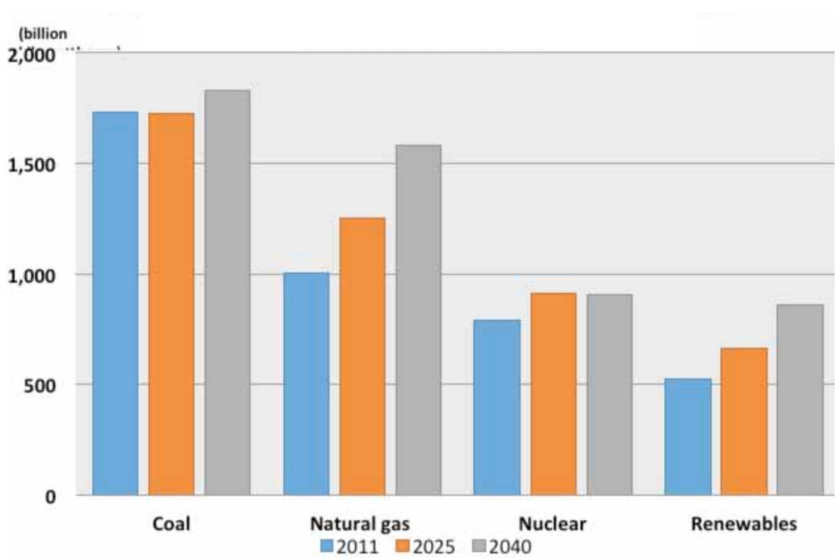


EIA. (2013). Annual Energy Outlook 2013.Retrieved from http://www.eia.gov/forecasts/aeo/MT_electric.cfm

Another challenge to the continued development of the nuclear power industry stems from obstacles to the commercialization of new technology. Small modular reactors hold substantial promise for the future, but industry estimates indicate that the Nuclear Regulatory Commission is not on track to license an SMR design until at least 2018.[115]

Perhaps the most difficult issue facing nuclear power is the disposal of spent fuel. Since there is currently no approved central repository for high-level waste, all spent fuel is being stored on-site at nuclear facilities. While the stored fuel is safe and secure, in the long run it will be advantageous to have a centralized storage facility.

Figure 1.22: Projected Electricity Generation by Fuel (2010, 2020, 2035)



EIA. (2013). Annual Energy Outlook 2013. Retrieved from http://www.eia.gov/forecasts/aeo/MT_electric.cfm

Chapter 2

Energy in the Pacific Rim

The state, territories and commonwealth in the Pacific Rim lack any conventional energy resources and are thousands of miles from the Continental United States. Because of this, the American Pacific Islands have long relied on petroleum imports to meet the majority of their energy needs. As the price of oil continues to rise and public concern about the possible impacts of rising sea level caused by greenhouse gases grow throughout the islands, reducing dependence on petroleum imports has become a priority.

Energy in Isolation: Procurement in the Pacific Rim

Energy development in the Pacific Islands followed the same basic course as elsewhere in the nation during the 20th Century. Inexpensive and plentiful fossil fuel resources led to the construction of infrastructure designed to utilize them. Given that the islands possess no fossil fuel resources, each is dependent upon imports to meet the majority of energy demand. The logistical challenge associated with the maritime transport of energy resources led to petroleum becoming the dominant fuel in both transportation and electricity generation.

Reliance on petroleum imports has resulted in a number of longstanding challenges to the American Pacific Islands. Chief among these is the state of acute energy insecurity that comes with reliance on external suppliers. Supply disruptions can result in severe energy shortages, with the potential loss of electric power for prolonged periods.[116] And for the state of Hawaii and the territory of Guam, where the armed forces have large installations that draw from the civilian power grid, supply disruptions can also pose a threat to national security.

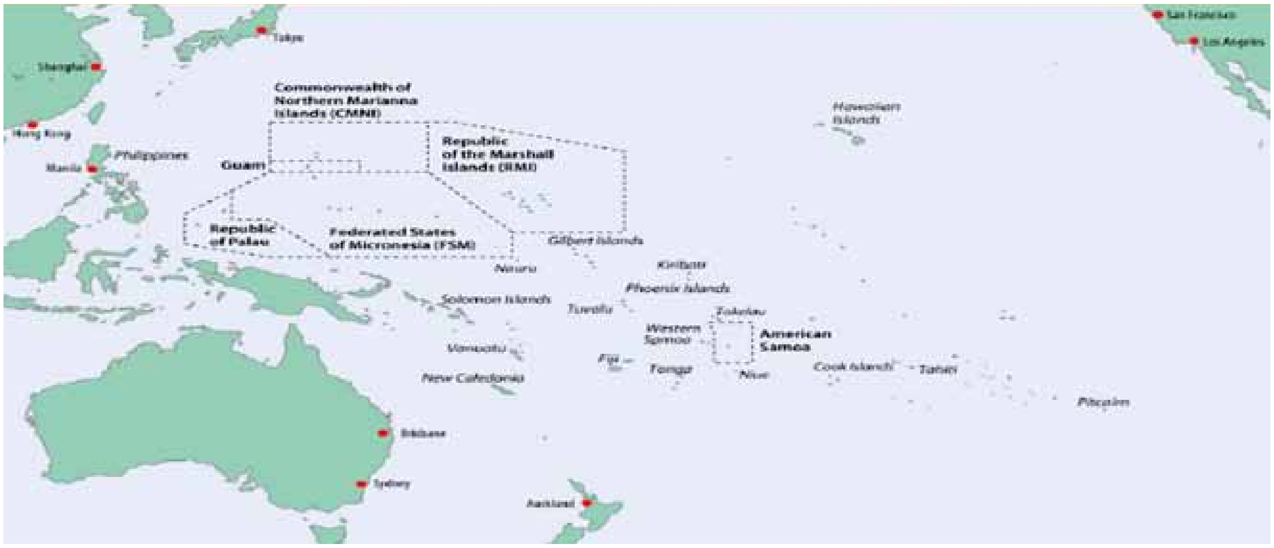
Distance of WGA Pacific Islands from Mainland
Miles

American Samoa	4,860
Guam	5,849
Hawaii	2,471
N. Mariana Islands	5,869

The use of petroleum for the majority of electricity generation also poses price stability challenges. Price fluctuations on the international oil market have long been a source of economic disruption in the United States, with rising fuel prices slowing economic growth and reducing disposable income for households. The extensive use of petroleum-fired power plants leaves the American Pacific Islands doubly vulnerable to sudden changes in the price of oil because of their impact on electricity prices. Indeed, the price of electricity in the islands is high even under stable market conditions. Petroleum-fired power plants generally produce electricity at higher costs per kilowatt-hour than other forms of generation. As the price of oil continues its steady ascent, so too will the price of electricity in the American Pacific Islands.

According to EIA data for December, 2012, the state of Hawaii produced 72.5 percent of its electricity using petroleum fuels.[117] The extent of petroleum use in electricity generation is similarly high in the territories and commonwealth, though

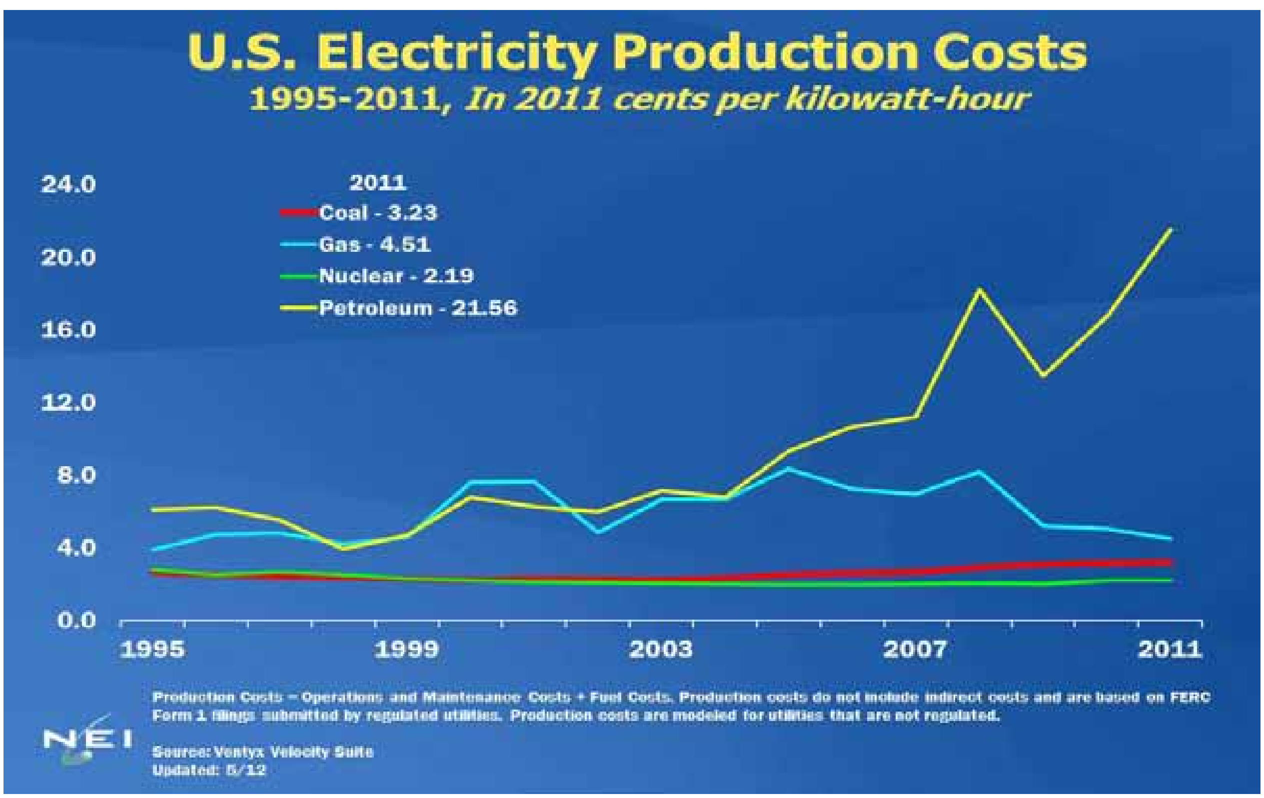
Figure 2.1



precise estimates are not currently available. When faced with additional factors ranging from the need to maintain reserves and the inability to develop large networks that produce economies of scale, the use of petroleum-fired generation has resulted in the American Pacific Islands having electricity prices higher than anywhere in the Continental United States.

Heavy petroleum dependence in the Pacific also presents a challenge with respect to American geopolitical interests. To obtain the fuel required, the territories and commonwealth in the South Pacific must look to nearby suppliers. In Guam, for example, much of the 15,000 barrels of petroleum the territory consumes daily is imported from Singapore, which procures oil for

Figure 2.2



resale on the regional market from Iran. [118] As a territory and important base of operations for American military forces in the region, Guam is dedicated to promoting the national security and economic interests of the United States. To this end, it is working towards developing partnerships to procure petroleum from domestic sources while also reducing demand overall.[119] Indeed, such efforts are also under way in the territory of American Samoa and the Commonwealth of the Northern Mariana Islands.

Energy Security and National Security

The Guam Military Buildup

In 2008, the United States and Japan signed an agreement that would result in the transition of 9,000 U.S. Marines out of Okinawa by 2014. Estimates from the Congressional Research Service suggest that the buildup will involve as many as 79,000 people in Guam at the peak of the transition, which would temporarily increase the territorial population by nearly 50 percent. This project will result in a massive increase in energy demand. Although the 2014 deadline is unlikely to be met, Guam faces the immediate challenge of how to develop infrastructure capable of supporting the buildup without compromising the energy security of its population. [120]

Energy Development Initiatives in the Pacific

Reliance on external suppliers of fossil fuels has resulted in pervasive energy insecurity and high prices throughout the American Pacific Islands. Further encouraged by environmental stewardship efforts aimed at maintaining the natural beauty that enriches quality of life and attracts tourism, each has sought to reevaluate energy use and harness existing resource reserves. In the case of the American Pacific Islands, this has led to the development of energy efficiency initiatives and investment in renewable energy projects.

Geothermal energy is among the most abundantly available renewable resources in the American Pacific Islands. For the Hawaiian Islands, this resource is derived from the volcanic activity that originally formed the islands and remains active. As to the territories and commonwealth, they are situated in a geological expanse referred to as the "Ring of Fire." This area is comprised of a nearly uninterrupted expanse of active volcanic arcs and belts, ocean trenches and points of tectonic activity.

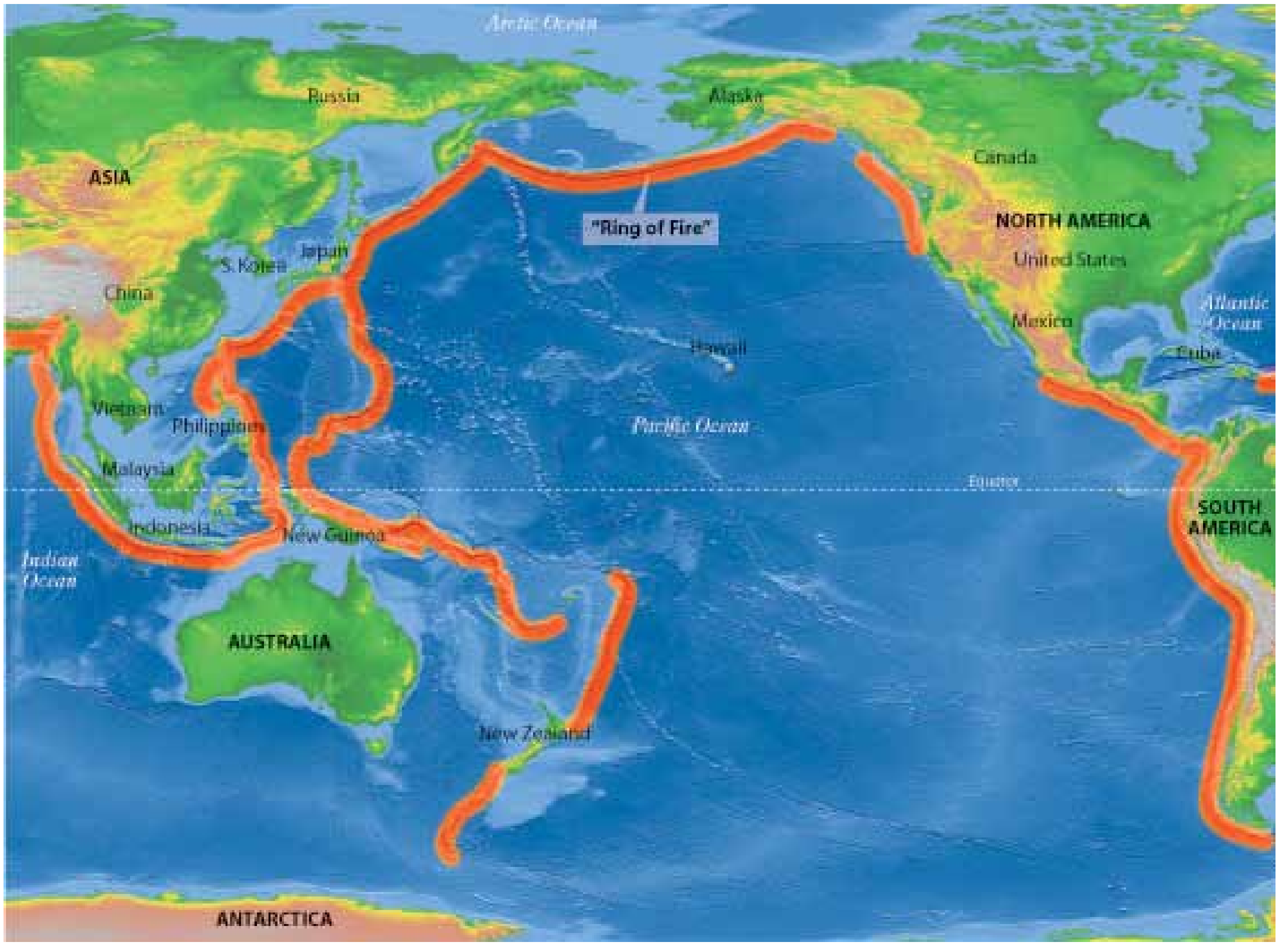
Hawaii has long utilized its geothermal resources to generate electric power. In 1982, a 3 MW test well was drilled in the district of Punu on the Big Island. A little over a decade later, the project had evolved into a full-scale geothermal power plant with an output capacity ranging up to 30 MW. [121] This single facility meets nearly 20 percent of all electricity demand on the Big Island, a success that has sparked interest in additional geothermal capacity[122] and seen continuing geothermal exploration in the south Maui and Kona areas.

The sunshine that makes the islands an attractive tourist destination also provides opportunities for solar energy development. Each of the four Pacific Island members of WGA are developing solar projects involving PV and CSP technology. American Samoa has been particularly active. In 2012, construction was completed on a 1.75 MW PV power plant jointly sponsored by the American Samoa Power Authority (ASPA) and the U.S. Department of Energy.[123] Once several other utility-scale projects are completed, the total solar power output of the territory will increase to 4.2 MW, enough to meet 23 percent of total baseload electricity demand.

In addition to harnessing available resources, the American Pacific Islands are working to reduce energy use overall. The Guam Energy Office has joined with the U.S. Department of Energy to offer a Weatherization Assistance Program to low-income families.[124] Efforts to improve energy efficiency have also included a $10 million grant from DOE to engage in projects ranging from a community education and outreach program on energy literacy to a comprehensive review for the retrofitting of public facilities.[125]

Strong ocean winds offer the potential to generate

Figure 2.3



Solar in the Aloha State

As the price of oil continues to rise, Hawaii has sought to incentivize the development of alternatives to the petroleum-fired generation that has left it with the highest average electricity prices in the nation. State tax credits covering 30 percent or more of new solar PV, solar hot water and solar attic fan installations have produced substantial growth. From 2011 to 2012, solar installations in Hawaii increased by 196 percent. This growth has made Hawaii the national leader in solar energy as a share of electricity, reaching 2.6 percent in 2012. [126]

electricity using wind power technologies throughout the American Pacific Islands. In recent years, the Commonwealth of Northern Mariana Islands has worked to assess and develop its wind power potential. The offshore wind power resources of the Commonwealth reach class 6 in some areas, which is double the minimum rating required for utility-scale generation and comparable to the high levels found throughout the Mountain West.[127] Discussions are currently under way for the development of a pilot project.[128, 129]

Challenges to Renewable Energy Development in the Pacific

Each of the American Pacific Islands has taken meaningful steps towards reducing energy use and harnessing renewable energy resources. However, utilizing renewables to meet the majority of demand can run up against limitations and pose costly resource allocation choices.

Entity	Square Miles
American Samoa	6,423
Guam	76
Hawaii	209
N. Mariana Islands	184

The American Pacific Islands face difficult tradeoffs with respect to land use for energy development. One of the principal challenges is the limited availability of land. Although Hawaii is larger than several Northeastern states, its area is noncontiguous. For the Commonwealth of the Northern Mariana Islands and the territories of American Samoa and Guam, available land area is severely limited even in comparison to Hawaii. Further, the high value of land per acre in the islands drives up the price of energy development projects. This is particularly challenging in the case of renewables.

Solar radiation is one of the most abundant energy resources in the American Pacific Islands, but the development of utility-scale installations can face major challenges with respect to land use. According to SEIA, the typical CSP power plant requires 5 to 10 acres of land per MW.[130] Although steady gains in the efficiency of PV units are reducing overall land requirements for utility-scale PV solar parks, these projects will continue to face the same challenge as CSP in the foreseeable future. However, rooftop PV units do offer an attractive small-scale option for electricity generation and water heating.

Across the Continental United States, utility-scale wind power generation has increased at a dramatic rate in recent years. Success has also been achieved in the American Pacific Islands, with a 21 MW wind farm on the Hawaiian island of Maui providing a

strong example of the wind power in the region.[131]

However, a number of challenges may constrain the potential for growth. Despite the availability of ample high wind resources, the average wind farm creates a direct permanent impact area of approximately 0.3 hectares per MW. [132] Given high property values in the Pacific Islands, the footprint of a utility-scale wind farm can be challenging from a land lease cost perspective. The large-scale utilization of wind power is also controversial in the Pacific because of its potential impact on the tourism industry. Whether on land or offshore, wind turbines are large structures that change the appearance of the landscape. For the islands, where tourism constitutes a major source of economic activity, concerns have been raised that the presence of wind turbines may have a negative impact on tourism.

Ample geothermal resources offer one of the most compelling and readily available renewable sources of energy for the American Pacific Islands. But as with other renewables, the development of a geothermal power facility depends on the availability of land. This poses an especially difficult challenge in the territories and commonwealth, where land is scarce. The nature of geothermal power generation, along the "Ring of Fire," also requires that special precautions be taken to ensure human health and safety. Unlike with dry steam deposits used in California and Nevada, volcanic geothermal can result in the release of toxins and heavy metals. [133] Thus, geothermal power plants in the Pacific must be located at distances that ensure nearby inhabitants are not exposed to the steam.

As innovation continues to drive efficiency gains in renewables, the tradeoffs associated with harnessing the energy resources will lessen in severity. However, the attainment of greater energy security at lower cost is an immediate priority for the American Pacific Islands. To that end, additional steps are being taken to import energy from the Continental United States and deploy promising new technologies capable of meeting present and future demand.

Future Energy Development in the Pacific: Prospects and Challenges

There are a number of potential avenues for energy development beyond those already under way in the American Pacific Islands. Emerging and established technologies offer substantial promise in meeting the growing energy needs in a responsible fashion.

• Liquefied Natural Gas

The Shale Gas Revolution that has driven domestic production to unprecedented levels has driven down natural gas prices for consumer across the Continental United States. Trade in liquefied natural gas (LNG) offers to extend these benefits to the American Pacific Islands, while also opening up new markets for producers. There is currently no appreciable trade in natural gas between the mainland and the islands. However, the rising price of oil and fall in gas prices has spurred interest in LNG among the Pacific Islands.

The state of Hawaii has expressed strong interest in diversifying its energy mix with the import of LNG. In August, 2012, the state's only natural gas company submitted an application to the Federal Energy Regulatory Commission (FERC) to allow for LNG containers ship deliveries in Hawaiian ports. The application was later dismissed, with FERC deciding that the import station in question

did not constitute a full-scale LNG terminal. Hawai'i Gas has also developed a three-phase, LNG-centered program aimed at providing emergency backup for existing utilities, increasing natural gas to meet greater consumer demand, and providing greater access to natural gas for industrial use.[134]

Guam has also expressed strong interest in procuring natural gas from the mainland. The influx of natural gas would allow for the conversion of petroleum-fired power plants to gas-fired generation, utilizing a fuel source that is approximately 15 percent less expensive and cleaner burning.

Despite greater interest in procuring domestically produced LNG from the Continental United States, provisions of existing federal maritime law place severe limits on the potential for exports to Hawaii and Guam. According to Section 27 of the Merchant Marine Act of 1920, commonly known as the Jones Act, the transportation of cargo between U.S. ports may only be carried out if the following criteria are met: (1) the vessel was constructed in an American shipyard, (2) is owned by an American citizen, (3) flies the American flag, and (4) has a crew consisting of at least 50 percent American citizens or permanent residents. There are currently no LNG carriers in the Jones Act fleet proper [135] and the last to be produced in an American shipyard was completed in September of 1980.[136] Of the 458 LNG vessels currently in operation, 11 were constructed in the United States. None of these currently fly the American flag and there are no LNG carriers under construction in U.S. ports.

Domestic LNG Carriers

America's Cup Act of 2011

Although there are no LNG carriers that fully comply with the Jones Act, there are currently three vessels permitted to ship LNG between domestic coastal ports. The LNG carrier vessels Virgo, Gemini and Leo were constructed at U.S. shipyards during the 1970s. Subsequent to construction, each was sold off to foreign buyers and all currently fly Marshall Islands flag. However, the passage of the America's Cup Act of 2011 provided these particular vessels with an exemption from the Jones Act. These three vessels represent the entirety of American domestic LNG shipping capacity among domestic coastal ports, with a collective capacity of 379,100 cubic feet. If this total were devoted exclusively to electric power generation, the output would be sufficient to meet the demand of approximately 4,000 households for a month.[137]

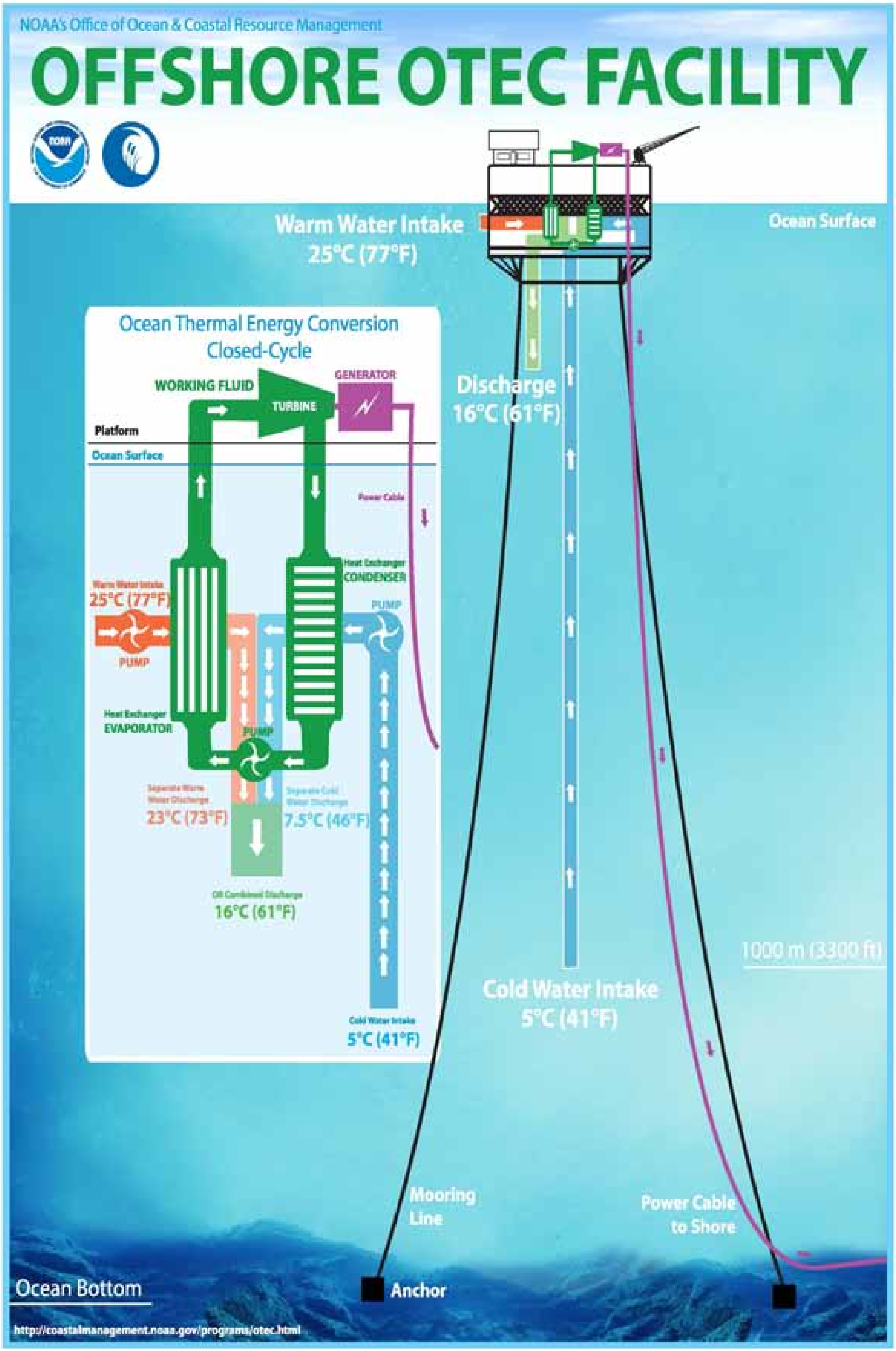
Given this limited transport capacity, Hawaii has called on the U.S. Congress to reform the Jones Act to incorporate exemptions for LNG exports to noncontiguous jurisdictions of the United States. There are other options, including the construction of LNG vessels in American shipyards. However, this option would require time and investment that will depend on market conditions. Another option would be the passage of a federal exemption from the Jones Act like the one recently awarded to Guam (46 U.S.C. 12111).

Should the Jones Act barrier be overcome, the opening of new markets stands to benefit natural gas producers and transmission companies throughout the West. A glut of inexpensive natural gas on the North American market has resulted in a slowing of production and exploration in areas such as Wyoming. However, this will depend on the increased utilization of existing LNG terminals, such as in Kenai, Alaska. Additionally, increased dependence on LNG from the Continental United States would likely also entail the development of new export terminals.

• Ocean Thermal Energy Conversion

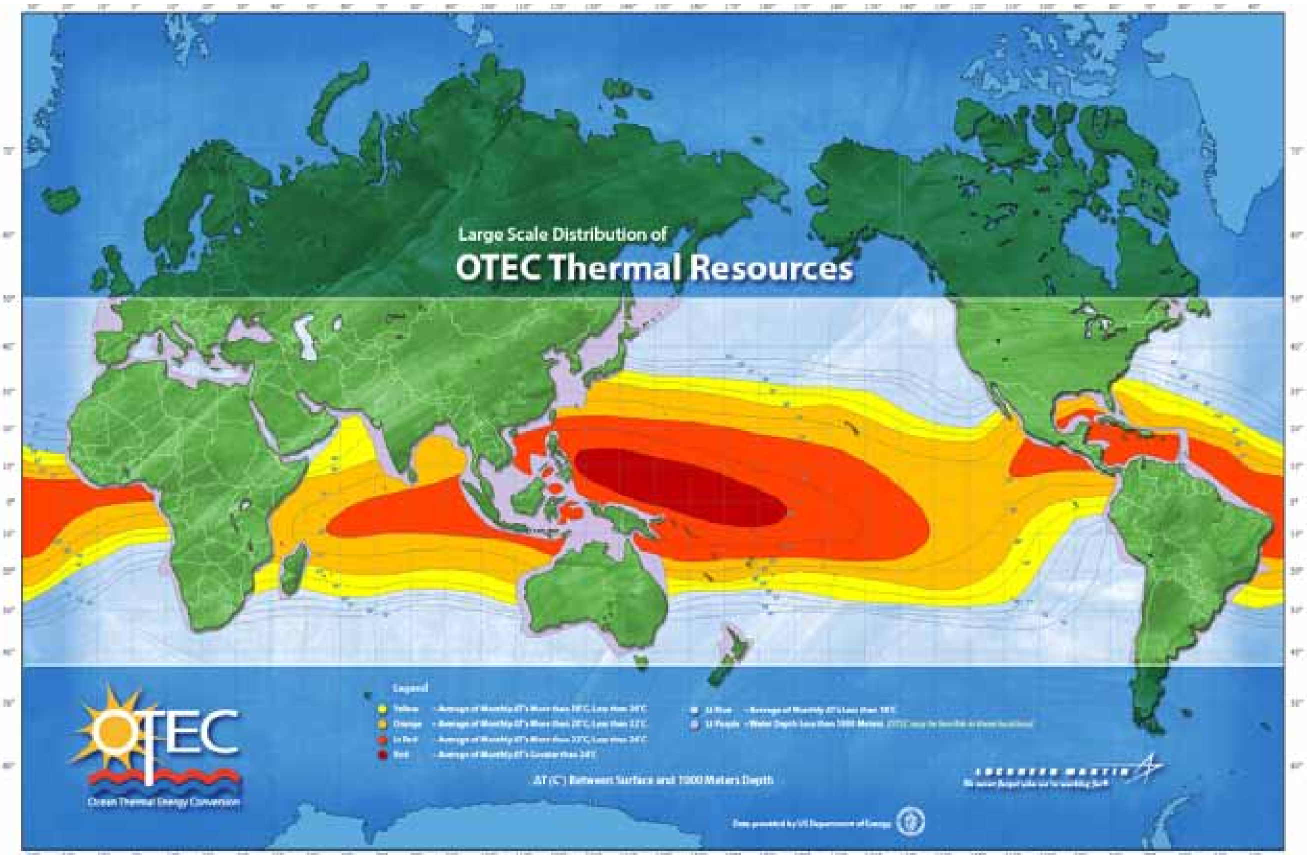
Ocean Thermal Energy Conversion (OTEC) offers another promising option for reducing energy import dependence in the Pacific. This technology uses the temperature difference between warm ocean surface waters and cooler temperatures found at depth to run a heat engine that generates electricity. This involves the deployment of floating platforms fitted with a conversion engine system, which includes an intake tube extending deep into the ocean and moorings to anchor the platform to a stationary position (see Figure 2.4).

Figure 2.4



NOAA. (2013). Ocean Thermal Energy Conversion. Retrieved from http://coastalmanagement.noaa.gov/otec/docs/oteconepage07202010.pdf

Figure 2.5



Lockheed Martin. (2013). Ocean Thermal Energy Conversion Overview. Retrieved from http://www.lockheedmartin.com/us/products/otec.html

As Figure 2.4 shows, OTEC facilities must be located at a distance offshore sufficient to reach depths with suitably cold water for intake. This requires the use of an undersea cable that transports electricity from the facility to the shore, where it is fed into the local transmission grid.

The advantages of renewable OTEC electricity generation are well-suited to the conditions and priorities of the American Pacific Islands. Given that electricity is generated through the cycling of deep and shallow water, OTEC facilities produce no greenhouse gas emissions. In fact, the carrying of nutrients from the ocean depths to the surface may produce ecological benefits to the area of the facility.

Since the temperature differentials used to power OTEC facilities remain constant at all times they represent a reliable source. This allows for uninterrupted power and makes OTEC suitable for use as a baseload source. Existing designs for OTEC facilities range in output from 10 MW to 100 MW. This allows for development of facilities specifically targeted to meet the existing and projected needs of the given community. Additionally, OTEC power plants can be used to produce hydrogen and serve as desalinization facilities.

The development of an OTEC facility depends on the availability of warm surface water temperatures. As the Figure 2.5 shows, the conditions for such development are favorable for all of the American Pacific Islands.

Given resource availability and the absence of land use involved in the deployment of OTEC, this technology is among the most promising for the American Pacific Islands and development is under way. In 2012 plans were announced for the construction of a 100 MW OTEC power plant off the coast of West Oahu, Hawaii. Slated for completion in 2018, this project will be among the first of its kind at an estimated cost of several hundred million dollars.[138]

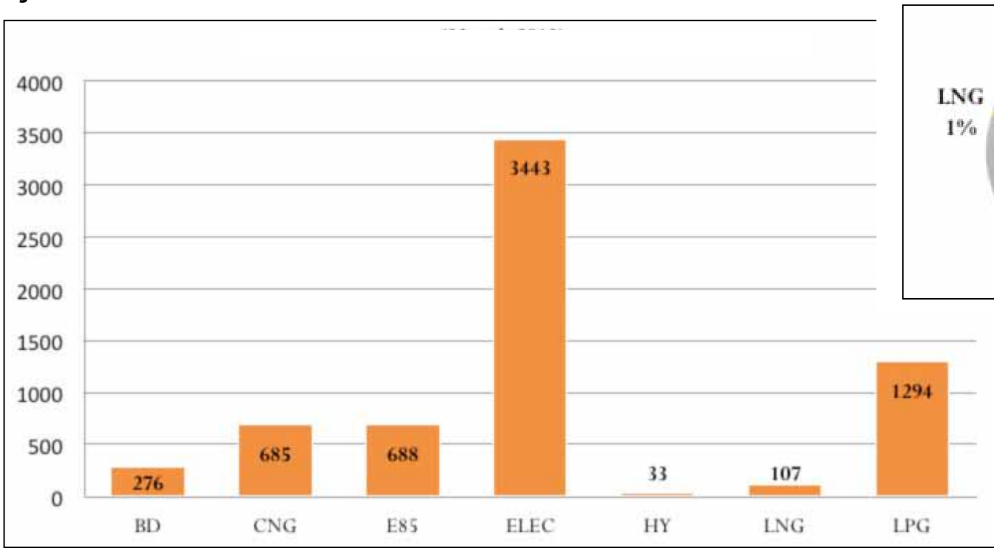
CHARGIN
STATION
Oregon

Chapter 3

Alternative Vehicles and Fuels

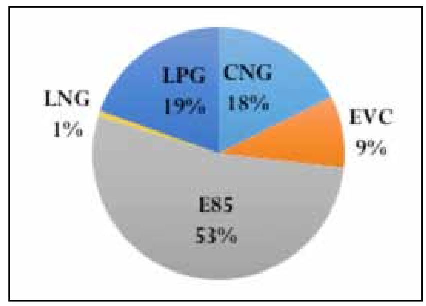
Reliance on petroleum in the American transportation sector is nearly absolute. In 2011 refined petroleum products accounted for 93 percent of all transportation fuel use nationally.[139] This dependence has been a critical factor in energy security discussions over the past several decades.

Figure 3.1: Alternative Fuel Stations in the West



DOE. (2013). Alternative fuel stations data set. Retrieved from http://www.afdc.energy.gov/data_download/

Figure 3.2: Alternative Vehicles in the West (2010)



EIA. (2012). Alternative Fuel Vehicle Data. Retrieved from http://www.eia.gov/renewable/afv/users.cfm

Natural Gas Vehicles

The abundance of domestic reserves and the ability to meet automotive emissions standards has made natural gas the most widely used alternative to petroleum fuel in the transportation sector. In 2011, natural gas held a 3 percent share of transportation-related energy use.[140]

There are two types of natural gas vehicles driven on American roads. Compressed natural gas (CNG) vehicles, fueled by a pressurized tank of natural gas, have a limited range relative to conventional automobiles because of the lower energy density of natural gas compared to petroleum fuels. CNG vehicles are most frequently used for high-mileage fleet vehicles with a limited operation range, such as delivery trucks and city buses.

Liquefied natural gas (LNG) vehicles are fueled by natural gas that has been cooled to -260 degrees Fahrenheit, the temperature at which it condenses into a liquid. Liquefaction condenses natural gas and allows for a greater amount of energy to be stored in the same amount of space. However, a cryogenic cooling system is required to keep the fuel in its liquid state. LNG vehicles are thus used primarily for medium and heavy-duty trucks with capacity to haul the additional weight required to accommodate the cooling system.

There are a number of advantages that come with utilizing natural gas as a transportation fuel. Natural gas is typically less expensive per unit of energy relative to gasoline. On average, natural gas costs between 79 cents to $1.50 per gallon of gas equivalent, making it an attractive option from a cost perspective.[141] According to the DOE, there are also fewer emissions associated with natural gas relative to conventional vehicles.

Several challenges must be recognized and overcome in order for NGVs to account for a greater share of the transportation sector. Although natural gas is less expensive per unit of fuel than gasoline and diesel, it also has a lower energy density than either. The difference in range depends on the type of vehicle, but the average NGV has a range of between 20 and 30 percent less than a conventional vehicle. The availability of NGVs on the market also remains limited, although options such as a CNG version of the Honda Civic do exist. While the conversion of a gasoline or diesel vehicle is possible, a professional conversion can range from $6,500 to $12,000. Once a vehicle has been obtained or converted, natural gas fueling station availability remains limited. There are currently 1,197 CNG stations and 66 LNG fueling stations in the United States, though these include both public and private fueling stations. [142]

Western CNG Fueling Stations *March 2013*	
Alaska	1
Arizona	34
California	271
Colorado	37
Hawaii	1
Idaho	8
Kansas	6
Montana	2
North Dakota	2
Nebraska	8
New Mexico	11
Nevada	7
Oklahoma	97
Oregon	14
Texas	61
Utah	90
Washington	23
Wyoming	11

DOE. (2013). Alternative fuel stations data set. Retrieved from http://www.afdc.energy.gov/data_download/

The West leads the country in terms of NGV fueling station availability. According to the Department of Energy, 55 percent of all CNG stations and 91 percent of all LNG stations are located in the Western states. California leads the nation with 271 CNG stations, more than double the next state. The Golden State is also the national leader in LNG stations, with its 41 accounting for more than quadruple the next state. Western states also account for 42.4 percent of all natural gas use in the transportation sector in 2010, with Texas leading the nation in use at 84.9 trillion BTUs. [143]

Hybrid and Electric Vehicles

Hybrid electric vehicles (HEVs) utilize a system that combines an internal combustion engine with an electric motor, the latter of which is powered by an electric battery. There are several HEV designs available on the market. A standard HEV captures the energy generated by braking to charge the onboard electric battery. The battery is then used to provide power to an electric motor that allows the internal combustion engine to shut off when the vehicle is at rest, increasing fuel efficiency and providing additional power when the vehicle accelerates.

Plug-in hybrid vehicles (PHEVs) can be driven for short distances and low speeds using battery power alone, with the conventional engine taking over for long distances and high speeds. Electricity for full hybrids is drawn by plugging the vehicle into the power grid, but many also feature a regenerative braking system that also charges the battery. Full electric vehicles (EVs) are vehicles powered exclusively by an electric motor powered by a battery. EVs feature larger batteries than hybrid electric vehicles, with electricity being drawn from both the power grid

Bipartisan Interstate Cooperation on Natural Gas Vehicles

Working together on a bipartisan basis, Gov. Mary Fallin of Oklahoma and Gov. John Hickenlooper of Colorado have undertaken a joint effort to help realize the promise of natural gas as a transportation fuel. In July of 2012, the governors met with senior executives from GM, Ford and Chrysler to discuss prospects for developing new CNG cars and trucks. By helping to lessen dependence on OPEC oil and give domestic natural gas producers a new market, the governors have provided a powerful how bipartisan efforts can improve energy security and foster economic growth in the West.

and a regenerative breaking system.

There are several advantages that suggest continued growth in the HEV market. Because these vehicles represent an evolution of conventional vehicles rather than a completely new alternative, the infrastructure challenges associated with gaining an increased share of the American automobile fleet is minimal. Mild-hybrid vehicles offer efficiency gains over conventional automobiles without the need for any changes to fueling infrastructure. As to PHEVs and EVs, the models available on the market require the use of a commercial electric charging station. There are currently more than 15,000 electric fueling stations across the country, making electricity the leading form of alternative fuel type in terms of station availability. In 2011, there were more than 2 million hybrid vehicles on American roads.[144] Recent estimates indicate that hybrids account for approximately 3 percent of all automobile sales nationally, a share expected to grow over the next 10 years.[145]

The West is leading the nation towards a cleaner national automobile fleet. According to recent market research, the top 15 markets for hybrid vehicles were in California, Oregon, Washington and Arizona. More than half of the 15,461 electric charging stations operating across the nation in February of 2013 were located in the Western states, with nearly a quarter of the national total found in California. State-level incentives aimed at promoting hybrid and electric vehicles are found throughout the West and range from purchase vouchers for vehicles to tax credits for charging equipment.

Both varieties of HEV produce emissions and require the use of petroleum-based fuels. However, the use of an electric motor offers a substantial efficiency gain over conventional automobiles, leading to fewer emissions and a reduction in overall fuel consumption per mile. The fuel economy gains of a hybrid vehicle depend on the particular model and use. Hybrid fuel economy is outstanding, with some of the plug-in hybrids rating close to 100 miles per gallon.[146]

Western State Electric Charging Stations

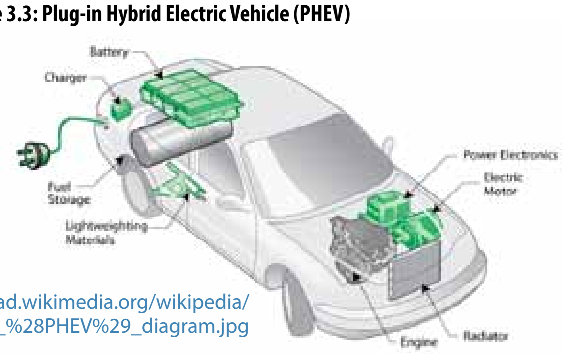
March 2013

Alaska	1
Arizona	231
California	1,471
Colorado	105
Hawaii	149
Idaho	10
Kansas	47
Montana	2
North Dakota	4
Nebraska	9
New Mexico	16
Nevada	30
Oklahoma	21
Oregon	345
South Dakota	8
Texas	546
Utah	47
Washington	401
WGA	3,443
Rest of U.S.	3,856
U.S.	7,299

DOE. (2013). Alternative fuel stations data set. Retrieved from http://www.afdc.energy.gov/data_download/

In order for hybrid and electric vehicles to realize their potential, several challenges must be met. The lithium-ion battery technology used to power electric motors remains expensive and requires a large amount of rare earth minerals relative to such devices as computers and mobile phones. Efforts to ramp up domestic extraction of our nation's rare earth mineral reserves must be undertaken to ensure that the increased reliance on existing battery technologies does not create an energy security vulnerability vis-à-vis transportation battery construction. Widespread adoption of PHEVs and EVs will also require that electric power generation be substantially increased to accommodate higher electricity demand, thus necessitating commensurate upgrades to the nation's electricity transmission network to handle the increased load. Difficult choices will be presented by this eventuality. If a critical goal is to reduce emissions by way of an effort aimed at the transportation sector, a balance must be struck between meeting demand and limiting energy-related emissions in the electric power industry.

Figure 3.3: Plug-in Hybrid Electric Vehicle (PHEV)



Wikimedia Commons. (2009). Retrieved from http://upload.wikimedia.org/wikipedia/commons/6/64/Plug-in_hybrid_electric_vehicle_%28PHEV%29_diagram.jpg

Alternative Fuels

Establishing greater control over the American energy security requires a reduction in the intensity of petroleum use in the transportation sector. Restructuring and diversifying the national transportation sector poses a significant challenge that cannot be solved with a single approach. A number of technologies and fuel types will contribute to improving the state of energy security in the United States. Alternative fuels offer great promise in working toward that goal.

Ethanol is currently the most widely used alternative fuel in the United States. Federal regulations currently require that ethanol be mixed with standard gasoline at an average of 15 percent by volume. However, purer ethanol fuel blends can also be used in flexible fuel vehicles. E85 is one such blend, with an 85 percent concentration by volume, producing lower carbon emissions in comparison to gasoline or diesel. American ethanol is primarily derived from corn; stations offering E85 are primarily located in the Midwest. In the West, E85 is most widely available at stations throughout California, Colorado and the Dakotas. As to the vehicles capable of running on E85, most are flexible-fuel vehicles with engines capable of running on higher concentrations of ethanol than standard vehicles. As of January, 2012, the West accounted for approximately 33 percent of national ethanol production.[147]

Biodiesel is another form of biofuel, derived from animal fats or vegetable oil, which can be refined into a pure diesel fuel or blended with conventional hydrocarbon-based diesel products. The blending of these fuels is advantageous from an emissions perspective, since biodiesel produces fewer toxic emissions than conventional diesel. B20 is the most commonly used form of biodiesel blend in the U.S., consisting of 20 percent biodiesel and 80 percent conventional diesel. This blend is compatible with a number of biodiesel vehicles while avoiding the problem of poor cold-weather performance associated with higher blends. The West accounted for nearly 30 percent of total biodiesel output capacity in 2012, with Texas leading the nation at 408 million gallons.

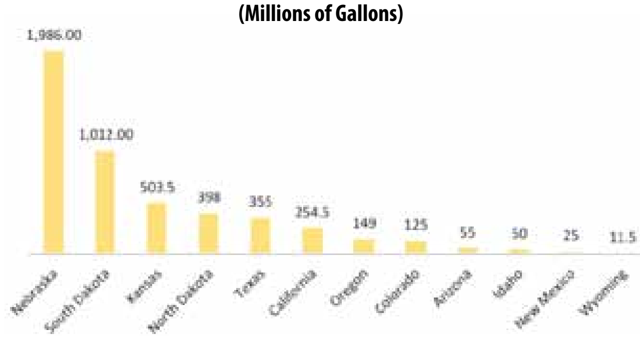
Western Biodiesel Output Capacity in 2012

(in millions of gallons)

Arizona	2
California	57
Kansas	1
Montana	0
Nevada	1
Oklahoma	15
Oregon	1
South Dakota	2
Texas	408
Utah	10
Washington	109
WGA	606
Rest of U.S.	1,521
U.S. Total	2,127

DOE. (2013). Alternative fuel stations data set. Retrieved from http://www.afdc.energy.gov/data_download/

Figure 3.4: Annual Ethanol Production Capacity in the Western States in 2012 (Millions of Gallons)



Nebraska Energy Office. (2012). Ethanol Facilities' Capacity by State. Retrieved from http://www.neo.ne.gov/statshtml/121.htm

Liquefied propane gas (LPG) is among the most widely available and commonly alternative fuels. As with other fossil fuels, LPG is used in transportation to power an internal combustion engine. There are currently 2,790 fueling stations in the U.S. that offer LPG (1,285 of which are in the West).[148] Texas and California are the national leaders in LPG transportation fuel availability, with 471 and 227 stations respectively. The application of LPG in transportation is similar to natural gas, typically being used to fuel such fleet vehicles as police cars and delivery trucks.

Methanol is a high octane form of alcohol that can be burned at a variety of concentrations ranging from 100 percent down to blends as low as 5 percent. There are currently no automobile manufacturers that offer pure methanol vehicles commercially, but a number of flexible fuel vehicles capable of running on methanol blends of up to 85 percent are available.[149] Although methanol has a lower energy concentration than gasoline, it is also cheaper. Feedstocks for methanol are widely available throughout the West and include biomass, natural gas and coal. According to a recent study by MIT, 10 billion gallons of methanol could be produced annually if 10 percent of domestic natural gas and coal production were employed in the production of the fuel.[150] The production and use of coal methanol is currently estimated to produce twice the level of GHG emissions as gasoline, despite the fact that it is used as a feedstock for approximately 25 percent of domestic methanol production. If the challenge of reducing these emissions to the point of parity with gasoline or lower can be met, a substantial new market for America's coal resources could emerge. With the average cost of converting a standard gasoline automobile to methanol fuel standing at only $100, efficiency gains in methanol production could make it a highly attractive alternative fuel.

Western State Hydrogen Fueling Stations

March 2013

Arizona	1
California	24
Colorado	1
Hawaii	2
Nevada	2
Texas	1
Washington	1

Source: DOE. (2013). Alternative fuel stations data set. Retrieved from http://www.afdc.energy.gov/data_download/

Hydrogen Fuel Cell Vehicles

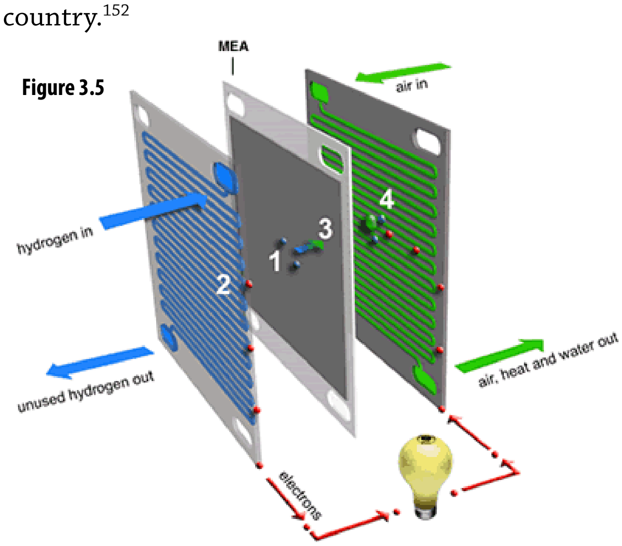
Hydrogen fuel cell vehicles (HFCVs) are powered by the conversion of chemical energy found in hydrogen into electricity. This electricity is used to power an electric motor to propel the vehicle in a fashion similar to an EV. The hydrogen used to power an HFCV is stored in a pressurized tank on board, which is fed into the fuel cell to generate electricity as needed. Because the generation of electricity involves only hydrogen and an oxidizing agent, the only tailpipe emission generated by the vehicle is water vapor.

Although hydrogen is the most abundant element on earth, it is not found independent of others. It must therefore be separated from other molecular compounds to which it has bonded. A number of feedstocks can be used in the production of hydrogen, including biomass, natural gas, water electrolysis using electricity and coal gasification.[151] The most common method of production is steam reforming of natural gas into hydrogen and carbon monoxide. However, even this most widely used process – employing relatively inexpensive feedstock – makes hydrogen prohibitively expensive as a viable mass market transportation fuel. According to the Department of Energy, the current average price of hydrogen production using a small-scale natural gas reformer would make the fuel approximately four times as expensive as gasoline, even before the application of a fuel tax.

HFCV technology remains in the early stages of development. Given the costs associated with both the production of hydrogen and the use of noble metals in many fuel cell designs, additional technological breakthroughs are required in order for HFCVs to become a compelling and commercially viable option. Although the majority of attention and investment in technological developments in the automobile industry have focused on hybrid and electric vehicles over the past decade, recent developments indicate a renewed interest in bringing HFCVs to market. In January of 2013, Daimler, Ford and Nissan announced a joint effort to develop a common fuel cell system that may bring fuel cell vehicles to the market as early as 2017.

The West is leading the way in the development of hydrogen fuel cell technology. Thirty-three of the nation's 58 hydrogen fueling stations are located in the region. Much of this development has occurred in California, a state that accounts for 41 percent of hydrogen vehicle fueling stations across the country.[152]

Figure 3.5



Chapter
4

Energy Efficiency

Stopping energy waste and using resources wisely is the cornerstone of any energy strategy. It has often said that the cheapest kilowatt-hour is the one that is never generated. In that sense, energy efficiency is a resource that can be developed just like any other resource.

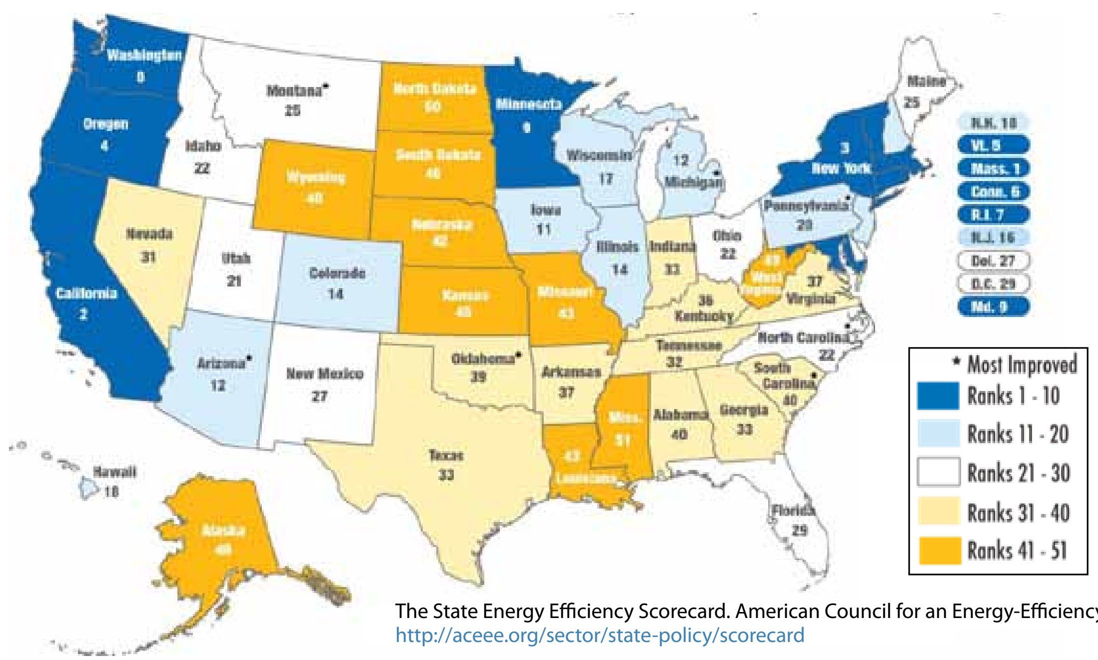
Energy efficiency is increasing in the West thanks to tighter building energy codes, utility energy efficiency programs, federal appliance and equipment efficiency standards, and technological innovation and market forces. Every year new energy efficiency measures, such as LED lamps, enter the marketplace and are being adopted by households and businesses.

Assessing the Benefits of Energy Security

The American Council for an Energy-Efficient Economy (ACEEE) grades states with respect to their energy efforts. In its most recent state energy efficiency scorecard, California ranked second in the nation and Oregon ranked fourth. In addition, Arizona, Colorado, Hawaii, Idaho, Montana, Utah and Washington were among the top 25 states (see 2012 Scorecard map).

Electric utilities in the region have ramped up energy efficiency programs and plan to meet the majority of future energy demand growth through energy savings from efficiency improvements. For example, the most recent Northwest Power and Conservation Plan calls for energy efficiency measures to meet 85 percent of regional load growth during the next 20 years.[153] Energy efficiency has been an important energy resource in

Figure 4.1: 2012 State Energy Efficiency Scorecard Rankings



The State Energy Efficiency Scorecard. American Council for an Energy-Efficiency Economy. 2013.
http://aceee.org/sector/state-policy/scorecard

Oregon's Energy Action Plan

Oregon is committed to meeting all new electric load growth through energy efficiency and conservation. As part of this, every state-owned building will establish baseline energy use, undergo an energy audit, and identify cost-effective retrofits.

California for more than 30 years, and is the "first resource" in energy procurement decisions today.

Energy efficiency improvements can provide a wide range of benefits, including:

- Lower utility bills for households and businesses;
- Increased business and industrial productivity & competitiveness;
- Reduced need for new power plants or transmission lines;
- Lower air pollution emissions;
- Less water consumption for power generation.

Even though great strides have been made in increasing energy efficiency in the past 20 years, the West still has vast untapped potential to stop energy waste. A recent study by the Southwest Energy Efficiency Project (SWEEP) estimated that best practice utility energy efficiency programs could cut electricity use in the Southwest 21 percent by 2020. Achieving this target would save consumers in the region $20 billion (net), avoid the need for 32 large power plants, support 28,000 new jobs, and cut CO_2 emissions by nearly 32 million metric tons per year.[154] Likewise, dynamic pricing and other demand response strategies present opportunities for large reductions in peak power demand.[155]

Residential buildings represent more than one-third of all electricity use and 20 percent of natural gas use in the U.S. Energy use per occupied home in Western states fell 27 percent between 1978 and 2009.[156] Significant additional reductions are possible through adoption of highly efficient lighting, appliances, heating and cooling systems, and improvements to building envelopes. Highly efficient new homes consume less than half the energy of typical homes constructed in recent years.

Reducing residential energy use in the Western region by 20 percent would save consumers around $20 billion per year.[157]

The industrial sector accounts for 31 percent of U.S. primary energy consumption. Industrial energy intensity declined significantly during the past 30 years due to a combination of structural changes and energy efficiency improvements. The WGA industrial energy efficiency report estimated that U.S. industry could reduce energy use 14-22 percent by 2020 through cost-effective energy efficiency improvements. [158]

Since manufacturing industries in Western states such as petroleum and coal, paper and food sectors are the largest sources of energy consumption, cutting manufacturing energy use in the Western region by 15 percent would save industries around $2 billion per year.

Commercial buildings account for about 35 percent of electricity use in the U.S. Office buildings, retail space and educational facilities in the Western region represent about half of commercial sector energy consumption. In spite of past progress, savings potential for commercial buildings continues

Energy Efficiency in California

35 Years of Outstanding Achievement

California has been a national leader in energy efficiency since key legislation was adopted in the state in the mid-1970s. Due to a combination of cutting-edge building energy codes, state appliance standards, and well-funded utility energy efficiency programs, electricity use per capita has remained nearly constant in California for the past 30+ years, while climbing more than 50 percent in the rest of the country. In 2010-2012 alone, investor-owned utilities in California were expected to invest $3.1 billion in energy efficiency programs for their customers and thereby save more than 8,000 GWh/yr, equivalent to the electricity consumption of around 850,000 average households.

Northwest Energy Efficiency Alliance: Transforming Energy Efficiency Markets

The Northwest Energy Efficiency Alliance (NEEA) is a non-profit organization working to transform the energy efficiency of products, services, and practices in the Pacific Northwest. NEEA has helped to expand the market for energy-efficient new buildings, lighting, appliances, televisions, commercial and industrial measures, and agricultural practices over the past 15 years. In addition, NEEA trains builders, contractors, energy managers, consultants, and other professionals. NEEA estimates that households and businesses in the Northwest are saving about 7,000 GWh/yr as a result of its efforts during 1997-2011—equivalent to the electricity use of almost 600,000 typical households in the region.

to be 30 percent or greater.[159] Cost-effective savings are available in all major end-uses: heating, cooling, lighting, refrigeration, electronic equipment and other plug loads. Reducing energy use in commercial buildings by 30 percent would save businesses in the Western region around $7 billion per year.[160] Energy efficiency can meet a significant part of the West's growing energy demand, but there are challenges and barriers that currently inhibit greater investment in energy efficiency.

Energy Waste: A lack of information and understanding

Many consumers are not aware of the opportunities and benefits of energy efficiency because they lack information. Because they do not understand the benefits, consumers often do not consider, or value, energy efficiency when replacing appliances or cooling systems. At the very least, it is difficult for them to make calculations of how switching to energy efficient lighting, windows, heating and cooling, or appliances can pay for itself. Generally, only very large businesses employ dedicated energy managers to investigate energy efficiency opportunities.

Obstacles to Energy Efficiency: Imperfect Markets, Financing Challenges and Regulatory Barriers

In many cases the entity designing, constructing or purchasing a building or major piece of equipment does not pay the operating cost and thus does not have an incentive to invest in energy efficiency. This is known as the "Split Incentives" barrier. This is true both in the commercial and residential sectors. In the commercial rental property, building owners have an incentive to keep initial construction costs low, and tenants pay the utility bills. As long as a building is competitively priced in the rental market, cutting utility costs often takes a back seat to limiting the initial capital investment.

In the same regard, households or businesses often lack capital to invest in energy efficiency measures. Plus, businesses often limit energy efficiency investments to those with a payback period of two years or less. Finally, fiscal incentive policies can discourage investment in energy efficiency; e.g., allowing businesses to expense energy purchases for tax purposes but not investments in energy efficiency.

Regulatory policies can discourage investment in energy efficiency. For example, the traditional utility model ties profit to electricity sales, but does not motivate or reward utilities that help their customers reduce electricity or natural gas consumption. Similarly, combined heat and power systems, a particular type of energy efficiency measure, often face a variety of regulatory and utility barriers.

While a great deal is being done by state and local governments, utilities, households, and businesses to realize the economic, comfort, and other benefits offered by improved energy efficiency, there are substantial gains left to be made.

Chapter 5

Electricity Transmission and the Transportation of Oil and Gas

The states in the Western Governors' Association footprint cover all of the five electricity interconnections in the United States. Alaska, Hawaii and most of Texas each have their own separate interconnections. The westernmost 11 states (plus British Columbia, Alberta and a small part of Baja, California) are part of the Western Interconnection, while the remainder of the country is part of the Eastern Interconnection.

The presence of a robust and reliable energy infrastructure system that delivers low cost energy is vital to America. Upgrading and building new transmission and pipeline infrastructure is the critical element for enabling the development of remote energy sources throughout the West and ensuring a reliable source of electricity. Reliable electricity is integral to "keeping the lights on," but also maintaining other infrastructure systems throughout the country.

System outages have serious financial consequences. The Southern California outage in September of 2011, for example, averaged only 9 hours of disruption, but was estimated to cause $100 million[161] in economic damage. This number could jump substantially in future years as the economy becomes more dependent on computerized controls, information technology and electronics. Furthermore, there is the lost opportunity for economic development associated with a weak transmission backbone.

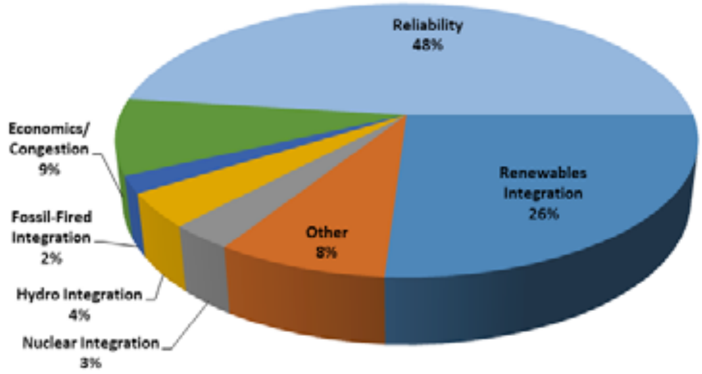
Projects for new renewable and gas generation facilities are abundant. However, the inability, associated with the lack of transmission, to move the generation to the load centers hinders construction and increases cost for consumers. This translates into lost jobs and tax revenue, as well as a more vulnerable, less flexible and resilient grid.

Transmission lines facilitate the efficient exchange of energy between regions, taking advantage of daily and seasonal diversities. This reduces the amount of new power plants that need to be built and helps keep rates low. Unfortunately, bottlenecks on much of the backbone transmission system are preventing additional exchange of energy.

Transmission Planning, Siting and Permitting

Meeting projected electricity demand growth requires the planning and the construction of new transmission lines in advance of the onset of that demand. Given that the majority of Western states have renewable portfolio standards in place that mandate a greater contribution of renewable energy as a share of state energy demand in the near future, the need for new transmission lines is clear. Additionally, the recent report by the American Society of Civil Engineers indicates that much of the 17,000 miles of high voltage transmission lines[162] currently planned at the national level may not be completed due to permitting obstacles. [163]

Figure 5.1: Relative Transmission Mile Additions > kV by Primary Driver (2011)



Silverstein, A. (2011). Transmission 101. Retrieved from http://www.naruc.org/grants/Documents/Silverstein%20NCEP%20T-101%200420111.pdf

The current siting and permitting processes frequently require duplicative efforts involving local, state, and federal agencies. This is particularly true if the project crosses Federal land and both a state permitting process and the National Environmental Policy Act (NEPA) process is required. Moreover, in the past some agencies have either overtly discouraged the use of public land for transmission and renewable projects or made it excessively difficult to get a project approved. In a June, 2012, report to the Governors, the key concepts to improve transmission included: improved coordination among state, local and federal agencies; robust outreach prior to formal permit application; collaborative planning processes to properly allocate staff resources and agency analysis.

As the above Figure indicates, the introduction of renewable energy generation accounts for over a quarter of transmission mile additions on a per mile basis. The primary contributing factor to this high share is the relative isolation of many renewable energy projects. For instance, factor capacities for on-shore wind power tend to be the highest in isolated regions in the mountain states. Utilization of these resources requires the construction of comparatively long transmission lines. However, the construction of new renewable power projects face difficulties with respect to having the required transmission lines approved.

The federal government holds direct ownership of nearly 640 million acres of land, with the vast majority in the West. Obtaining approval for the development of transmission lines across these lands requires a lengthy federal permitting process that can take from 8 to 20 years. As part of the American Recovery and Reinvestment Act, the Obama Administration sought to streamline the transmission approval process. However, this pilot project has only resulted in a handful of lines being targeted for expedited processing.

Constructing transmission lines requires a large investment in time and financial resources. The time it takes to build a line is not limited to the actual construction, but also the large amount a time attributed to planning, siting and permitting. While the siting and permitting process makes up 80 percent of the time to build a transmission line, it only consumes 20 percent of the cost.[164]

The Endangered Species Act (ESA), and other federal wildlife laws, can also present substantial challenges to the development of new transmission projects. The designation of a particular area as critical habitat that is essential for the recovery of a species can hold back or prevent the development of energy process across it. Any project that may "adversely modify" the habitat to the point where it can no longer aid in the recovery of a given species is prohibited under the ESA. Given that the Act empowers the U.S. Fish and Wildlife Service (FWS) and the National Oceanic and Atmospheric Administrations (NOAA) to designate any area of United States as critical habitat or potentially critical habitat, provided that there is sufficient evidence to show the presence of threatened or endangered species, the federal government can exercise ultimate authority over development on state lands.

The application of the ESA on state lands in particular has generated a substantial amount of controversy with respect to the comparatively limited role of state entities in the management of threatened and endangered species. The effectiveness of conservation and environmental policy may be enhanced through meaningful cooperation between state and federal authorities. The establishment of genuine partnerships may reduce friction at all levels of government and

maximize compliance by affording states a larger role in management decisions.

Collaboration among decision makers at all levels of government is imperative to an effective transmission planning process. For the past 15 years, the Western Governors have exercised critical leadership to initiate and improve Interconnection-wide transmission planning. At the height of the western electricity crisis in 2000-2001, Western Governors asked industry and state public utility commissioners to prepare a transmission plan in 90 days to alleviate the power shortage and skyrocketing electricity prices. In response, industry and western states collaborated to produce an Interconnection-wide "conceptual" transmission plan in 2001, ultimately institutionalizing the planning efforts under the banner of the Seams Steering Group-Western Interconnection (SSG-WI) between 2002 and 2006.

In 2006, with the backing of the Western Governors and others, the Western Electricity Coordinating Council (WECC) agreed to assume responsibility for Interconnection-wide transmission expansion planning in the Western Interconnection.

Transmission expansion planning accelerated dramatically in 2009 under a multi-year Department of Energy (DOE) grant through the American Recovery and Reinvestment Act of 2009 (ARRA) to the WGA and the WECC in the Western Interconnection, ERCOT in Texas, and the Eastern Interconnection States Planning Council for the Eastern Interconnection. The grant enabled those regions to launch the Regional Transmission Expansion Project (RTEP), which expanded and improved many aspects of the regional transmission planning processes.

As part of the project, the WECC developed new analytical tools such as the Long-term Planning Tool (LTPT) which optimizes both the future electric generation additions and the location of new transmission lines subject to policy, environmental, and land-use constraints. In 2013, the Western Interconnection will produce the first transmission plan that includes both a 10- and 20-year time horizon.

Western states and provinces have contributed to the interconnection-wide planning process through the creation of the State-Provincial Steering Committee (SPSC). This group was created to facilitate input on transmission planning from representatives of Governors, public utility commissions, and western Canadian provinces.

In 2011 the Federal Energy Regulatory Commission (FERC) issued Order 1000 requiring transmission owners to engage in regional transmission planning. Under the new Order 1000 framework, the four existing regional planning groups in the West are required to perform transmission planning in their respective footprints, adopt a cost allocation methodology and create agreements on interregional coordination.

It appears unlikely that activities performed to meet the Order's interregional planning requirements would be an acceptable substitute for current Interconnection-wide planning activities. Under a strict interpretation of Order 1000, there would not be a single entity looking at the entire Western Interconnection as a whole, causing an inefficient fragmentation of planning activities. The fragmentation would make it more difficult to evaluate long-distance transmission projects that cross the footprints of the current regional planning groups. Moreover, there would be no guarantee of consistent modeling techniques and methodologies among the six regional planning groups. It is important for cost analyses to be based on the consistently-created information on capital costs for generation and transmission, as well as performance of different generation technologies. It is also likely that state or provincial policies on renewable portfolio standards, demand-side management, distributed generation, water resources, environmental regulations and wildlife will not be evaluated in a common and comprehensive manner.

An Interconnection-wide regional approach to transmission system planning is best suited to examine the effect of major transmission additions. Electric transmission infrastructure, loads and generation resources must be accurately represented when conducting transmission planning studies.

The future of Interconnection-wide transmission expansion planning in the Western

Interconnection is at an important crossroad as a result of the implementation of FERC's Order 1000.

Oil and Gas Pipeline Networks

The United States relies on extensive pipeline networks for the majority of overland crude oil and natural gas transportation. The totality of the national pipelines infrastructure extends over approximately 2.5 million miles and carries roughly two-thirds of the domestic energy supply.[165] The national pipeline infrastructure includes:

- Gathering pipelines, which collect energy resources from production areas to processing facilities and distribution centers;
- Transmission pipelines, which carry resources over extended distances to regional distributors and large-scale consumers such as industrial operations;
- Distribution pipelines, which split off from transmission pipelines to deliver natural gas to residential, industrial and commercial consumers.

As part of the larger pipeline system, there are approximately 175,000 miles of pipeline that carry material designated by the federal government as hazardous liquids. The liquids that fall under this classification primarily include crude oil, refined petroleum products, carbon dioxide, anhydrous ammonia and petrochemical feedstocks. [166] Approximately 75 percent of all crude oil and 60 percent of refined petroleum products are transported via this part of the pipeline system. [167]

Of the 175,000 miles of hazardous liquids pipelines, 123,348 (70%) are situated in the West. The Western States also include the longest intrastate pipeline in the nation, the Trans-Alaska Pipeline System (TAPS). This network spans more than 800 miles within Alaska and carries more than 10 percent of domestic oil production from oil fields along the North Slope to shipping terminals in Valdez.[168]The American natural gas transmission network consists of some 210 pipeline systems and has a collective length greater than 305,000 miles. [169] Western states contain 169,000 miles, a little over half of the national total.

Pipelines are statistically the safest and most cost effective approach to overland oil and gas distribution. While the national pipeline

Figure 5.2:

infrastructure has steadily grown over the last century, the advent of unconventional oil and gas production has created pressure to expand pipeline infrastructure. For various reasons, natural gas pipeline additions hit their lowest point in more than a decade during 2012, according to the U.S. Energy Information Agency. Although oil pipeline additions have remained relatively stable, increases in the cost of steel may limit additional construction in the near future.

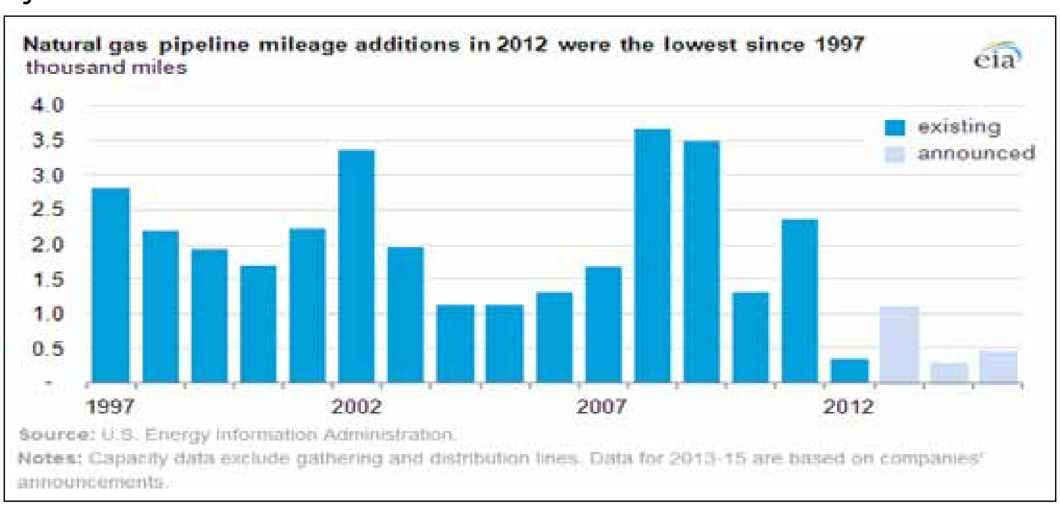
Statistically, pipelines cause fewer fatalities annually than transportation of many other commodities.[170] Nevertheless, recent spill incidents have resulted in an increased level of scrutiny of oil pipelines. In part, this is due to the fact that often the environmental impact of a single incident tends to be more significant and result in greater public attention.

According to federal records, the number of "significant" hazardous pipeline incidents averaged more than 100 per year over the past 20 years.[171] These spills are defined as those that caused serious injury, fatality, fire, the release of 2,100 gallons of hazardous liquids, and other factors. Although there are several causes for pipeline incidents, the factors with the largest contribution are related to weaknesses in the pipeline infrastructure itself (see Figure 5.4b).

As the Figure on page 59 shows, crude oil and petroleum pipeline spills accounted for the majority of spills.[172] The Figure also indicates that the primary contributing factor is infrastructure failure, although age is also an important factor.

The age of the national pipeline infrastructure makes maintainance an increasingly difficult challenge. More than half of hazardous liquids, gas transmission and gas gathering pipelines were constructed in the 1960s or earlier.[173] For crude oil pipelines, advancing age is accompanied with an increasing amount of corrosion. Older pipelines are still only subject to the safety regulations in place at the time of their construction, not the substantially tougher standards applicable today.[174]

Figure 5.3



Over half of U.S. natural gas pipeline projects in 2012 were in the Northeast. Washington, DC: U.S. Energy Information Administration. March 2013. http://www.eia.gov/todayinenergy/detail.cfm?id=10511

Figure 5.4: Average Spill Type (1990-2011)

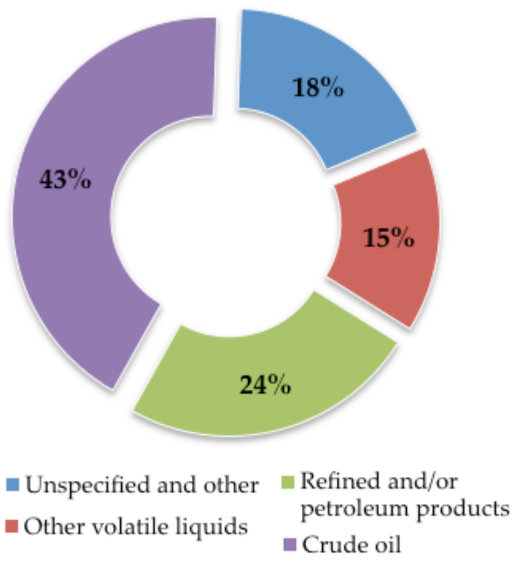
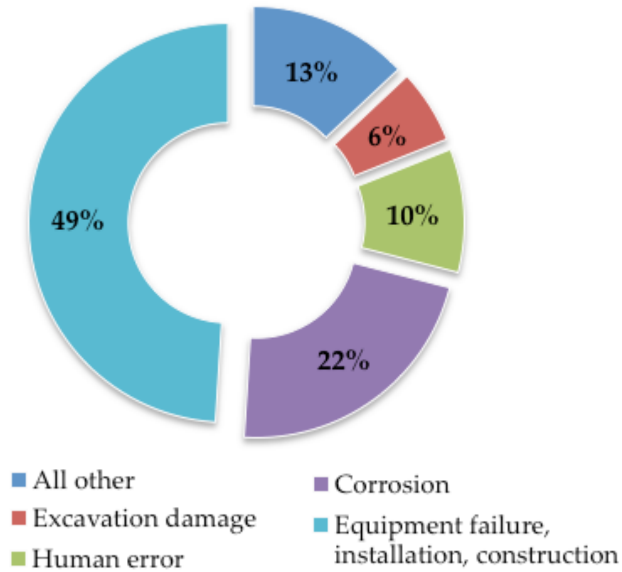
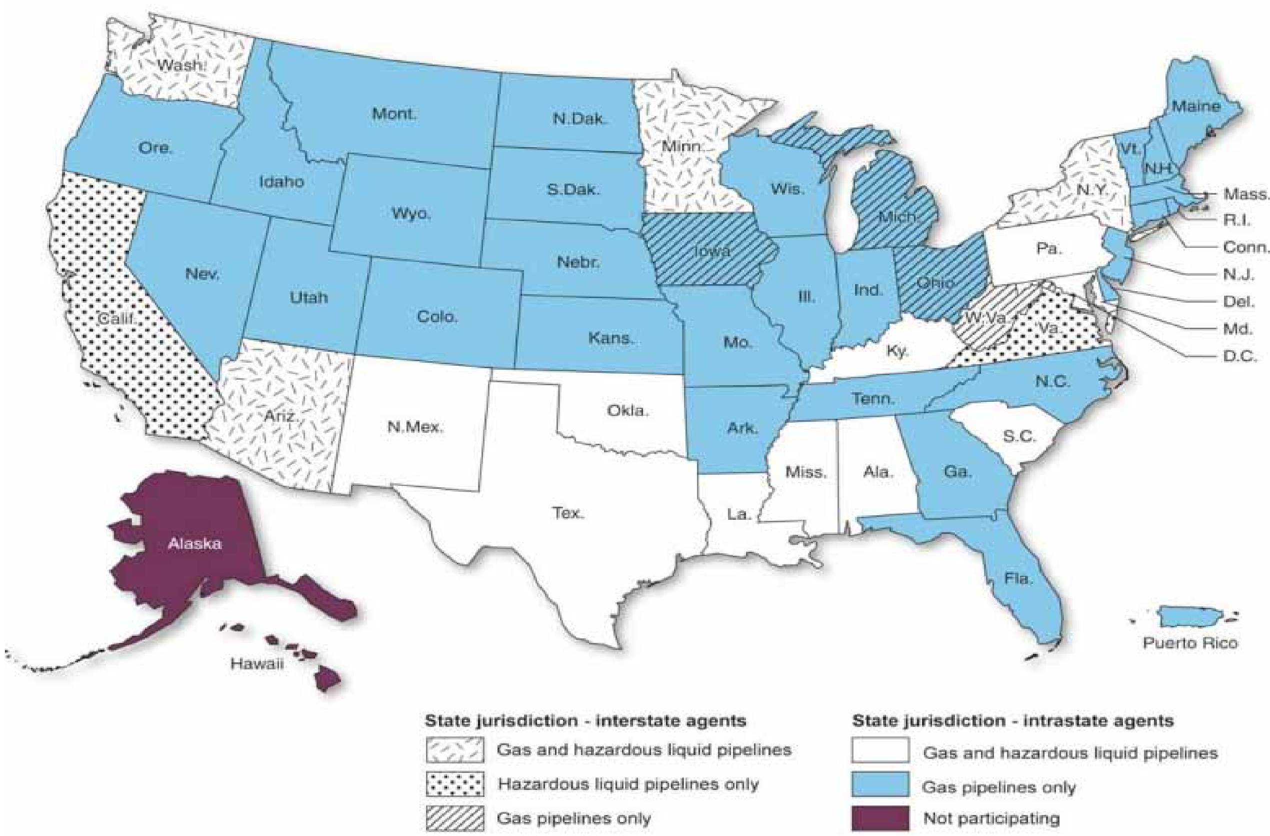


Figure 5.4b: Primary Spill Type (1990-2011)



Source: Adapted from "Two Decades of Spills." (2011, September 9). The New York Times. Available at: http://www.nytimes.com/interactive/2011/09/09/business/energy-environment/pipeline-spills.html?_r=1&

Figure 5.5



U.S. Government Accountability Office. (2012). Pipeline Safety: Collecting Data and Sharing Information on Federally Unregulated Fathering Pipelines Could Help Enhance Safety. Retrieved from http://www.gao.gov/assets/590/589514.pdf

Figure 5.6: Gas Transmission and Gathering Pipelines by Period of Construction

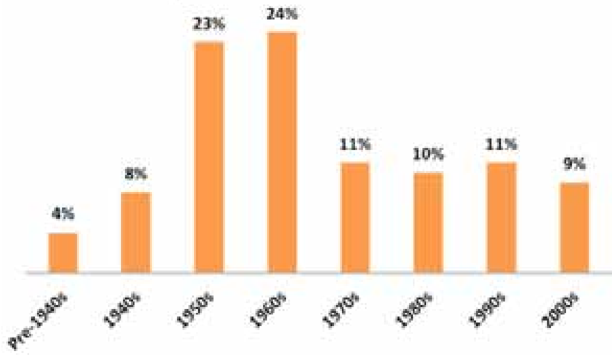
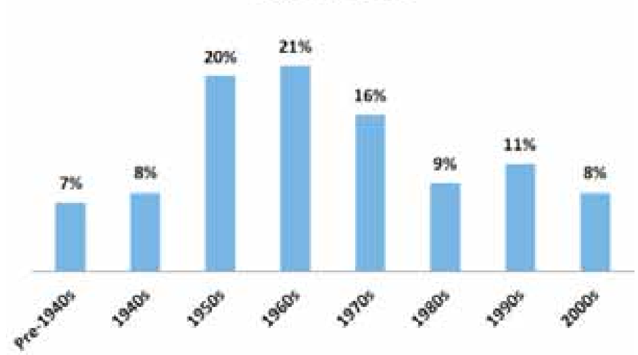


Figure 5.6: Hazardous Liquid Pipelines by Period of Construction



Based on data from The State of the National Pipeline Infrastructure. Washington, DC: U.S. Department of Transportation. June 2011. http://opsweb.phmsa.dot.gov/pipelineforum/docs/Secretarys%20Infrastructure%20Report_Revised%20per%20PHC_103111.pdf

The ability of the Pipeline and Hazardous Materials Safety Administration (PHMSA) to oversee maintenance of the national pipeline infrastructure is limited. PHMSA has suffered from consistent staffing shortages resulting from factors ranging from federal hiring process delays to high turnover, the latter a result of intense private sector demand for skilled pipeline inspectors.[175] However, these issues present an opportunity for Western states to play a larger role in ensuring pipeline safety.[176] Currently, most states only have authority to ensure natural gas pipelines are appropriately operated and maintained (see Figure 5.5).

The Western states can promote greater pipeline safety through a number of collaborative efforts. Active engagement with the private sector entities responsible for pipeline operation and maintenance can foster greater understanding of mutual need and expectations. States can also collaborate directly with one another, sharing information on pipeline safety issues, pipeline network security, and private sector engagement.

Pipeline Security

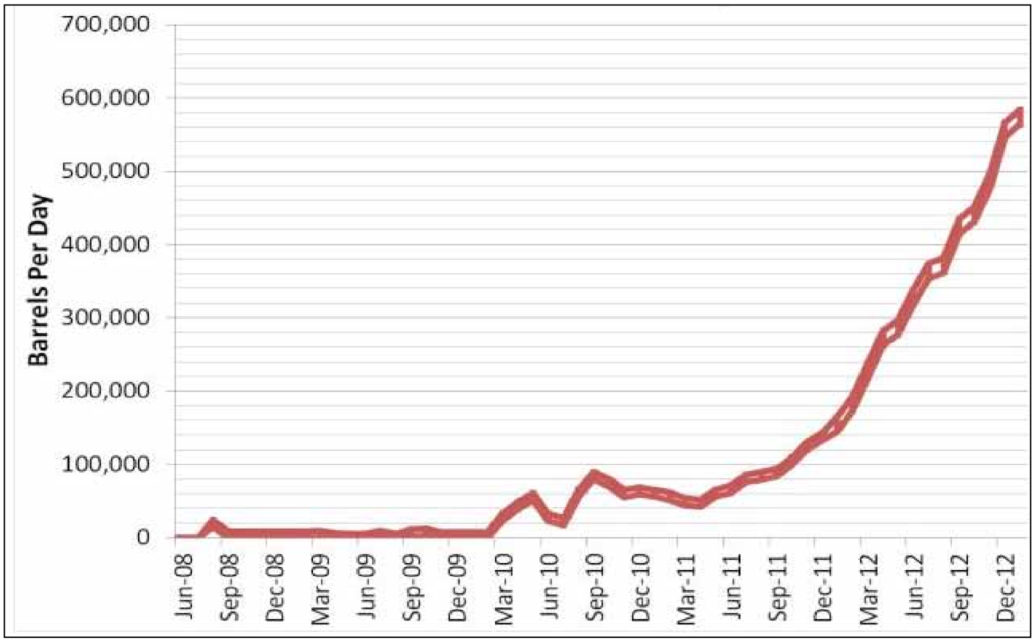
Since Sept. 11, 2001, increased attention has been paid to the vulnerability of oil and gas pipelines to attack. Such concerns have not been unfounded. In 2007, federal authorities apprehended and convicted a U.S. citizen intending to launch an Al Qaeda-sponsored attack on the Trans-Alaska Pipeline System. In addition to conventional attacks on infrastructure, pipelines are also potentially vulnerable to cyberattacks. In 2012, federal authorities uncovered a series of ongoing intrusions on natural gas pipeline operators dating back to December 2011. To combat such threats, the Western states can coordinate with federal authorities and private sector entities to increase the effectiveness of physical and cybersecurity.

Crude by Rail

The rapid growth of unconventional oil production has placed significant strain on the existing pipeline infrastructure. As rising costs and regulatory challenges slow the development of new pipeline capacity, many producers in unserved and underserved areas have looked to rail as an alternative approach to long distance overland transportation. The expansion of crude by rail operations has been particularly rapid in North Dakota, where many producers in the Bakken shale oil resource reserve still await access to the national pipeline infrastructure (see Figure5.7).[177]

Among the greatest advantages offered by rail is flexibility. Rail shipments of crude can travel to any point within the national railroad system. The availability of a multidirectional transportation option with a larger number of potential destinations allows producers to bypass regional markets and ship crude to wherever it will fetch the highest price.

Figure 5.7: Estimated North Dakota Rail Export Volumes



Rail Transportation. North Dakota Pipeline Authority. October 2012. http://northdakotapipelines.com/rail-transportation/

Environmental regulation differences between rail and pipeline reveal an advantage for the former. The approval process for new pipelines can be lengthy and difficult. Rail operators, by contrast, do not need special permits to ship hazardous products within their established network, although they are subject to regulations that pertain to the design of rail cars that carry hazardous materials. This difference has made it easier for rail operations to expand much more quickly than pipelines, including large new investment in rail terminals aimed at serving producers in North Dakota. To a large degree, access to crude by rail has enabled the North Dakota energy boom because it gives producers access to markets that would otherwise be inaccessible.

A higher rate of accidents per billion ton miles of shipment, however, is a concern with rail. According to the U.S. Department of Transportation and PHMSA, rail has a greater absolute number of incidents as well as a substantially higher number of incidents per billion ton miles.[178]

Rail also is typically much more expensive than transport by pipeline. The average cost of transporting a barrel of oil from the Midwest to refineries along the Gulf Coast is about $15, whereas the average price of pipeline transportation over that distance averages around $5 per barrel,[179] although losses can be partially recouped by exploiting price differentials across the country.

As the permitting approval process and the cost of constructing new pipelines continues to limit the development of new pipeline capacity, shipments of crude by rail will continue to increase and prove beneficial to the development of American crude oil operations in unconventional resources reserve areas.

Incident Rates for Overland Transportation of Hazardous Materials *(2005-2009)*

Mode	Billion Ton Miles of Shipments	Average Hazmat Incidents per Year	Average Hazmat Incidents per Billion Ton Mile
Railway	35.1	14,963	650.6
Hazardous Liquid Pipeline	584.1	718	20.5

Furchtgott-Roth, Diana. Manhattan Institute for Policy Research. June 2012. http://www.manhattan-institute.org/html/ir_17.htm

Chapter 6

Energy and the Environment

Western states have long played a leadership role in the protection and improvement of regional air quality through the work of individual states and the Western Regional Air Partnership. WRAP includes state, tribal, local and federal officials working together to assist with the development and implementation of strategies to meet federal health standards for air quality.

Air Quality

The Western Governors' work to improve air quality in the West began in 1991 with the creation of the Grand Canyon Visibility Transport Commission. The success of this commission informed EPA's rules for regional haze and led to the formation of WRAP. Since 1997 the partnership has contributed to the adoption of new federal standards for cars, trucks, and off-road equipment as well as worked on substantial reductions in sulfur dioxide and nitrogen oxide emissions from industrial sources and power plants. While continuing its work to address visibility degradation in national parks and wilderness areas (regional haze), WRAP is helping states understand and address the sources that contribute to unhealthy levels of ozone and fine particulate matter pollution in the West.[180]

The leadership of the Western Governors, starting with the Grand Canyon Visibility Transport Commission, has emphasized a "one-atmosphere" approach to regional air quality planning. This approach emphasizes regional and multi-pollutant assessment of air pollution from all sources and the development of integrated control options, including those needed to address transport of pollution across state lines. In the West, sources contributing to regional air pollution include industrial sources, power plants, mobile sources, energy production, wildland fire, windblown dust, off-shore shipping, and international transport of air pollution. WRAP's work on regional air quality has resulted in significant emission reductions and measurable improvements in air quality across the West in the past 10 years. Nevertheless, regional air quality challenges remain and the WRAP is using its expertise

International Cooperation on Emissions

California and China's Guangdong Province Launch Joint Effort

In April of 2013 the State of California and government leaders from China's Guangdong Province signed a Memorandum of Understanding, launching a joint effort to reduce energy-related carbon emissions. The partnership will promote the design implementation of low-carbon development policies and technologies, along with tools aimed at assessing the effectiveness of low carbon policies. This landmark agreement between important economic partners offers an example of how carbon reduction efforts can be coordinated at the international and sub-national levels.

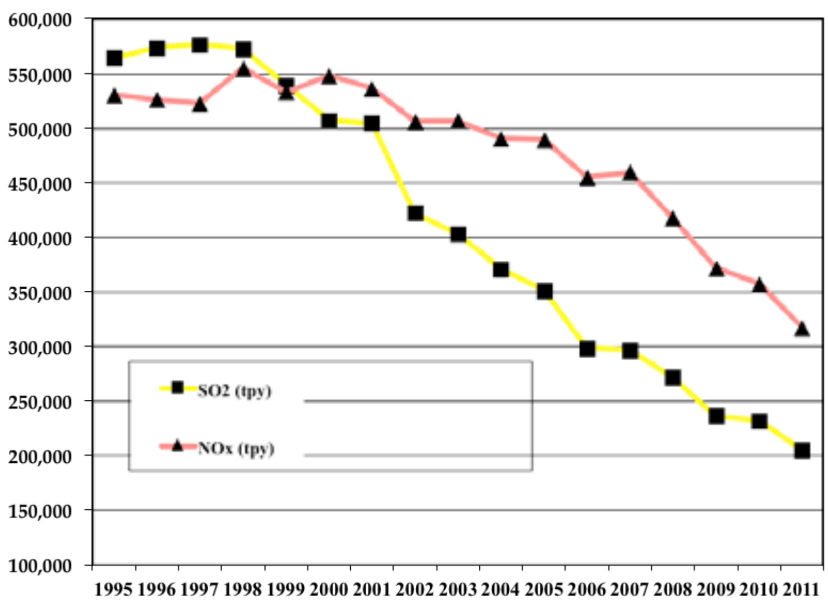
to help Western states meet these challenges, including achieving compliance with EPA health standards for ozone and fine particulate matter.

Water

Scarcity is the defining characteristic of water in the western United States. Freshwater is naturally limited to precipitation, runoff and aquifer storage. Demand for water continues to grow as cities, industry, energy developers and other users in the West seek new secure water supplies, so the need to find balance in the energy-water nexus becomes all the more important.

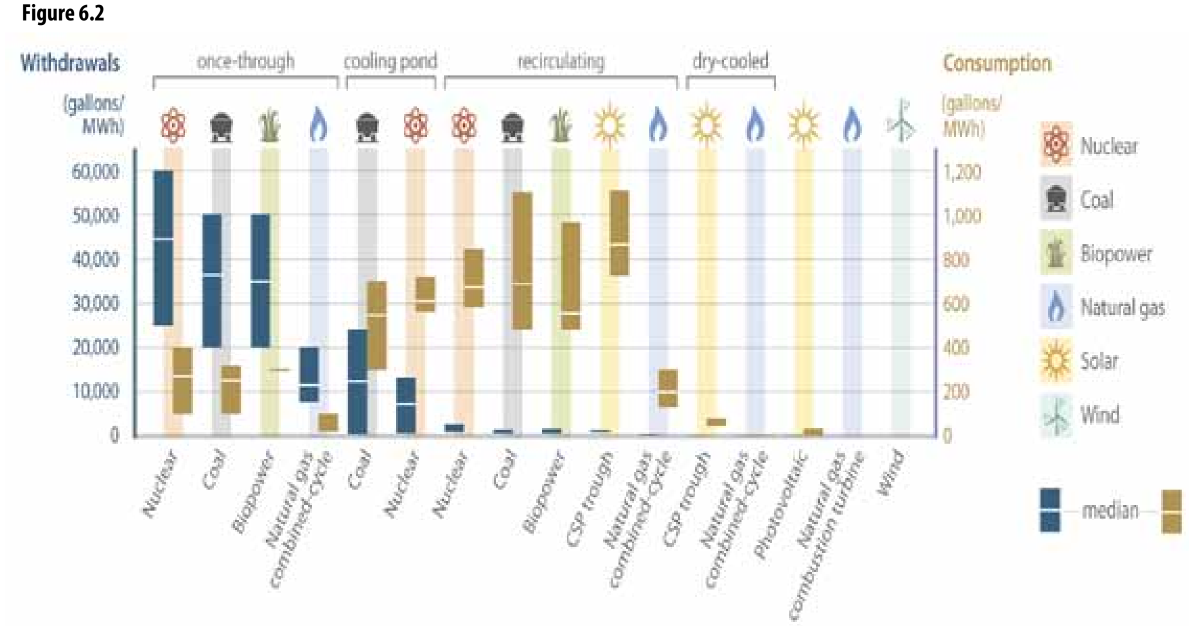
Water is critical to energy development. Water for resource extraction or cooling in thermoelectric plants is essential to operations. This does not mean, however, that the water is completely

Figure 6.1: Western State Power Plant Emissions Trends



Produced by WGA.

Figure 6.2



Based on data from Tidwell, V., Passel, H., Moreland, B. & Castillo, C. (2011). Energy Water Analysis of the 10-Year WECC Transmission Planning Study Cases. Available at http://prod.sandia.gov/techlib/access-control.cgi/2011/117281.pdf *consumed*, or taken out of the hydrologic cycle. The above Figure demonstrates that while water withdrawals for thermoelectric power production may be high (blue columns), the amount of consumed water is orders of magnitude lower. Power production accounts for 41 percent of US water withdrawals, but consumption is significantly lower, at only 3 percent of the total consumption.[181]

Studies have shown that proposed traditional and renewable power plants will be a major driver of new water demand during the next decade.[182] As the figure on page 66 shows, projections indicate that thermoelectric water consumption will increase between 42 percent and 63 percent by 2030, with 2005 as a baseline.[183]

Hydraulic fracturing, or "fracking," is another factor in growing demands across the West. Given that the average hydraulic fracturing operation requires between 2 and 4 million gallons of water, the steady increase in the use of this practice will increase water withdrawals in the West. However, the application of water reuse and recycling techniques casts uncertainty on the magnitude of those withdrawals.

In the past, the energy industry has developed new water supplies from unappropriated surface water or has tapped groundwater sources; however, these supplies are increasingly scarce in the West. Energy companies can acquire water from local municipalities, but this tactic may pose disadvantages: water may need to be trucked to the development site, the cost may be significantly higher, and it may result in a political battle in communities where energy development creates concerns.

One alternative to meet increasing needs for water in energy production: Water Transfers. A Water Transfer is a voluntary sale or lease of a water right that can change the type, time or place that the water has historically been used. Any rights holder can transfer a water right, and the energy industry can often look to farmers (who typically hold the most senior, and thus reliable, water rights available) or municipalities for water.[184]

Impacts to farmers and communities as water is transferred to another use can cause concerns, however. Since income from irrigated agriculture is a key component to many rural economies, the effects of a water transfer can reverberate throughout a community. Transfers also raise concerns for the environment – redirecting water to new uses can dry up streams or wetlands that depend on current irrigation practices, or allow invasive species to take hold in formerly irrigated farmland.

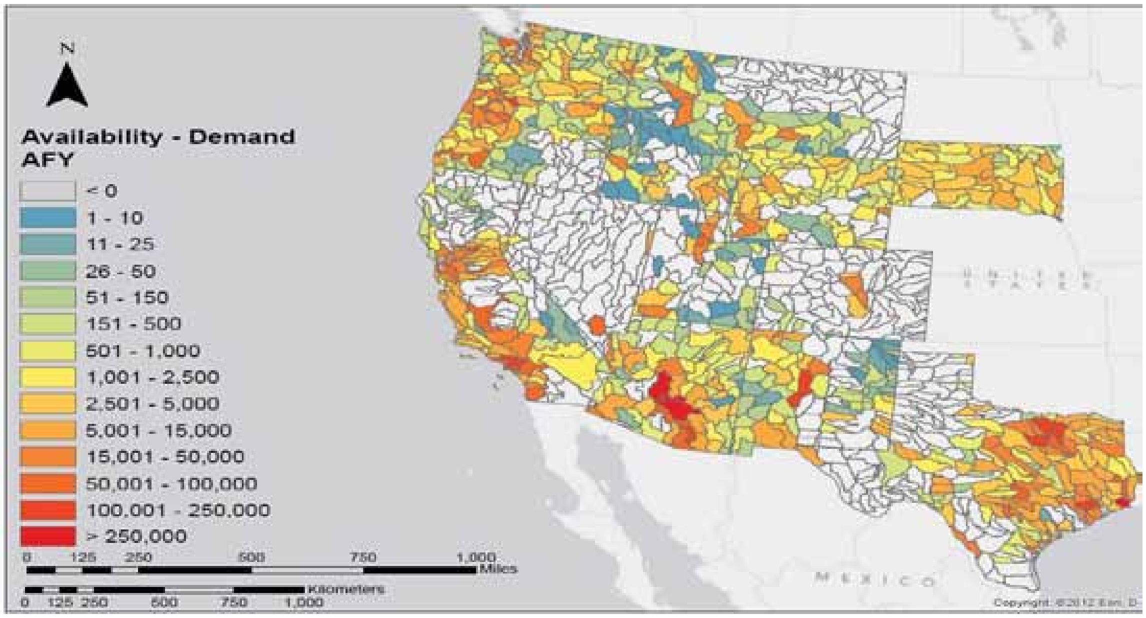
As the Figure 6.3 on the following page shows, projections for 2030 indicate that water basins with the highest demand are the growing urban areas. In much of the traditional agricultural land, water demand is projected as less than "0," indicating that water will be transferred away from those areas.

A conscious, transparent approach to securing water rights for energy uses will serve the industry well. Energy companies can work with state water managers to factor water availability into energy plans; likewise, they can encourage water managers to factor energy into water planning. Energy companies can also incorporate water efficiency into their operations, such as through dry or hybrid cooling systems.[185]

Using non-potable sources such as brackish groundwater or wastewater in cooling processes offers another alternative. The Palo Verde nuclear plant in Arizona struck a deal with five nearby cities, including Phoenix, to use their treated wastewater for its cooling system. The water may be more expensive – the wastewater will cost $300 per acre foot, as opposed to the price of $53 per acre foot it paid before the agreement – but it will offer a secure source of water for the expected life span of the desert power plant.[186]

Hydraulic fracturing also offers opportunities for efficient water use. Fracking water used in well construction can be reused or recycled. The wastewater generated from fracking processes, known as produced water, can also be used in operations. State regulations govern both produced and recycled water.[187] Although fears of methane or other pollution often dominate the public discussion of water and fracking, efficient approaches to using water can be part of a conscious and transparent approach to the issues of water quantity and quality.[188]

Figure 6.3: Water Availability and Intensity of Demand 2030



Map by Sandia National Labs with projections by WGA

In the case of water transfers from agriculture, energy companies can use community mitigation efforts or help to finance alternative mechanisms. Or companies can look to the model of Xcel Energy in Colorado, which has created agreements with water companies and irrigation districts in the state to ensure it has adequate water. Xcel's agreement with the North Sterling Irrigation District provides an insurance policy of sorts: Xcel pays for the option to divert up to 3,000 AF of water in the year, and pays an additional amount for the water it diverts in the years it needs to utilize the agreement.[189]

WGA and the Western States Water Council are developing a Water Data Exchange (WaDE) in order to compile and share water data from across Western states. This will inform regional analyses of potential stress points, support critical infrastructure investment, and promote cross-state learning and policy development.

Developers in the energy industry can use WaDE for preliminary analyses of potentially favorable sites for energy development, using water availability as a factor for consideration. Once WaDE launches, it will bring a great deal of potential for collaboration through WGA, WSWC and WECC as well as through state-industry partnerships.

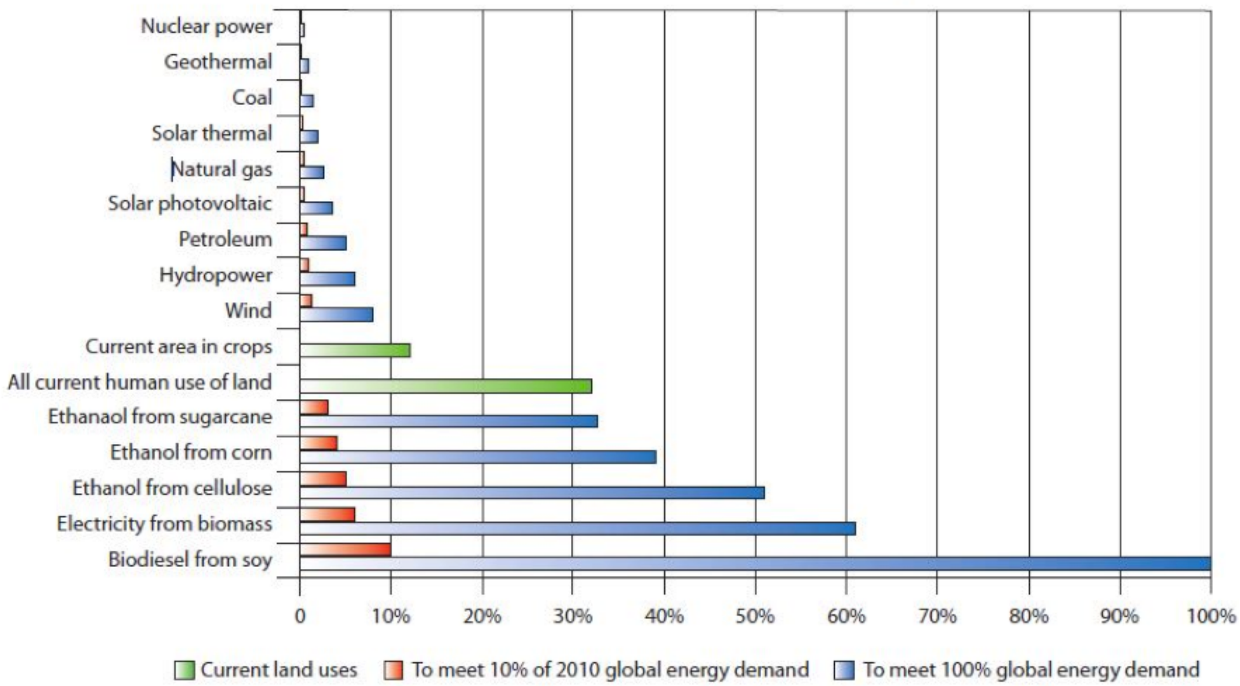
Land Use

In addition to impacts on wildlife, water and natural resources, energy development has land use requirements that vary by type. As the U.S. and other countries seek to ramp up renewable energy production, land use is becoming a more contentious issue. Proposed projects for large-scale fossil fuel, solar plants and wind farms have been opposed for aesthetic and environmental reasons, and in some cases because of their extensive land use requirements.

Figure 6.4 on page 67 shows how much land would be required for each energy source to supply both 10 percent and 100 percent of the world's current energy demand. As the Figure indicates, only 12 percent of the earth's land area is currently devoted to growing agricultural products, and all human activities only consume about 31 percent of the available land. With energy demand projected to continue to increase over the coming decades, energy development will require prudent planning that accounts for land use limitations.

Most of the traditional and renewable resources consume reasonable amounts of land, with nuclear power requiring the smallest land area to generate power. High thermal intensity sources such as nuclear, coal, solar thermal and natural

Figure 6.4: Percent of Earth's Land Area Taken for Energy Production



Andrews, Clinton J., Lisa Dewey-Mattia, Judd Schechtman and Mathias Mayr. "Alternative energy sources and land use." In G. Ingram & H. Hong, eds. Climate Change, Energy Use, and Land Policies. Cambridge, MA: Lincoln Institute of Land Policy. 2011. http://www.ucdenver.edu/academics/colleges/Engineering/research/CenterSustainableUrbanInfrastructure/CSISProducts/Workshops/Documents/Attendee%20Publications/Andrews_2011_Alternative%20Energy%20Sources%20and%20Land%20Use.pdf

gas have widely varying land use needs. A 1,000 megawatt nuclear power plant might take up a square mile of land, while the same square mile might accommodate a 500 megawatt combined cycle natural gas power plant, or produce only 80 megawatts of electricity from solar thermal. Still, even the most land-intensive of the renewable energy resources, wind, can be reasonably accommodated.[190]

Federal Lands

There are approximately 2.27 billion acres of land in the United States. Of this amount, the federal government owns roughly 640 million acres (28%). Most of the land (609 million acres) is administered by four agencies: the Forest Service (USFS) in the Department of Agriculture and the National Park Service (NPS), Bureau of Land Management (BLM), and Fish and Wildlife Service (FWS), all in the Department of the Interior (DOI). [191]

In addition to the lands managed by those agencies, the Department of Defense administers 19 million acres in military bases, training ranges and more. Numerous other federal agencies administer the remaining acreage.

Federal land ownership is concentrated in the West. Specifically, 62 percent of Alaska is federally owned, as is 47 percent of the 11 coterminous western states. By contrast, the federal government owns only 4 percent of lands in the other states. This Western concentration has contributed to a higher degree of controversy over land ownership and use in that part of the country.

The lands administered by the four agencies are managed for many purposes, primarily preservation, recreation and development of natural resources.[192] For example, the BLM manages 248 million surface acres and is responsible for 700 million acres of subsurface mineral resources. The BLM also has a multiple-use, sustained-yield mandate that supports a variety of uses and programs, including energy development, recreation, grazing, wild horses and burros, and conservation.

The USFS manages 193 million acres, also for multiple uses, and sustained yields of various products and services, including timber harvesting, recreation, grazing, watershed protection, and fish and wildlife habitats.[193] Most of the USFS lands are designated national forests. Wildfire protection is increasingly important for both agencies.

The FWS manages 89 million acres of federal land (plus several large marine areas), primarily to conserve and protect animals and plants.

State	Total Federal Land Acreage*	Total Acreage in the State	% of State
Alaska	225,848,164	365,481,600	61.8%
Arizona	30,741,287	72,688,000	42.3%
California	47,797,533	100,206,720	47.7%
Colorado	24,086,075	66,485,760	36.2%
Hawaii	833,786	4,105,600	20.3%
Idaho	32,635,835	52,933,120	61.7%
Kansas	301,157	52,510,720	0.6%
Montana	26,921,861	93,271,040	28.9%
Nebraska	549,346	49,031,680	1.1%
Nevada	56,961,778	70,264,320	81.1%
New Mexico	27,001,583	77,766,400	34.7%
North Dakota	1,735,755	44,452,480	3.9%
Oklahoma	703,336	44,087,680	1.6%
Oregon	32,665,430	61,598,720	53.0%
South Dakota	2,646,241	48,881,920	5.4%
Texas	2,977,950	168,217,600	1.8%
Utah	35,033,603	52,696,960	66.5%
Washington	12,173,813	42,693,760	28.5%
Wyoming	30,043,513	62,343,040	48.2%
Territories	161,967	not applicable	
TOTAL	**591,820,013**	**1,529,717,120**	

*The total is slightly understated because it only includes the four primary federal land owners plus Department of Defense. None of the figures includes national marine preserves.

Sources: For USFS: U.S. Dept. of Agriculture, Forest Service, *Land Areas Report—As of Sept 30, 2010*, Tables 1 and 4, http://www.fs.fed.us/land/staff/lar/LAR2010/lar2010index.html. Data reflect land within the National Forest System, including national forests, national grasslands, purchase units, land utilization projects, experimental areas, and other areas.

For NPS: U.S. Dept. of the Interior, National Park Service, Land Resources Division, *National Park Service, Listing of Acreage by State, as of 12/31/2010*, unpublished document. Data reflect federally owned lands managed by the NPS. For information on acreage by unit, see the NPS website, http://www.nature.nps.gov/stats/ acreagemenu.cfm.

For FWS: U.S. Dept. of the Interior, Fish and Wildlife Service, *Annual Report of Lands Under Control of the U.S. Fish and Wildlife Service, as of September 30, 2010*, Table 2, http://www.fws.gov/refuges/realty/archives/pdf/2010_Annual_Report_of_Lands.pdf. Data reflect all federally owned land over which the FWS has sole or primary jurisdiction.

For BLM: U.S. Dept. of the Interior, Bureau of Land Management, *Public Land Statistics, 2010*, Table 1-4, http://www.blm.gov/public_land_statistics/pls10/pls10_combined.pdf.

For DoD: U.S. Department of Defense, Office of the Deputy Under Secretary for Installations & Environment, *Base Structure Report, Fiscal Year 2010 Baseline (A Summary of DoD's Real Property Inventory)*, VIII. Total DoD Inventory, pp. DoD-36 to DoD-78, http://www.acq.osd.mil/ie/download/bsr/bsr2010baseline.pdf.

Figure 6.5: Federal Land Ownership by State and Agency Western United States

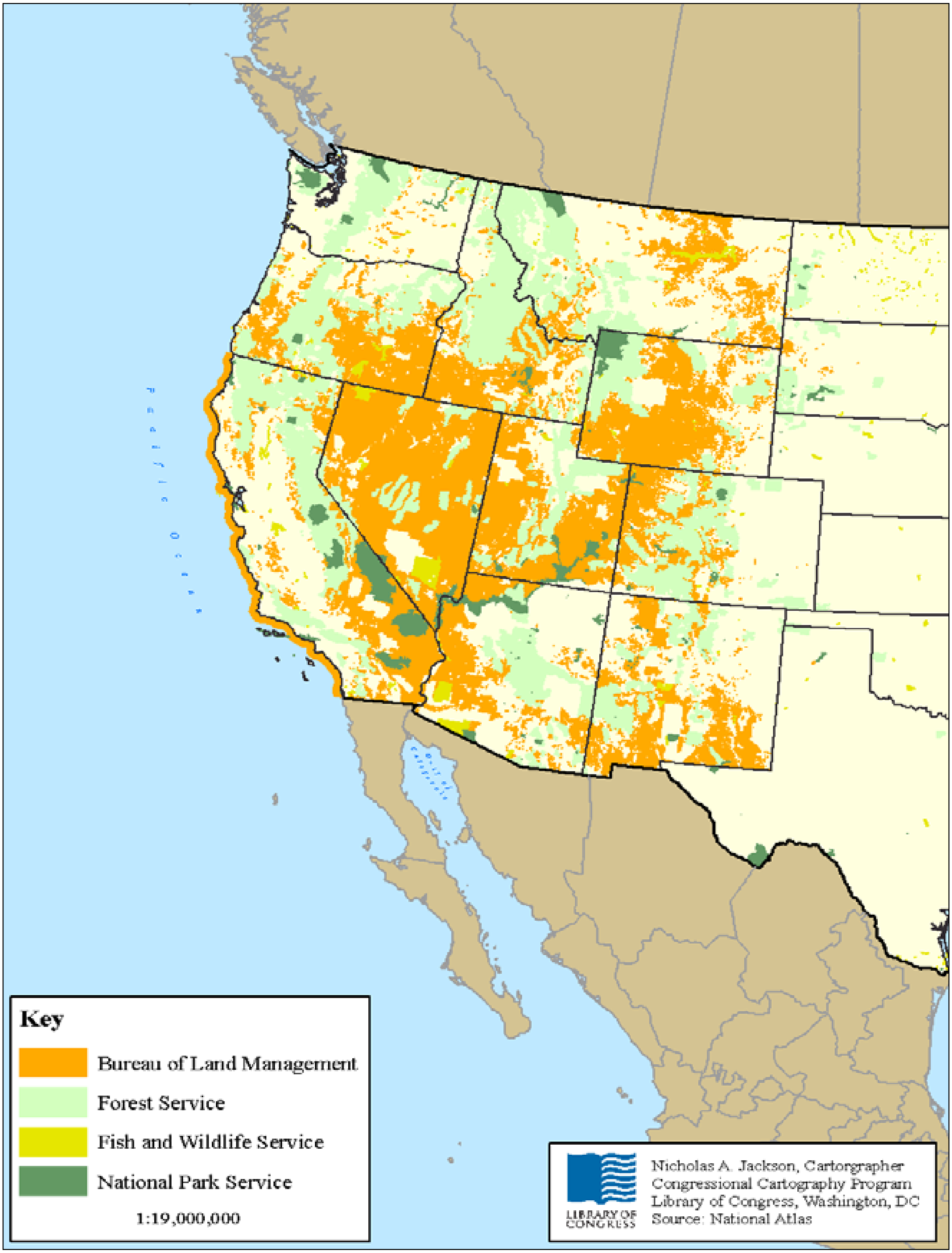


Figure 6.6: Federal Land Ownership by State and Agency Alaska and Hawaii

The National Wildlife Refuge System includes wildlife refuges, waterfowl production areas, and wildlife coordination units. The NPS manages 80 million acres of federal land in 397 diverse units to conserve lands and resources and make them available for public use. Figures 6.5 and 6.6 show federal lands by type in the Western states.[194]

Federal ownership of such large tracts of land has resulted in many issues and conflicts. There are a broad range of opinions about how federal lands management should occur, from the disposal of federal lands to state or private ownership to the continued acquisition of lands by the federal government. Debates also encompass the extent to which federal lands should be developed, preserved and open to recreation and whether federal lands should be managed primarily to produce national benefits or benefits primarily for the localities and states in which the land is located.

Development of facilities and infrastructure on federal lands has been a difficult issue in the West for a number of reasons. The time it takes to complete the federal permitting process can be extraordinarily long and difficult. It is not unusual for electrical transmission lines to take up to 12 years to permit, for example. As was discussed in the section on electrical transmission, this can have the effect of limiting new generation development, especially utility-scale wind and solar.

A second issue is past policy on certain federally-owned lands to push development off of federal lands onto private lands, even if those federal lands could successfully accept the development.

Finally, there has often been a lack of coordination between federal departments and even within agencies. For example, a transmission line that routes through different national forests is subject to separate consideration by the respective regional foresters. While there have been attempts by the federal lands agencies to coordinate, these efforts are still in the incipient stages.

Wildlife

Western states have a wildlife heritage that is unique and world renowned. Not only is the West in part defined by this heritage, but this resource provides a huge boost to the state economies, especially in rural areas.

Wildlife habitat often overlaps with prime lands for energy development. Energy – and even maintenance of the existing energy infrastructures of the West – can impact wildlife species and habitats. This intersection of interests has the potential to create conflict, but Western Governors are collaborating with federal agencies, stakeholders, landowners and energy industries to design conservation and mitigation strategies that significantly reduce the wildlife and energy development conflict.

These collaborative efforts recognize the value of wildlife. Recent studies put the annual economic contribution of hunting,[195] sportfishing[196] and wildlife viewing in the 19 Western states at more than $65 billion.[197] Some of this money helps states manage wildlife and habitat through their broad trustee, regulatory powers, and primacy over fish wildlife and water within their borders. The large majority of the economic contribution of wildlife fees goes to supporting jobs, communities and state economies.

Governors Matt Mead (WY) and John Hickenlooper (CO) co-lead a task force with BLM to identify and implement high priority conservation actions related to the Greater Sage Grouse. The group includes designees from the 11 Western states that have Greater Sage Grouse habitat and other federal land management agencies. The sage grouse is a species whose habitat often intersects with lands ideal for both conventional and wind energy production. The task force is identifying management practices to conserve the Greater Sage Grouse in order to avoid having it listed under the Endangered Species Act (ESA) in 2015. For example, the states are developing habitat mapping, implementing conservation measures with local working groups, and improving land management programs. Similar collaborative efforts are taking place in the five-western state region that hosts the Lesser Prairie Chicken, another ground-dwelling bird with habitat in areas of important renewable and fossil energy development and transmission.

Western states have long grappled with uncertainties regarding how government entities and landowners should conserve and recover species in a manner consistent with the ESA, thereby avoiding its penalty provisions. The application of long-term, predictive scientific models in ESA has also proven highly contentious in the West. A number of species have been named as candidates for listing as a precaution based on the projections of models that include potential long-term climatic variability as a factor. These models indicate a potential threat to currently healthy species whose habitat may be at risk decades into the future. Once a species is listed under the ESA, authority over its management becomes the exclusive right of the federal government. Although federal authorities do involve state wildlife agencies in the mangement of listed species, the state loses its status as the primary management authority. Even in cases where management responsibility is shared, friction often results from the asymmetrical distribution of decision making power.

Additionally, the designation of critical habitat has been expanded to include both currently occupied habitat and potentially occupied habitat. The issue of potentially occupied habitat has been subject to intense debate throughout the West. Although this new habitat designation may provide for additional protection of threatened and endangered species, it also places federal restrictions on the use of state lands, hindering or preventing the development of energy infrastructure. The bifurcation of management responsibilities has created concerns for the states, and highlights an important issue about conservation and at the national level, one that one that may be substantially improved through the establishment of genuine partnerships between state and federal authorities.

Western state concerns with the implementation of ESA grew in 2011 when settlements of two lawsuits brought by conservation groups resulted in agreement that 258 species on the candidate list would be reviewed for final listing as either threatened or endangered by 2016. Western states are particularly impacted by these settlements since more than half of the plant and animal species up for review make their homes in the West, particularly in Hawaii – where 69 candidates are subject to review – and California, Arizona, and Texas, all with more than 20 candidate species within their borders. Given the time and resources needed to review a single proposed listing, there is great concern over how this review can be effectively completed by the required date.

The governors are taking action to conserve the West's wildlife resources, as well as address the challenges the ESA brings to state wildlife management and energy resource development. In 2009, the Governors established the Western Governors' Wildlife Council and asked its members to develop an online GIS-based wildlife data map to identify crucial wildlife habitat and wildlife corridors in their states and across the region. This product, called the Crucial Habitat Assessment Tool (CHAT), will help developers identify ways to conserve wildlife resources in the pre-planning stages of a project.

Ten western state wildlife agencies have already established these non-regulatory CHATs to assist industry, federal agencies and the public to pre-plan economic development and conservation projects.

The state CHATs also can provide state-specific data useful for later stages of the planning process. Already, data from HabiMap™ Arizona, the state's CHAT tool, was used to inform planning for the Arizona Bureau of Land Management's Restoration Design Energy Project (RDEP). That project, which began in 2009, was designed to map areas where renewable energy development (solar and wind) would be most suitable. In order to accurately account for important wildlife habitat, the BLM partnered with the Arizona Game and Fish Department. The AGFD provided statewide data layers that were being developed for HabiMap™ to help identify areas with the least relative value for habitat conservation and where energy development may have the least impact to wildlife resources.

BLM used the Arizona data, along with other land and water use information, to provide guidance on which lands would likely face the least conflict for future energy development. Lands with minimal wildlife value, already disturbed, and close to population centers were proposed for designation as Renewable Energy Development Areas. In all,

Arizona	HabiMap Arizona™
California	Areas of Conservation Emphasis (ACE-II)
Montana	Crucial Areas Assessment and Planning System (CAPS)
Washington	Priority Habitats and Species (PHS on the Web)
Wyoming	The Wyoming Interagency Spatial Database & Online Management (WISDOM) System
Southern Great Plains	Southern Great Plains CHAT (for Lesser Prairie Chicken across range in Colorado, Kansas, New Mexico, Oklahoma and Texas)

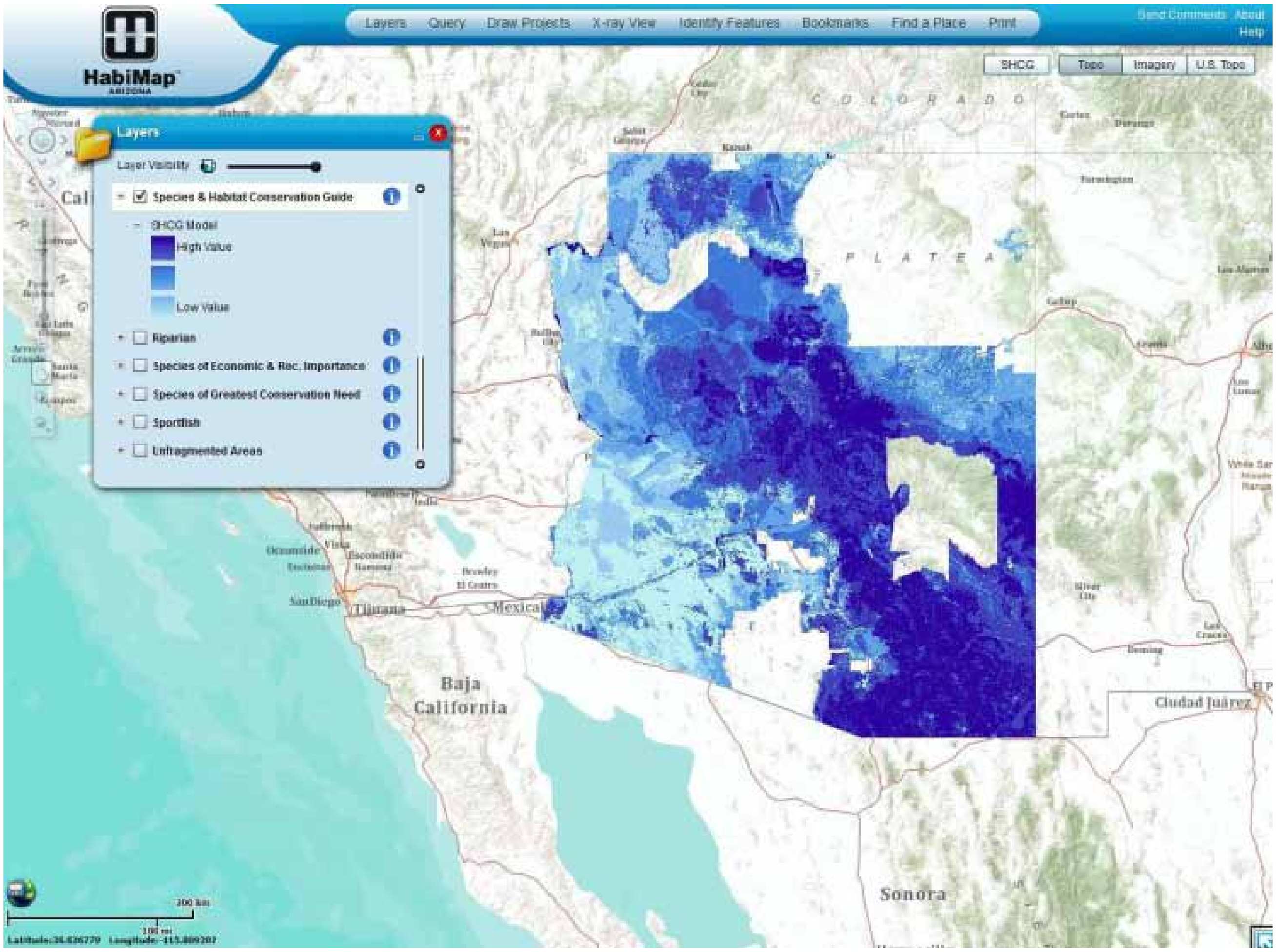
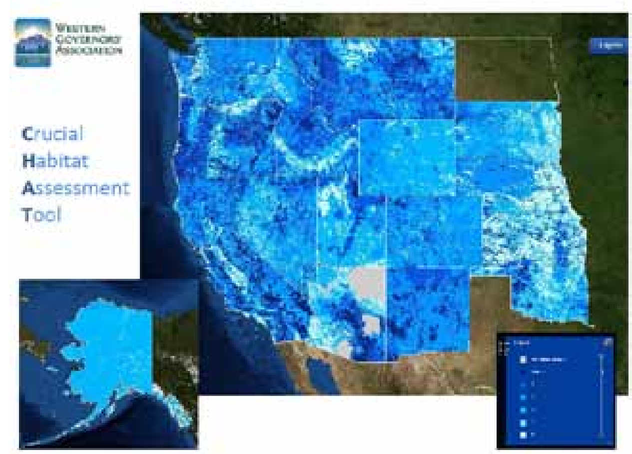


Figure 6.7: HabiMap™ Arizona is a state CHAT tool that depicts data on priority species and habitat.

more than 192,000 acres in Arizona have been identified.

In December of 2013 the Governors will launch the first version of a West-wide CHAT that will combine data from all the states to provide a seamless view of crucial wildlife habitat across the region to aid in the pre-planning of cross state development and conservation initiatives.

One of the values of having region-wide information is to allow for comprehensive evaluations of regional cumulative environmental effects associated with the construction of new energy facilities and transmission projects in the Western states. Energy development projects will obviously have local impacts, but can also have regional impacts over time. The opportunity to comprehensively address the broader, cumulative impacts of energy projects on fish and wildlife and associated habitats

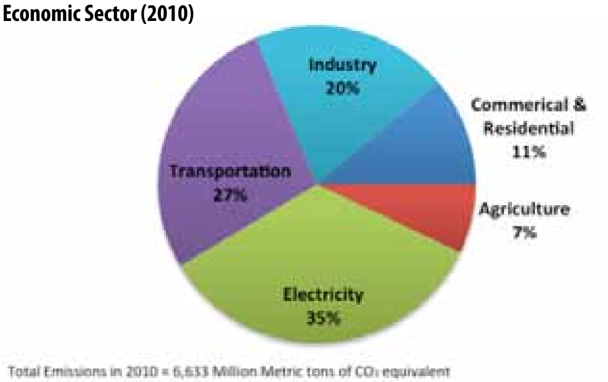


will be valuable to Western states, especially for aiding in the identification of the best locations for new energy projects.

Greenhouse Gas Emissions

Greenhouse gases trap heat and make the planet warmer. Indeed, without the "greenhouse effect" life on the planet would be impossible. Greenhouse gases come from a variety of sources, both natural and manmade. Water vapor makes up the largest percentage of the greenhouse effect, and is almost entirely from natural sources. However, the amount of water vapor in the atmosphere is highly dependent on temperature. As the temperature of the air rises, the carrying capacity of the atmosphere increases, leading to higher levels of humidity and a more intense greenhouse effect. The largest source of greenhouse gas emissions from human activities in the United States is from burning fossil fuels for electricity, heat, and transportation.

Figure 6.8: Total U.S. Anthropotenic Greenhouse Gas Emissions by Economic Sector (2010)



Source: EPA. (2013). Sources of Greenhouse Gas Emissions: Overview. Retrieved from http://www.epa.gov/climatechange/ghgemissions/sources.html

Greenhouse gases allow sunlight to enter the atmosphere freely. When sunlight hits the Earth's surface, some of it is reflected back towards space as infrared radiation, or heat. Greenhouse gases absorb this infrared radiation and trap the heat in the atmosphere. In order to maintain a temperature balance, the amount of energy sent from the sun to the Earth's surface should be about the same as the amount of energy radiated back into space, leaving the temperature of the Earth's surface roughly constant.

The three main man-made greenhouse gases are carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_20). These greenhouse gases have both natural and man-made sources, although most of the increases in their atmospheric levels in the last few decades are from man-made activities. Carbon dioxide from man-made sources comes primarily through the burning of fossil fuels. Nitrous oxide is primarily emitted by agricultural activities and sewage treatment. Agricultural activities, waste management and fossil fuel burning are the main contributors of methane.

Substantial increases in greenhouse gases can have a number of effects, including climate change and melting of the polar ice caps. The full consequences of changing the natural atmospheric greenhouse gases are difficult to predict, but certain effects seem probable:

- The overall average temperature of the planet will rise. This does not mean every area will experience warmer temperatures. Some may actually get colder or stay the same.
- If the planet warms, there may be an overall increase in evaporation and precipitation. However, individual regions will vary, some becoming wetter and others drier.
- Increased average temperatures will warm the oceans and partially melt glaciers and other ice, increasing sea level. Ocean water also will expand if it warms, contributing further to sea level rise.
- Some crops and other plants may respond favorably to increased atmospheric CO_2, growing more vigorously and using water more efficiently. At the same time, higher temperatures and shifting climate patterns may change the areas where crops grow best and affect the makeup of natural plant communities.

At the 2009 climate talks in Copenhagen, President Obama set a 17 percent target for the reduction of greenhouse gas emissions by 2020. According to a report from Resources for the Future, the United States should come very close to meeting that goal, mainly as a result of EPA emissions regulations for cars and trucks, new standards applicable to power plants and other industrial facilities, and the proliferation of natural gas in the electricity generating sector.[198]

State Carbon Reduction Efforts

California Cap-and-Trade

California has committed to reducing GHG emissions to 1990 levels by 2020 (a reduction of approximately 30%) and an 80% reduction from 1990 levels by 2050. California has also launched a cap-and-trade system on power plant emissions that will affect electric power producers and industry, with the revenues generated directed towards funding renewable energy and energy efficiency programs. Combined with mitigation programs in other states, this may lead to a cumulative reduction in national greenhouse gas emissions by 2020.

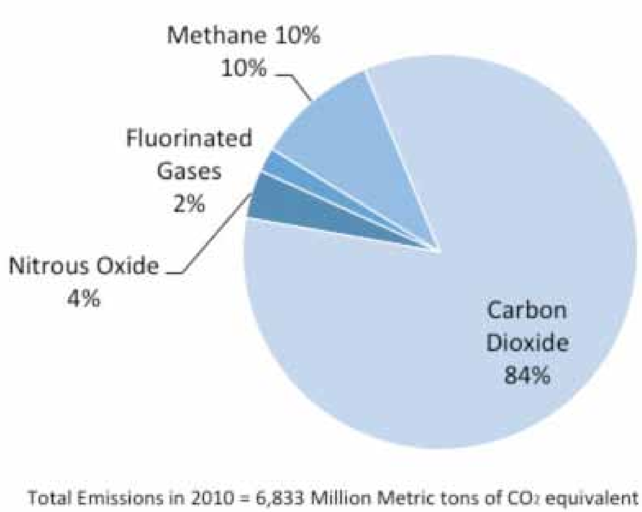
Washington GHG Emissions Reduction Goals

In 2008 Washington passed E2SHB 2815. This bill put into law the state's GHG emissions reduction targets of 1990 levels by the year 2020, 25% below 1990 levels by 2035 and 50% below 1990 levels by 2050. Washington's strategies are outlined in the *Interim Plan to Address Washington's Greenhouse Gas Emissions* published in December, 2010. Washington favors a market-based system that sets a limit on GHG emissions and allows the market to determine strategies to reduce emissions at the lowest cost to the economy.

Oregon GHG Emissions Reduction Goals

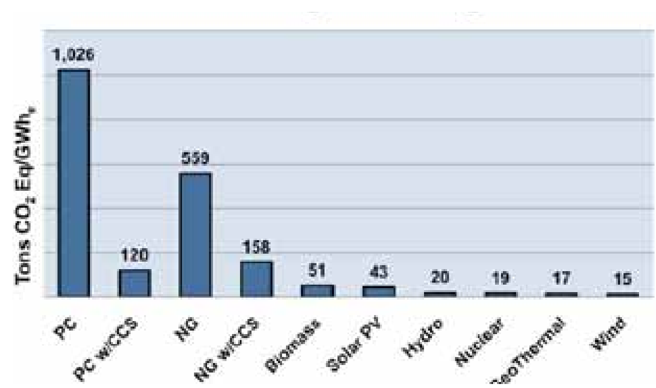
The Oregon State Legislature established GHG reduction goals of 10% below 1990 levels by 2020 and 75% by 2050. Significant investments in energy efficiency and conservation have allowed Oregon to reduce GHG emissions while maintaining a competitively low cost of energy. Oregon has also committed to making sure infrastructure investments account for climate risks.[199]

Figure 6.9: U.S. Greenhouse Gas Anthropogenic Emissions by Economic Type (2010)



EPA. (2013). National Greenhouse Gas Emissions Data. Retrieved from http://www.epa.gov/climatechange/ghgemissions/usinventoryreport.html

Figure 6.10: Comparison of CO_2 Emissions for Electricity Generating Technologies



WGA. (2011). The Future of Nuclear Energy: Shaping a Western Policy. Available at: http://www.westgov.org/reports/doc_download/1434-nuclear-energy-2011

Energy and the Economy in the West

The energy industry makes an important contribution to the economies of Western states. In recent years, activities associated with the utilization of conventional and renewable resources have made a needed contribution to economic growth and job creation in a recession economy. Recent trends and the projections of numerous public and private organizations indicate that this pattern will continue. A balanced approach to energy development can lead to the vast energy resources of the region being leveraged as an important driver of job growth and economic recovery.

Energy and the Economy: Contributions and Prospects for Job Creation

The current economic and employment contribution associated with any sector of the energy industry is a reflection of many things, including the historical significance of that resource in the American energy mix. As the leading source type of energy for over a century, fossil fuels currently make the largest contribution to employment in the West. In 2009, the oil and gas industry accounted for more than 5 percent of total state employment in 9 of the 19 states of the region.[200] In four of these states, this share exceeded 10 percent of total employment. As to the coal industry, it made a substantial contribution to the state economy of Wyoming, at better than 8 percent of total state employment.

In addition to being an important source of jobs, severance taxes paid for the extraction of fossil fuels also provides a direct source of revenue for many Western states. A severance tax is one levied on the extraction of a non-renewable resource which compensates for the loss and is used to mitigate any associated negative impacts. Severance tax rates vary by resource and from state to state, but all are based on the quantity of the resource extracted. The establishment of severance tax endowments has also allowed for the generation of revenue in perpetuity for the states of Alaska, Colorado, Montana, New Mexico and Wyoming. The contribution of severance taxes is of greater importance in the West than anywhere else in the nation. In 2011, over 85 percent of all state-level severance tax collection conducted across the country occurred in the Western States.[201]

The fossil fuels industry has made an important contribution to job growth during a period of stark economic hardship. From 2010 to 2011, the oil and gas industry added more than 37,000 new jobs and expanded sectoral employment by 4.9 percent. Accounting for all

Oil and Gas as % Share of Total Western State Employment *(2009)*

Alaska	10.30%
Arizona	2.70%
California	4.60%
Colorado	5.20%
Hawaii	2.70%
Idaho	2.60%
Kansas	6.50%
Montana	6.40%
Nebraska	3.70%
Nevada	2.90%
New Mexico	7.50%
North Dakota	7.50%
Oklahoma	14.10%
Oregon	2.50%
South Dakota	3.30%
Texas	14.30%
Utah	4.90%
Washington	2.80%
Wyoming	15.80%

American Petroleum Institute. (2011). The Economic Impacts of the Oil and Natural Gas Industry on the U.S. Economy in 2009. Retrieved from http://www.api.org/policy/americatowork/upload/economicimpacts_of_industry_on_us_economy_in_2009.pdf indirect and induced jobs created by this growth, the industry was responsible for approximately 9 percent of all employment at the national level during that time.[202]

Estimates produced by the World Bank indicate that every $1 million invested in the oil and gas industry produces 0.8 direct jobs and 5.2 total jobs after the value of the investment circulates through the economy. For coal, the same investment produces 1.9 direct jobs and 6.9 total jobs.[203]

The rapid development of the renewable energy industry has made an increasingly large contribution to Western state job creation. Much like fossil fuel industries, renewables have frequently managed to prosper in spite of the recent economic downturn. This growth has resulted from a combination of efficiency gains that have driven down costs, growing public support for low emission sources in the national energy mix, and increasing private investment in the sector.

Wind power currently has the most renewable energy generation capacity in the American energy mix. In 2012 the industry saw record growth and reached an important milestone by passing 60 GW of installed capacity at the national level. According to AWEA, the 39,577 MW of capacity located in Western states represents upwards of $70 billion in capital investments. These investments have produced more than 30,000 jobs throughout the region.[204] Some 129 permanent manufacturing facilities for wind power turbines are located in 15 of the 19 Western States.[205] In addition to employment, wind power also provided an important source of revenue to many rural communities. Aggregated across the region, wind farms annually generate in excess of $290 million in country property taxes and $118 million in lease payments to land owners.[206]

Western State Severance Tax Payments in 2011

Thousands of Dollars

Alaska	4,238,789
Arizona	40,237
California	31,879
Colorado	146,690
Hawaii	—
Idaho	7,787
Kansas	122,152
Montana	278,372
Nebraska	4,440
Nevada	272,240
New Mexico	804,586
North Dakota	1,883,816
Oklahoma	830,662
Oregon	13,119
South Dakota	10,596
Texas	2,677,604
Utah	101,665
Washington	26,706
Wyoming	1,044,150

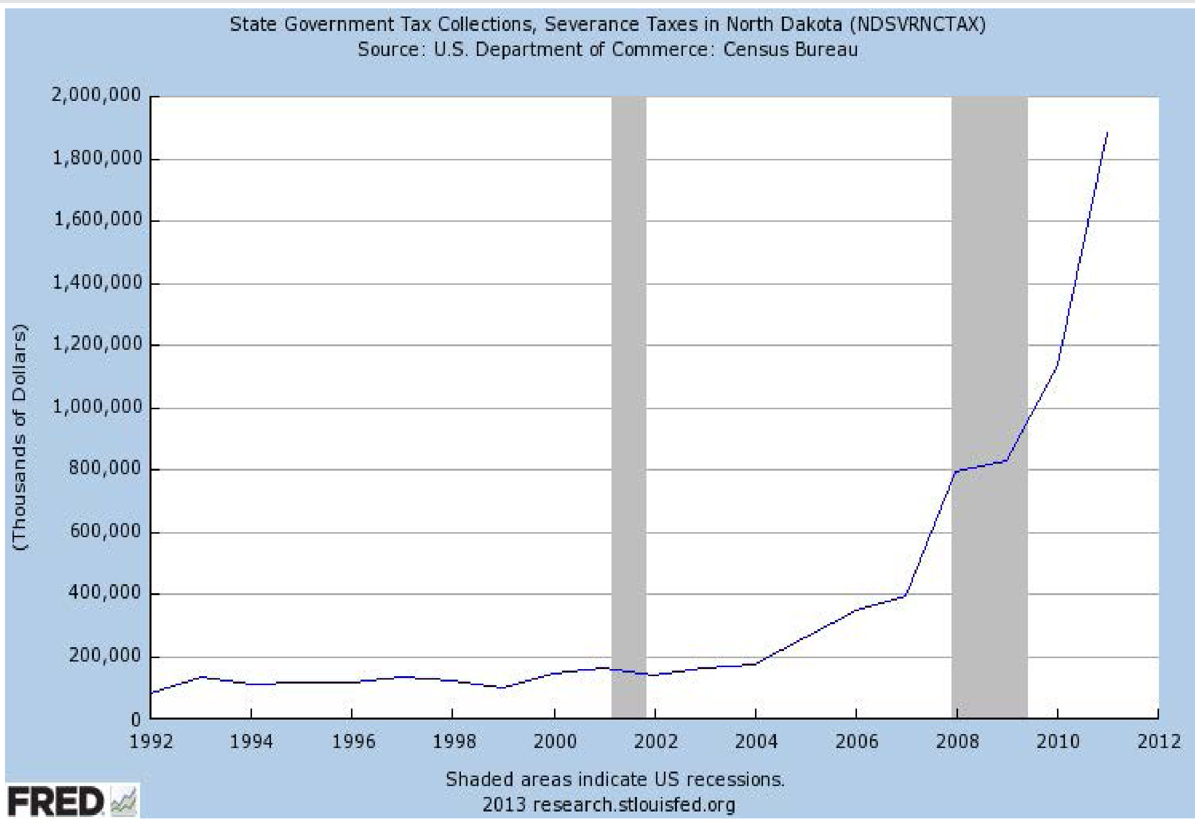
Telles, R., O'Sullivan, S. & Willhide, J. (2012). State Government Tax Collections Summary Report: 2011. Retrieved from http://www.census.gov/prod/2012pubs/g11-stc.pdf

According to estimates from the World Bank, a $1 million investment in wind power results in 4.3 direct jobs and 13.3 total jobs after the value of the investment circulates through the economy.[207] Wind power offers strong job creation in the manufacturing, construction and professional services sector. Approximately 20.3 percent of wind power jobs are in the construction sector. These jobs primarily benefit the rural communities in which they are sited. The income earned by these workers circulates through the

Energy-based Economic Growth in North Dakota: Defying the Recession

In 2008, a boom began in the production of unconventional oil and gas that has reshaped the state economy. The increase in fossil fuels production during that year shielded the state from the impact of the Great Recession, with unemployment peaking at 4.2 percent in May of 2009. Energy-driven growth has made North Dakota the fastest growing economy in the nation. From 2010 to 2011, state GDP grew by 7.6 percent. By contrast, national GDP grew by only 1.5 percent over the same period. As of March, 2013, the 3.2 percent unemployment rate in North Dakota is the lowest in the nation. Oil and gas revenue has also made an increasingly strong contribution to state government tax revenue, as indicated in the Figure.

Figure 7.1



Telles, R., O'Sullivan, S. & Willhide, J. (2012). State Government Tax Collections Summary Report: 2011. Retrieved from http://www.census.gov/prod/2012pubs/g11-stc.pdf

local economy and provides a stimulus effect that creates additional jobs that are not time-limited to the construction project, thereby improving the overall economic health of the community.

The solar power industry has also contributed to job creation in the West during recent years. Current estimates indicate that there are more than 199,000 people employed in solar power across the United States. This estimate includes the addition of 13,872 new jobs from November of 2011 to December of 2012, which represents a 13.2 percent increase in solar employment. By comparison, Bureau of Labor Statistics data indicates that employment growth throughout the economy occurred at only 2.3 percent over the same period. According to estimates from the Solar Foundation, 1 in 230 jobs created nationally over that period were in the solar industry.[208]

Employment growth associated with solar power is among the strongest of any energy source. World

Bank estimates indicate that for every $1 million invested in solar power in the United States, 5.4 direct jobs are created and a total of 13.7 jobs are produced once the investment circulates through the economy. [209] CSP plants are labor intensive and require the ongoing presence of multiple skilled laborers for operations and maintenance. Another factor at work is the division of the value chain in PV solar. The industry includes panel manufacturers, installation companies, operations and maintenance crews for solar parks, and marketing firms. Like wind power, the sectoral distribution of solar power job creation is primarily in the areas of manufacturing, construction and professional services.

Geothermal is a small but growing portion of the regional energy mix. At the current level of installed capacity, the total number of jobs associated with geothermal energy is estimated at approximately 20,316 by the Geothermal Energy Association.[210] The announcement of three additional geothermal projects in 2012 stands to add an additional 2,717 jobs associated with every stage of the project development process. As with wind and solar, geothermal offers a strong advantage for job creation in rural communities where the skills of blue collar workers are required.

The total jobs associated with the development of an average 50 MW geothermal facility can be as high as 860 jobs.[211] The distribution of these jobs is heavily favored towards plant design and construction, requiring an average of 383 to 489 workers. The mixed requirement of advanced technical knowledge and blue collar sets are ideal for areas with both displaced manual laborers and recent college graduates unable to find work in a difficult job market. However, the promise of geothermal energy will be more fully realized once enhanced geothermal systems (EGS) are further developed. Although employment projections for EGS installations remain preliminary at present time, utilization of the technology will allow for the widespread deployment of geothermal across the West.[212]

As a leading source of power generation in the Pacific Northwest, hydroelectric makes an important contribution to regional employment. Current estimates suggest that national employment associated with hydroelectric is between 200,000 and 300,000, with approximately 170,000 of those jobs in the West.

The job creation potential associated with hydroelectric projects is strong in the West. According to a recent study by Navigant Consulting, new hydropower projects produce between 5.3 and 6.5 full time jobs per MW of installed capacity for both upgrades to large hydro facilities and new small-scale hydro installations.[213] Once the induced and indirect job creation associated with new investment in capacity is factored in, total employment increases to approximately 13 jobs per MW. Given the need for uprating turbines and the availability of more than 5,000 potential small hydro sites distributed

throughout Western states, the potential for job creation is strong.

Agriculture has long been an important economic activity in Western states. Recent developments in biomass energy and biofuels have helped ensure this sector will continue to thrive. Current estimates indicate that the typical 30 MW biomass power plant generates 120 total jobs.[214] Given the current generation capacity of biomass sources in the West, biomass power plants employ approximately 7,336 people throughout the region. Employment associated with biofuels production is also substantial, though estimates vary. According to one estimate by the Renewable Fuel Association, the ethanol industry accounted for approximately 401,000 jobs in 2011.[215]

Biomass energy offers strong potential for promoting employment in the West. World Bank estimates place the employment associated with the production of biomass sources at 7.4 direct jobs per $1 million, with the total number of jobs created after investment circulation coming to 17.4 jobs.[216] Given that more than 60 percent of the jobs created by biomass production are in the agriculture sector, this energy type can help create new jobs and maintain existing employment in the event of a fall in demand for conventional output. Additionally, more than 20 percent of biomass job creation is in the manufacturing sector. This increases demand for the skill sets of blue collar workers across the region in need of new opportunities.

Nuclear power is another source of clean energy that creates high paying jobs in West. There are approximately 15,000 jobs in the nuclear power industry at the national level and about 2,400 direct jobs in the region.[217] Given that the average nuclear power plant generates $40 million in revenue annually, the nine nuclear power plants located in the West generate approximately $360 million for the region each year.

The nation's fleet of nuclear reactors is aging, requiring that new capacity be installed to meet the shortfall in demand generated when older ones are taken offline. The Western states can seize upon this opportunity to meet regional and national electricity demand with the construction of new capacity in the West, an effort which will produce, on average, between 400 and 700 long-term salaried positions per installation.[218] Estimates produced by the Nuclear Energy Institute indicate that these jobs are highly beneficial to local communities, typically paying 36 percent higher than average salaries.[219] But much like geothermal, the full promise of nuclear power will be realized once small nuclear reactor (SMR) technology is further advanced. Estimates of job creation associated with SMR deployment are still a matter of academic speculation, given that the Nuclear Regulatory Commission has yet to approve an SMR design for commercial deployment. However, the introduction of commercial SMRs will introduce new jobs in construction and operations requiring advanced skill sets and offering high salaries.

Chapter 8

Western State Contributions to National Energy Security

Energy security for the United States means being able to meet all domestic energy needs from North American sources. Our information-based society requires uninterrupted access to electricity sufficient to drive the economy and meet the needs of everyday life. Ensuring that this demand continues to be met requires expensive and difficult transmission grid upgrades, as well as security against domestic and foreign cyber-attacks. Energy security is also directly linked to national security, as the Department of Defense is the largest single consumer of energy in the federal government.

In the West, efforts to modernize and expand the regional transmission grid will meet the challenge of increasing electricity demand. As to the production and utilization of energy resources, a comprehensive approach to development is well-suited to the establishment of a well-diversified portfolio of generation and fuel types.

Petroleum Security

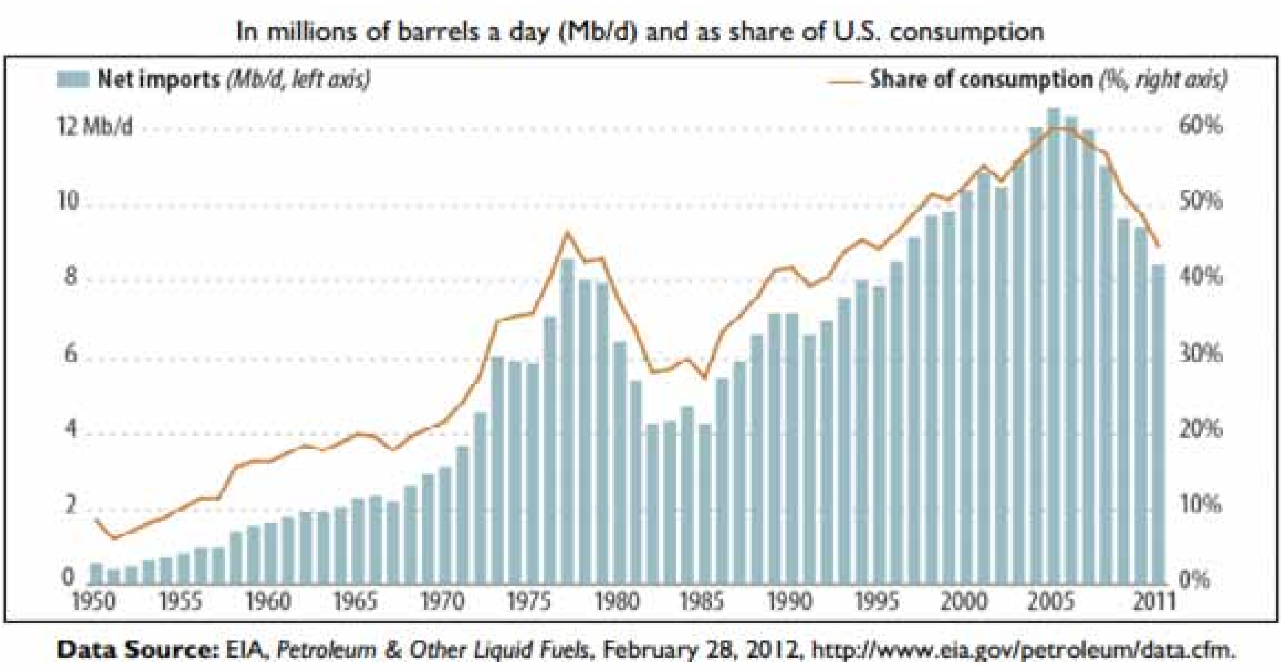
Dependence on foreign oil has been the most prominent energy security issue of the past four decades. Since the Oil Crisis of 1973, the American public has been acutely aware of the vulnerability of our nation to disruptions in the international petroleum market – particularly those intentionally manufactured by antagonistic foreign powers. Although American crude oil imports dropped to a 15-year low in 2012, OPEC producers still accounted for 40 percent of the total.[220]

• Increasing Domestic Production

Absolute petroleum independence is unlikely for any country that participates in the global economy. However, this does not mean that increased energy security for petroleum is beyond reach for the United States, which can wield greater control over prices on the international market by increasing its share of global production. Advances in petroleum extraction and the ramping up of conventional drilling are changing outlooks on the security of American's petroleum supply. The vast majority of this production is taking place in the West, which can be a key to unchaining the nation from dependence on foreign oil and bring forth greater influence over the international petroleum market.

The United States has been dependent on foreign oil since the late 1940s (see Figure 8.1 on next page). The severity of this dependence peaked during the mid-2000s, when imported oil accounted for more than 60 percent of total demand. However, recent projections from the International Energy Agency indicate a reversal of this trend. If current trends persist, the U.S. will become the world leader in oil production by 2017. The Agency further projects that by 2025, the oil trade deficit will be eliminated and our nation will become a net exporter of

Figure 8.1: U.S. Net Oil Imports



the commodity. The historic turnaround will be driven by production in the West, but only so long as prudent regulatory actions and a business environment that allows increased oil development exists.

The West will play an indispensable role in bringing about American energy independence with respect to oil. Already responsible for more than 90 percent of all non-federal domestic oil production, the projected increase in American production is, in actuality, an increase in Western states' production. The unconventional oil reserves of the Bakken region, which extends through much of North Dakota and Montana, are estimated to contain the equivalent of 3.65 billion barrels of oil.[221] Additional large deposits of heavy oil and bitumen have also been found in Texas, California, Alaska and Colorado. Major oil shale reserves have also been identified throughout the Mountain West region. As outlined in the World Energy Outlook 2012, the United States does not have a disproportionate reserve base of any fossil fuel other than coal. The growth of production is attributed entirely to what IEA officials have cited as "conditions on the ground."[222] With favorable market conditions, investment opportunities and a sound regulatory framework in oil producing states in place, the West offers more favorable conditions for private enterprise to expand than virtually anywhere else on the planet. Thus, the Western states are set to greatly outpace production in many other countries with a comparable potential for extraction.

• North American Energy Independence

Growth in domestic production will be a critical factor in improving the security of our nation's petroleum supply, but it is not the only factor. The United States must seek to deepen its trade relationship in energy with its NAFTA partners. Achieving a cumulative output level sufficient to meet the needs of our three nations will promote economic growth and transcontinental cooperation, further decreasing the influence of OPEC in our region.

Much like the U.S., Canada has recently experienced an unconventional oil boom that will bring output of unprecedented proportions. The production of unconventional oil sands and shale oil resources promise a dramatic increase in oil production over the next decade. As the

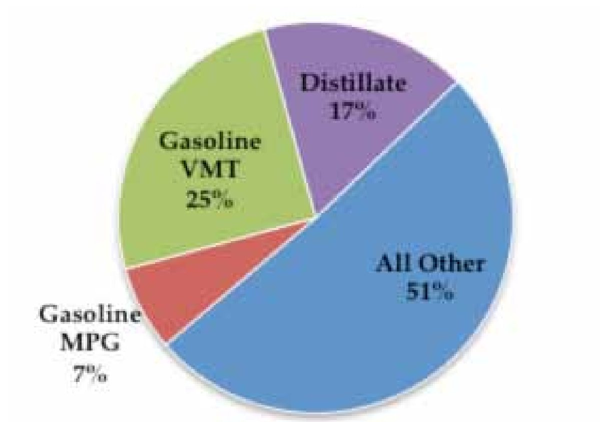
largest single supplier of oil to the American market, Canada already plays a critical role in meeting demand. Fostering even stronger trade ties ensures that Canadian oil will remain in North America, rather than being sold on the world market to nations with antipathy towards the United States.

Mexico has long been one of our nation's leading suppliers of crude oil and petroleum products. Although the country's oil output has been on the decline since 2004, recent events indicate a return to higher production. In March of 2013, Mexico's ruling Institutional Revolutionary Party changed its bylaws regarding foreign investment in Petroleos Mexicanos.[223] The state-owned oil company, commonly referred to as Pemex, has been closed to private foreign investment since nationalization in 1983. During his 2012 campaign, newly-elected President Enrique Peña Nieto pledged a restructuring of Pemex that would drive up production with the help of foreign investment.[224]

• Reducing Petroleum Use Intensity in Transportation

In addition to increasing domestic and regional production, reducing the intensity of petroleum use in the economy can create greater energy

Figure 8.2: Breakdown of Savings in U.S. Oil Consumption



Tverbre, Gail. "Why is US Oil Consumption Lower? Better Gasoline Mileage?" Our Finite World. 31 January 2013. http://ourfiniteworld.com/2013/01/31/why-is-us-oil-consumption-lower-better-gasoline-mileage/

security. The decline in American oil demand has been under way for several years, though it was exacerbated by the onset of the current economic slowdown. According to a recent estimate, U.S. oil consumption was 20 percent lower in 2012 than projected by EIA.[225] As the percentages presented in the Figure indicate, the combination of improved vehicle mileage and decreased usage of distillates in fuel accounted for 24 percent of fuel savings from the pre-2005 annual petroleum demand growth rate of 1.5 percent.[226] Although the reduced vehicle miles traveled and other factors largely result from a reduction in industrial output and lower levels of disposable income associated with economic contraction, the trend towards more stringent Corporate Average Fuel Efficiency standards will continue to moderate growth even as domestic production increases precipitously.

Expanding the share of alternative fuels and vehicles in the transportation sector can also make an important contribution to reducing petroleum demand. For private consumers, the increasing availability of hybrid electric vehicles has driven growth in the American automobile industry while reducing petroleum demand. Meanwhile, the share of natural gas vehicles in public and private automobile fleets has increased and is projected to expand further. The integration of biofuels has also increased over the past several years, with continued growth anticipated in line with blending mandates introduced in the Energy Independence and Security Act of 2007.

The United States has sought to free itself from acute dependence on foreign oil for 40 years. If production continues in line with current projections, this goal will be well within reach.

Transmission and Access to Electricity

The Information Revolution has brought transformational change to the American economy and way of life. Growing reliance on information services and digital devices has driven up electricity demand and rendered the availability thereof more critical than ever before. Though efficiency gains will slow the growth in electricity demand, it will not be halted. According to projections of the Western Electricity Coordinating Council, regional electricity demand in the Western Interconnection alone is anticipated to rise from 860,526 GWh in 2009 to 999,120 GWh in 2022.[227]

Reliable access to electricity at affordable prices requires the modernization and expansion of the transmission grid infrastructure throughout the region, as well as a greater reliance on decentralized generation. In its recent report assessing the state of the national transmission grid infrastructure, the American Society of Civil Engineers highlighted the likelihood of increased power outages in the coming years and vulnerability to cyber attacks. Frequent or large-scale outages pose a signficiant threat to economic and societal well-being throughout the West. The economic losses associated with a blackout can result in billions of dollars. A prolonged loss of power can also prove life threatening, depending on climatic conditions. It is important to take all necessary steps to ensure that the security of the electric power supply remains robust in the West.

• Grid Modernization and Cyber Security

To ensure that electricity is delivered without interruption, the transmission grid must be modernized and expanded. The West has taken the lead with its efforts towards grid modernization. The deployment of phasor measurement units (PMUs) by 18 regional utilities and power authorities in 14 Western states have made the regional transmission smarter by greatly improving grid monitoring and management capabilities; it has also afforded greater control over the grid, which allows it to absorb variable generation from renewable sources more efficiently.[228] The improvements to grid management offered by PMUs allow utilities to quickly identify the source of grid disruptions, a capability that can prevent mass outages such as the Northeast Blackout of 2003.

Grid modernization is not limited to better monitoring and management. The recent revelation of extensive cyber-attacks on American firms and institutions by foreign sources poses serious questions about the vulnerability of our nation's transmission grid infrastructure. Federal efforts to safeguard against such threats are being undertaken by the National Security Agency, which began a five-year grid cyber security initiative dubbed "Perfect Citizen" in 2009. Despite the existence of this $91 million program, the Federal Energy Regulatory Commission (FERC) has expressed concern over "fast-moving cybersecurity threats." [229]

The impact of a cyber-attack resulting in a large-scale and prolonged power outage poses a severe threat to both energy security and national security. An outage of greater than 10 days would cause 80 percent of economic activity in the affected area to cease, [230] an impact comparable to a conventional military attack.

Academic institutions in Western states have taken up the challenge of advancing smart grid technology and training future professionals for careers in cyber-security. At Washington State University's Smart Grid Demonstration and Research Investigation Lab, efforts are under way to advance PMU data processing tools and techniques.[231] Training future professional for careers in cyber security is also a priority for the state. The University of Washington in Seattle is home to the Center for Information Assurance and Cybersecurity, which operates in collaboration with partners that include Microsoft and the United States Department of Defense (DoD). The DoD also sponsors cybersecurity scholarships at Oklahoma State University and the University of Texas at San Antonio.

• Distributed Generation

Distributed generation offers the potential to increase energy security without the need for significant additions to the transmission grid infrastructure. The prevailing approach to the provision of electric power is centralized generation, which involves large-scale generation at power plants that feed electricity into the grid. By contrast, distributed generation employs small-scale generation to provide electricity closer to the point of end use. Technologies that can be deployed for small-scale electricity production include PV solar, wind power, small hydro, biomass and natural gas. The community-based approach to electricity production taken in distributed generation offers a number of energy security advantages over centralized generation.

The existing transmission infrastructure is designed to provide electricity across regional areas by way of an interconnected system. Because the grid requires the careful balancing of electricity loads to maintain stability, a disruption at a given point in the infrastructure can cause a cascading blackout that can leave large areas without power. Such was the case with the Northeastern Blackout of 2003, which left a number of communities without power for more than a day and resulted in economic losses estimated as high as $10.3 billion. [232] Given that the distributed generation approach delivers electricity across localized transmission infrastructure, known as microgrids, a cascading blackout will not result in an absolute loss of power. Although distributed generation technologies may not produce sufficient electricity for the entire community in such events, a supply of electricity would remain available for critical services (e.g. providing electricity to a hospital after its generator reserves are depleted).

A move towards greater decentralization in electric power generation would also make the United States less vulnerable to cyberattacks and terrorism. Large power plants that make a critical contribution to meeting regional electricity demand are high value targets for enemies of the state. By making communities more self-sufficient with respect to electricity generation, the potential impact of an attack on a major power plant or the transmission grid infrastructure would be reduced. However, the small-scale generation technologies available at this time place limits on the extent to which communities can rely on distributed generation.

The commercialization of small modular nuclear reactors (SMRs) would greatly increase the contribution of distributed generation to meeting local power needs. SMRs are capable of producing baseload level electricity generation sufficient to meet a large share of community power demand, with a single unit capable of producing up to 300 MWe, enough to power 240,000 average American households. Because of their modular design, multiple SMRs can be situated at a single location to provide output at levels commensurate with local demand.[233]

Energy Security and the Armed Forces

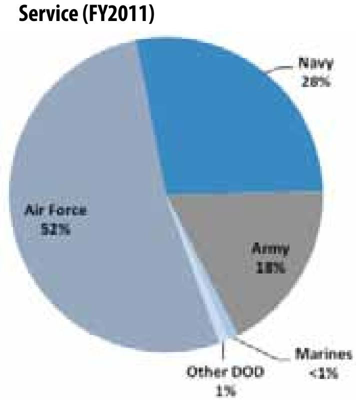
The national security of the United States depends on the ability of our armed forces to meet their energy needs at home and abroad. Meeting this challenge requires significant effort and financial resources. The Department of Defense (DoD) is the single largest consumer of energy in the federal government, accounting for approximately 80 percent of total consumption in 2010. DoD is also the largest organizational consumer of petroleum in the world. Its expenditures on petroleum-based fuels came to $17.3 billion in 2011, roughly 6 percent of the total operations and maintenance outlay for that year. [234]

• Operational Energy Use

The largest share of DoD energy use is in operations. Accounting for approximately 75 percent of its consumption, operational energy is legally defined as "the energy required for training, moving and sustaining military forces and weapons platforms for military operations."[235] In terms of both cost and energy security, the most critical component of operational energy is the use of petroleum-based fuels. The extent of the energy security vulnerability in this area is evidenced by the growing petroleum-related expenditures over the past decade. Despite achieving a 4 percent decrease in petroleum use between 2005 and 2011, petroleum expenditures over that period increased by 381 percent.[236] Given the current national discussion regarding the federal budget deficit, the need to reevaluate the vulnerability of the military to price fluctuations in the international petroleum market is apparent.

In recognition of the growing energy security vulnerability posed by the intensity of petroleum use in the armed forces, DoD has initiated energy management and reduction efforts in each branch of service. The largest consumer of petroleum of these branches is the Air Force, which accounted for 53 percent of military petroleum use. [237] The high level of Air Force consumption is the product of its requirement for high octane jet fuel. Current objectives for Air Force energy use include a 10 percent reduction in the use of aviation fuel by 2015 and the procurement of 50 percent of domestic aviation fuel using alternative fuel blends by 2016.[238]

Figure 8.3: DoD Petrolium Use by Service (FY2011)



Schwartz, M., Blakeley, K. & O'Rourke, R. (2012). Department of Defense Energy Initiatives. Retrieved from http://www.fas.org/sgp/crs/natsec/R42558.pdf

The Navy is the second largest consumer of fuel in the U.S. military in terms of purchases. Efforts on the part of the Navy and Marine Corps to reduce energy consumption are aggressive, with a heavy emphasis on biofuels utilization. They are developing a "Green Strike Group" of ships and aircraft powered by biofuels targeted for deployment overseas by 2016. The Navy is also seeking to obtain a minimum of 50 percent of total energy use from renewable sources by 2020 and aims to achieve a 15 percent afloat fuel consumption reduction by the same year.[239]

Fuel utilization by the Army is the lowest of the three branches; the focus of its energy-related efforts is on installation energy use. The branch also has started a number of operational energy initiatives aimed at improving the fuel efficiency of turbine engines and tanks. Additionally, the branch has employed the use of flight simulators to reduce fuel use and reduce maintenance costs.

• Installation Energy Use

The term installation energy use refers to the use of energy for fixed military installations and any purpose not described in the legal definition of operational energy use. In 2011, DoD expenditures on installation energy amounted to approximately $4 billion. The composition this energy use was primarily comprised of electricity and natural gas, though other sources also contributed (see Figure). [240] The costs associated with installation energy are reflective of the organizational footprint of DoD, which includes more than 300,000 buildings amounting to 2.3 billion square feet.[241]

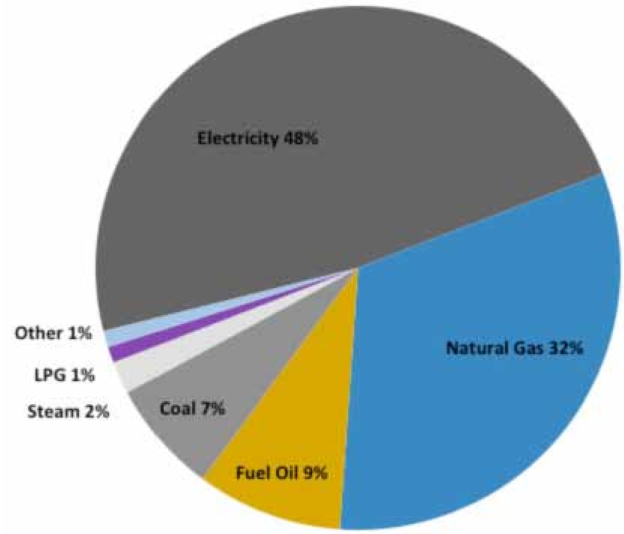
Installation energy use is critical to the armed forces. The integration of advanced technology into combat operations has made the support services provided by DoD facilities increasingly critical. These facilities also make an essential contribution to the staging of humanitarian and homeland defense missions. Given this importance, reliance on the commercial power grid to meet electricity demands poses a serious threat to energy security of the armed forces.

Current efforts to achieve greater security in installation energy use focus on several areas. First, DoD seeks to reduce traditional demand through energy efficiency and conservation efforts. Second, they are working to deploy renewable energy technologies to provide distributed generation in order to make installations self-sufficient with respect to electricity supply. A third component of the strategy is to deploy new energy-saving technologies, as well as investigate technologies capable of allowing greater independence from commercial transmission grids.

Private sector innovation in smart grid technology and small modular reactor design will prove vital components to the attainment of installation self-sufficiency with respect to electricity. State university research, in collaboration with the private sector, can provide valuable insights into how renewable sources can be integrated into transmission in the most efficient manner possible, thereby improving the performance of the wind, solar and biomass renewables already contributing to distributed generation at military installations.

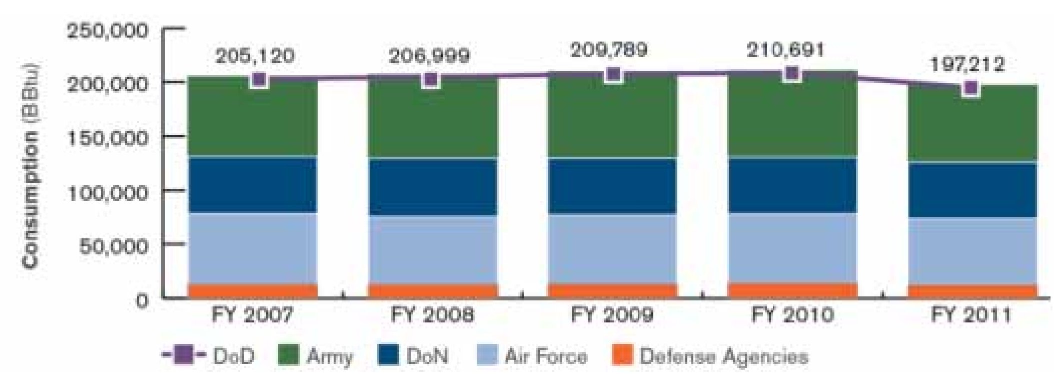
Public and private efforts in the Western states can be undertaken to encourage the Nuclear Regulatory Agency to expeditiously approve a design for commercial deployment of small modular reactors. Such deployment can demonstrate the viability of the technology and help expedite their deployment at military installations. Given that SMRs are both compact and capable of generating baseload level generation, they are ideal for DoD use. Moreover, concerns regarding SMR security are dramatically reduced when situated on a military installation closed to the general public.

Figure 8.4: DoD Installation Energy Use (2011)



DOD. (2012). Department of Defense Annual Energy management Report. Retrieved from http://www.acq.osd.mil/ie/energy/library/FY.2011.AEMR.PDF

Figure 8.5: Facility Energy Consumption by Military Service (2011)



DOD. (2012). Department of Defense Annual Energy management Report. Retrieved from http://www.acq.osd.mil/ie/energy/library/FY.2011.AEMR.PDF

Chapter 9

Energy Literacy, Vocation Education and Technology Development

The United States is one of the largest consumers of energy in the world. For this demand to be met, policymakers must often make difficult choices regarding policies that ultimately influence the composition of the energy mix. Balancing the preservation of a competitive market with the need to account for public sentiment regarding external impacts presents a complex challenge.

No energy policy proposal can meet the expectations of every constituent, and constituencies differ considerably from region to region. This underscores the need to take an all-of-the-above approach to regional energy development. It is just as critical to recognize that when the public lacks energy literacy, unrealistic expectations and uninformed views can drive public debate. Energy policy works best when informed by a common set of impartial facts and the best scientific evidence available.

Energy Literacy: Education and public outreach

Given the complexity surrounding energy choice, informed decision making can be difficult and time consuming. For that reason, states have worked to introduce students to energy issues at an early age. The integration of energy and natural resource education into K-12 science education can afford students an opportunity to gradually absorb the complex details.

The approach taken by Wyoming, to create a K-12 energy and natural resources curriculum, allows states to focus on energy issues that are locally pertinent, providing a greater familiarity with the resource choices that will impact those who live in the state.[242] Additionally, the public-private cooperation called for in the initiative sets a potentially useful example for other states seeking to develop similar curriculum on a limited budget.

States Initiatives: Energy Education in Wyoming

In November of 2012, Gov. Matt Mead proposed the inclusion of K-12 energy and natural resource education as part of the Wyoming Energy Strategy for 2013. The initiative calls for the development of curriculum and web-based learning tools for students and teachers. Specific educational targets of this effort include promoting student awareness and knowledge of state resources, as well as familiarizing them with employment opportunities related to energy and natural resources.

The current K-12 Science Framework for California Public Schools has included consideration of energy and natural resource issues for nearly a decade. For K-8 students, the framework includes a detailed discussion of the various types of energy utilized in the United States. As students move into high school, they are introduced to the possible impact of anthropogenic greenhouse gas emissions

on climate. Also included is an introduction to the computer models used to predict the impact of GHG emissions "on climate for the planet as a whole and for specific regions."[243]

Public outreach campaigns offer another avenue for improving energy literacy, especially among adults. As part of his 10-Year Energy Plan for Utah, current WGA Chairman Gov. Gary R. Herbert called for a campaign of education and public awareness regarding energy efficiency, conservation and demand-response. The plan calls for the development and implementation of a single-messaging communication program sponsored by the state and led by Gov. Herbert. This effort specifically aims to raise public awareness and understanding of the benefits of energy efficiency. Among the other targets identified in the plan: energy efficiency education outreach for home buyers and low income households, as well as incorporating energy-code as a mandatory component of continuing education programs in the construction industry.[244]

Gov. Herbert's approach to public outreach demonstrates how targeted messaging can raise awareness of an issue in energy education. Faced with the challenge of educating an adult population with limited time and receptivity, this focused approach around a single important issue maximizes the potential impact of the outreach. The audience identification reflected in the targets also constitutes a valuable example of how best to engage the public, particularly in regard to potential cost savings. The integration of energy education into continuing education also provides an excellent example of how more complex information can be communicated beyond traditional educational structures.

Energy Education: Advanced studies and professional training

The development of energy resources can make an important contribution to future economic and employment growth throughout the West. From the extraction of fossil fuel resources to the construction of wind turbines and nuclear power plants, the potential for growth is rich and diverse. However, ensuring that the available resources can be utilized to the maximum benefit of a given state requires the availability of relevant post-secondary training and job placement programs.

The unconventional oil and gas boom in North Dakota has driven the need for skilled workers with expertise in energy. To that end, the National Energy Center of Excellence (NECE) was established at Bismarck State College in February of 2006. NECE partners with numerous energy industry entities operating in the state to ensure the development of relevant job skills and career development post-graduation. As of 2012, NECE enrollments accounted for a quarter of the Bismarck State College student body. In addition to benefiting from an Advisory Board consisting of local and national industry experts, the center offers online degree programs and affords flexible training through the availability of online study programs. The center also offers industry training and certification programs aimed at existing workers seeking to enhance their skill sets.[245] Given the success of NECE, other states are now seeking to establish similar centers.

The development of skills oriented towards the creation of renewable energy industry jobs has been a focus of Nebraska Gov. Dave Heineman.

The State Energy Sector Partnership (SESP) aligns the Governor's Workforce Vision with the development of renewable energy training programs. Initiated with grants to the Nebraska Energy Office under the *American Recovery and Reinvestment Act of 2009,* six community college systems in the state have introduced coursework and training aimed at preparing students for careers in wind, solar, geothermal biomass and hydroelectric power. [246] The programs have been developed in accordance with national competency standards and have been instructed by experts from the national associations of Wind, Hydropower, Geothermal and the Solar Energy Institute.

Energy industry job skills creation has also been a focus in the Pacific Northwest. In response to prompting from Gov. Jonh Kitzhaber, the Oregon Workforce Investment Board developed a strategic workforce development plan for 2012 to 2022.[247] The plan centers on an assessment of industries where the state has a global competitive advantage, one of which is clean energy. Included in this category are biomass energy, electric vehicles, energy efficiency, solar energy and wind energy. To promote the creation of jobs in these areas, the plan focuses on industry-specific strategies for employer-driven partnerships b etween business, education and training providers, labor and economic development entities.

Retraining: The Oregon Wood Energy Cluster Pilot Project

The Oregon Wood Energy Cluster Pilot Project, under the joint sponsorship of the Oregon Department of Energy and the U.S. Forest Service, aims to develop six biomass energy clusters that will generate long-term jobs in rural communities throughout the state. The cluster approach taken in Oregon is ideal for communities with displaced workers in need of retraining, applying the advanced skills and economic resources of established entities to create new jobs that build upon existing skills through on-the-job training. [248]

The continued development of relevant educational opportunities will help to promote interest in energy industry careers among high school and college level students in the West. Advanced knowledge can also spur entrepreneurship and foster innovation. Successfully leveraging energy resources to the benefit of the region and nation will require not only developing professional skills and expertise relevant to the industry as it exists today, but also scientific advances enabled by public-private partnerships and basic research.

Energy Technology

Technological advances have always been instrumental in bringing about fundamental changes to energy production and consumption and the West is on the leading edge of research and development. More than at any time in the past, collaboration between institutions of higher learning and private sector entities drives innovation. The Western states understand the importance of developing new energy technologies. Here's a look at some of the technologies.

• Waterless Fracking

The advent of hydraulic fracturing has driven explosive growth in the development of unconventional oil and gas reserves. However, concerns regarding water use and environmental impact have generated controversy and led to serious discussions regarding the balancing of human health and water consumption with the need for economic growth. Given that one of the most mentioned concerns regarding hydraulic fracturing is water use, recent research and development of waterless technologies may offer significant promise in mitigating perceived challenges associated with conventional operations.

The majority of research into waterless fracking has centered on the use of gaseous compounds to induce geologic fracture. CO_2 and nitrogen have been subject to research and testing in this area, but the most widely used approach employs propane. Two North American firms, GASFRAC and eCORP, have developed and deployed a new form of fracking technology that utilizes liquefied propane gas (LPG). Although there are differences between the methods developed by the two, both take the same basic approach of injecting an LPG gel into a well. Once injected, the gel is activated and the expansion of propane vapor induces fracture in the geological formation to release oil and gas reserves.

LPG fracking offers several potential advantages over conventional hydraulic fracking. Given that operations are dependent entirely on the LPG compound, the challenges of water supply limitations and the management of wastewater byproduct are overcome entirely; this also allows for the production of resources in areas where water is unavailable or impractical to use, such as deserts or subarctic climates. The conversion of LPG gel into vapor also allows operators to recover the entire volume injected into the ground. This makes LPG operations more efficient from a resource use perspective, eliminating the need for wastewater treatment and the potential risk of induced seismic activity associated with large quantities of fracking fluid remaining in the ground after completion of conventional operations.[249] Because LPG has a lower specific weight than water, the challenges posed by truck traffic on rural or municipal roads are also reduced. An LPG fracking operation requires only one gallon of propane instead of the five gallons of water that would otherwise be required in conventional hydraulic fracturing.[250] Gas-induced geological fracture has also been cited for procuring 20 to 30 percent higher yields than conventional fracking, a result of gas producing larger fractures.[251, 252]

However, a number of potential drawbacks associated with LPG fracking have limited its adoption since it was first commercialized in 2008.[253] The most frequently cited of these is the increased risk associated with using a highly combustible compound such as fracking fluid. Although LPG fracking offers savings related to water use and treatment, the up-front costs are currently higher than conventional fracking. The cost of LPG fracking is approximately double that of hydraulic fracturing when LPG is flared and 20 percent higher when it is captured.[254]

• Energy Storage and Fuel Cell Technology

Electricity storage and fuel cell technology offer the potential to ensure greater energy security and a larger role for renewables in the energy mix. Energy storage technology can help to meet the challenge posed by variability in renewables generation, with electricity generated at off-peak periods being stored for when it is needed. Fuel cells offer the potential to generate electricity for small-scale use and in the transportation sector.

Battery technology is the most common approach to energy storage. Although widespread in electronic devices, storage of electricity at a large scale has posed difficult challenges. One promising new development is the liquid metal battery. This storage battery uses an inexpensive combination of molten salt and liquid metal to store energy, and it does so using no rare earth metals. Roughly the size of a shipping container and with a storage capacity of approximately 2MWh, these batteries may be ready for commercial applications as early as 2014.[255] Once deployed, they will be a clean and cost-effective way to firm up renewable generation.

A leading source of advances in fuel cell technology is the National Fuel Cell Research Center (NFCRC) at the University of California, Irvine. Since its establishment in 1998, the center has been particularly noteworthy for its work in the area of hydrogen fuel cell technology. One of its current areas of research is the reversible fuel cell, which uses electricity to generate hydrogen gas as a means of storing energy generated by variable renewable energy sources.[256] When generation from these sources is not available, the cell can then reverse the process and convert the stored hydrogen back into electricity.

In addition to the reversible fuel cell, NFCRC is also at the forefront of fuel cell vehicle technology. Current research includes consideration of a variety of different fuel types that include hydrogen, natural gas, methanol, methane and ethanol.[257] Fuel cells are powered by the conversion into electricity of chemical energy found in hydrogen. This electricity is used to power an electric motor to propel the vehicle in a fashion similar to an EV. The hydrogen used to power an HFCV is stored in a pressurized tank on board, which is fed into the fuel cell to generate electricity as needed. Because the generation of electricity involves only hydrogen and an oxidizing agent, the only tailpipe emission generated by the vehicle is water vapor.

• Carbon Dioxide Capture and Sequestration

The United States has a wealth of fossil fuel resources, the majority of which are found in the West. The major drawback of fossil fuels has been their emissions profile. There is broad recognition that the future of fossil fuels such as coal will be tied to their ability to become cleaner, especially through the capture and storage of carbon emissions.

A leading source of innovation in the development of carbon capture and sequestration (CCS) is the Carbon Management Institute (CMI) at the University of Wyoming. CMI is a world leader in research and development in the area of geological CO_2 sequestration. The primary focus of the center in recent years has been the Wyoming Carbon Underground Storage Project. Using three-dimensional seismic data, CMI researchers have helped to advance the understanding of how sub-surface rock can store carbon dioxide by surveying the sequestration potential of Southwest Wyoming's Rock Springs Uplift.[258] If successful, the project will be the state's first successful CCS project and make the state a world leader in that technology.

Texas has also emerged as a leader in the development of sustainable carbon resource use. The Gulf Coast Carbon Center (GCCC) at the University of Texas at Austin has been a leader in the CCS research since 1998.[259] The Carbon Center is engaged in a number of research projects in the area of carbon sequestration, which includes the development of site-specific standards for CCS monitoring technology. The project is pioneering the development of monitoring techniques and guidelines essential to the future deployment of CCS technology in the United States.[260]

• Advanced Nuclear Power

Advances in nuclear power may play a critical role in an increasingly electrified economy. If electric vehicles enter into widespread use, the demand for electricity will increase in relation to the reduction of petroleum fuel use. One possible avenue for large-scale increase in the electricity production is through the deployment of nuclear power. Historically nuclear energy has had two major challenges: it is capital intensive to construct, and permanent waste storage has still not been secured. However, advances in a new generation of reactors may make nuclear worth reconsidering.

Idaho National Laboratory is a leading institution in the development of next generation nuclear power. Established in 1949, INL is currently engaged in next generation reactor research that utilizes process heat for industrial purposes and the production of hydrogen. INL is currently in collaboration with private sector entities to develop new reactor designs for commercial deployment. Research at INL is also important to the continued operation of the existing fleet of nuclear reactors. The Light Water Reactor Sustainability Program at the lab serves as a critical source of information regarding the continued operation of a nuclear power plant after the 60-year operational lifespan currently allowed by the NRC.[261]

Development of next-generation nuclear power is also occurring in the private sector. Established with private sector funds and the Los Alamos National Laboratory, Terrapower is developing a new form of nuclear power plant that employs traveling wave reactor (TWR) technology. TWR nuclear power plants utilize a small amount of enriched uranium that begins a reaction, which then be sustained using existing spent nuclear waste from conventional plants. Given that this technology employs a closed fuel cycle, a new plant can enter into operation with enough fuel to sustain the reaction for a period ranging from 40 to 60 years. Several TWR designs exist, ranging from 300 to 1,000 MW in output. Depending on permitting and licensing issues, the first TWR plan could enter into service by 2020.[262]

Regardless of which technologies ultimately define our energy future, the key will be to ensure entrepreneurs are not impeded. By encouraging public-private partnerships and having a regulatory environment that allows those entrepreneurs to compete, a secure, reliable, and affordable energy future is possible.

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